Thesis submitted for the degree of Doctor of Philosophy (PhD)

**The Economics of Diabetes in Middle-Income**

**Countries**

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**Publications and statement of**

**authorship**

The research reported is my own original work which was carried out in col-laboration with others as follows:

**Chapter 1:** Written by Till Seuring.

**Chapter 2:** Till Seuring was the lead author of a paper published as:

Seuring, T., Archangelidi, O., and Suhrcke, M. (2015). “The Economic Costs of Type 2 Diabetes: A Global Systematic Review.” *PharmacoEconomics* 33 (8), 811–831.

Till Seuring, Marc Suhrcke and Olga Archangelidi designed the study. The search strategy was designed and executed by Till Seuring. Till Seuring and Olga Archangelidi screened the initial results and extracted the data from the primary studies. Till Seuring drafted the original manuscript which was criti-cally reviewed by Olga Archangelidi and Marc Suhrcke.

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Till Seuring, Yevgeniy Goryakin and Marc Suhrcke designed the study. Till Seuring analysed the data. Till Seuring drafted the original manuscript which was critically reviewed by Yevgeniy Goryakin and Marc Suhrcke.

**Chapter 4:** Till Seuring was the lead author of a working paper publishedas: Seuring T., Serneels P., M. Surcke, 2016, The impact of diabetes on labour market outcomes in Mexico: a panel and biomarker data analysis. It has ap-

peared as IZA Discussion Paper 10123, and York University Centre for Health Economics Research Paper 134, and has been submitted for publication.

Till Seuring, Pieter Serneels and Marc Suhrcke designed the study. Till Seuring analysed the data. Till Seuring drafted the original manuscript which was critically reviewed by Pieter Serneels and Marc Suhrcke.

**Chapter 5:** Till Seuring and Max Bachmann designed the study. Till Seuringanalysed the data. Till Seuring drafted the original manuscript which was critically reviewed by Max Bachmann and Pieter Serneels.

**Chapter 6:** Written by Till Seuring.

**Abstract**

This thesis researches the economics of type 2 diabetes in middle-income countries (MICs). Given its rising prevalence, in-depth country specific analysis is key for understanding the economic consequences of T2D in MICs. I analyse the economic burden of type 2 diabetes in terms of labour market consequences, taking into account the heterogeneity of the diabetes population, for both Mexico and China. For China I further investigate the eﬀects of a diabetes diagnosis on health behaviours.

The thesis consists of four studies with the unifying theme of improv-ing our understanding of the causal impact of diabetes on economic out-comes. Study (1) provides an updated overview, critically assesses and identifies gaps in the current literature on the economic costs of T2D using a systematic review approach; study (2) investigates the eﬀects of self-reported diabetes on employment probabilities in Mexico, using cross-sectional data and making use of a commonly used instrumen-tal variable  [(IV)](#page14) approach; study (3) revisits and extends these results via the use of fixed eﬀects  [(FE)](#page14) panel data analysis, also considering a broader range of outcomes, including wages and working hours. Further, it makes use of cross-sectional biomarker data that allow for the investi-gation of measurement error in self-reported diabetes. Study (4) researches the eﬀect of a diabetes diagnosis on employment as well as health behaviours in China, using longitudinal data and applying an alternative identification strategy,: marginal structural model  [(MSM)](#page14) es-timation, while comparing these results with FE estimation results.1

The findings of the first paper document a considerable increase in studies on the economic costs of diabetes in MICs. It also illustrates that most of the evidence is based on cost-of-illness studies and the literature on adverse labour market eﬀects of diabetes in MICs is scarce. The thesis fills part of this void and shows that self-reported diabetes has a considerable impact on employment probabilities of people living in Mexico and China. The findings are robust to the application of diﬀerent estimation strategies. No consistent evidence of an adverse eﬀect of diabetes on wages or working hours is found. The findings for Mexico in the second and third paper indicate that it is the poor and less protected as well as women that are most negatively aﬀected by the disease. Taking into account those unaware of the disease, the adverse eﬀect of diabetes is reduced because undiagnosed diabetes itself does

* Chapters 2 and 3 have appeared as journal articles in PharmacoEconomics and Economics
  + Human Biology, respectively. Chapter  [4](#page101) has appeared as a working paper and been submitted for publication. For further details see page **??**.

not show an adverse association with any labour market outcome. This suggests that the undiagnosed population is distinctly diﬀerent from the diagnosed population, likely due to diﬀerences in health information and health status. With regards to the eﬀect of a diabetes diagnosis on health behaviours, the results from China in the fourth paper suggest that a diagnosis leads to moderate reductions in body mass index (BMI), waist circumference, alcohol and caloric consumption. Perhaps surprisingly, especially men appear to be able to lose weight and reduce their caloric consumption. Not accounting for unobserved heterogeneity leads to a change in the coeﬃcient sign for the eﬀect of a diagnosis on body mass index  [(BMI)](#page14) and waist circumference, while the diﬀerences in estimates are less pronounced for other outcomes.

The thesis identifies a considerable economic burden of diabetes in MICs. Eﬀorts to reduce this burden should consider inequities in the economic burden.

**Contents**

|  |  |
| --- | --- |
| **1 General Introduction** | **16** |

1. [Background to the thesis](#page17) . . . . . . . . . . . . . . . . . . . . . . 17
   1. [Types of diabetes](#page18) . . . . . . . . . . . . . . . . . . . . . . 18
   2. [Diabetes complications](#page19) . . . . . . . . . . . . . . . . . . . 19
   3. [Diabetes prevention](#page20) . . . . . . . . . . . . . . . . . . . . . 20
   4. The need for further economic research on diabetes . . . 20
2. [Objectives of the thesis](#page21) . . . . . . . . . . . . . . . . . . . . . . . 21

1.2.1  [The global economic burden of diabetes](#page21)  . . . . . . . . . 21

1. [The labour market impact of type 2 diabetes](#page21) . . . . . . . 21

|  |  |
| --- | --- |
| [1.2.3 Diabetes, behavioural risk factors and employment statu](#page25)s | 25 |
| 1.3 Thesis methods and structure . . . . . . . . . . . . . . . . . . . | 26 |
| **2 The Economic Costs of Type 2 Diabetes: A Global Systematic** |  |
| **Review** | **28** |

1. Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30
2. Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 31  [2.2.1 Search strategy](#page32) . . . . . . . . . . . . . . . . . . . . . . . 32

2.2.2 Inclusion and exclusion criteria . . . . . . . . . . . . . . 32

* 1. [Data extraction and analysis](#page32) . . . . . . . . . . . . . . . . 32

1. Results . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 36
   1. [Cost-of-illness studies on type 2 diabetes](#page36) . . . . . . . . . 36
   2. [The impact of diabetes on employment chances and pro](#page51)- [ductivity](#page51) . . . . . . . . . . . . . . . . . . . . . . . . . . . 51
2. Discussion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 66
   1. [General findings and developments since the 2004 revie](#page66)w

of diabetes cost-of-illness studies . . . . . . . . . . . . . . 66

* 1. Labour market studies . . . . . . . . . . . . . . . . . . . 68
  2. [Comparison of COI and labour market studies: commo](#page69)n

|  |  |
| --- | --- |
| themes and lessons learned . . . . . . . . . . . . . . . . . | 69 |
| 2.4.4 Limitations . . . . . . . . . . . . . . . . . . . . . . . . . | 71 |

1. Conclusion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 72

|  |  |
| --- | --- |
| **3 The Impact of Diabetes on Employment in Mexico** | **74** |

1. Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 75

[3.2 Methodology](#page78)  . . . . . . . . . . . . . . . . . . . . . . . . . . . . 78

1. [Dataset and descriptive statistics](#page78)  . . . . . . . . . . . . . 78

3.2.2  [Econometric specification](#page81)  . . . . . . . . . . . . . . . . . 81

1. Results . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 85
2. Probit results . . . . . . . . . . . . . . . . . . . . . . . . 85

|  |  |  |
| --- | --- | --- |
| 3.3.2 | IV results . . . . . . . . . . . . . . . . . . . . . . . . . . | 87 |
| [3.3.](#page91)3 | [Diﬀerences by age groups](#page91)  . . . . . . . . . . . . . . . . . | 91 |

* 1. [Diﬀerences by wealth](#page93) . . . . . . . . . . . . . . . . . . . . 93
  2. [Diﬀerences by employment type](#page95) . . . . . . . . . . . . . . 95

1. Conclusion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 97

**4 The Impact of Diabetes on Labour Market Outcomes in Mexico: a**

|  |  |
| --- | --- |
| **Panel Data and Biomarker Analysis** | **101** |

1. Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 102
2. [Diabetes and labour outcomes—existing evidence](#page105)  . . . . . . . . 105
3. Data . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 107
4. [Estimation strategy](#page113) . . . . . . . . . . . . . . . . . . . . . . . . . 113  [4.4.1 Panel data on self-reported diabetes](#page114) . . . . . . . . . . . . 114

4.4.2  [Self-reported diabetes duration](#page116)  . . . . . . . . . . . . . . 116

1. [Cross-section: biomarker and self-reported data](#page117)  . . . . . 117

4.5 Results . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 119

* 1. [Incidence of self-reported diabetes](#page119) . . . . . . . . . . . . . 119
  2. [Duration of self-reported diabetes](#page126) . . . . . . . . . . . . . 126
  3. [Cross-sectional biomarker analysis](#page131) . . . . . . . . . . . . . 131

1. Conclusion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 136

**5 The relationship between diabetes, employment status and be-havioural risk factors: An application of marginal structural models**

|  |  |
| --- | --- |
| **and fixed eﬀects to Chinese panel data** | **140** |

1. Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 142
2. Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 146
   1. [Study sample](#page146)  . . . . . . . . . . . . . . . . . . . . . . . . 146
   2. Assessment of diabetes . . . . . . . . . . . . . . . . . . . 147

5.2.3 Assessment of outcomes . . . . . . . . . . . . . . . . . . 148

5.2.4  [Statistical analysis](#page148)  . . . . . . . . . . . . . . . . . . . . . 148

5.2.5 Random eﬀects . . . . . . . . . . . . . . . . . . . . . . . 153

1. Results . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 154
2. Discussion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 165

5.4.1 Limitations . . . . . . . . . . . . . . . . . . . . . . . . . 165

5.4.2 Potential mechanisms . . . . . . . . . . . . . . . . . . . . 166

1. Conclusion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 169

|  |  |
| --- | --- |
| **6 Discussion and conclusions** | **171** |

1. [Chapter overview](#page172) . . . . . . . . . . . . . . . . . . . . . . . . . . 172
2. [Summary of principal findings](#page172) . . . . . . . . . . . . . . . . . . . 172
3. [The context of the findings and their implications](#page176) . . . . . . . . 176
4. Reflections on the methods used in the thesis . . . . . . . . . . . 184
5. [Strengths and limitations](#page185) . . . . . . . . . . . . . . . . . . . . . . 185
6. [Suggestions for future research](#page187) . . . . . . . . . . . . . . . . . . . 187
7. [Concluding remarks](#page189) . . . . . . . . . . . . . . . . . . . . . . . . . 189

**List of Figures**

1  [PRISMA](#page15) flowchart. . . . . . . . . . . . . . . . . . . . . . . . . . 34  [2 Number of](#page39)  [COI](#page14)  [studies, by costing approach and income group.](#page39) 39

* [GDP](#page14)  [to direct costs ratio by estimation approach.](#page45) . . . . . . . . 45
* [Direct and indirect cost relation in studies estimating total cost](#page48)s

[of type 2 diabetes.](#page48)  . . . . . . . . . . . . . . . . . . . . . . . . . 48

* [Kernel-weighted local polynomial regression of employment sta](#page127)-

tus on diabetes duration. . . . . . . . . . . . . . . . . . . . . . . 127

* [Kernel-weighted local polynomial regression of log hourly wage](#page127)s

on diabetes duration. . . . . . . . . . . . . . . . . . . . . . . . . 127

* [Kernel-weighted local polynomial regression of working hours o](#page128)n diabetes duration. . . . . . . . . . . . . . . . . . . . . . . . . . . 128

|  |  |  |  |
| --- | --- | --- | --- |
| 8 | [Direct acyclic graph for the marginal structural mode](#page149)l | . . . . . | 149 |
| 9 | [Direct acyclic graph for the fixed eﬀects model](#page152) . . . . . | . . . . . | 152 |

1. [Analysis of the eﬀect of time since diabetes diagnosis on em](#page162)- [ployment status and behavioural outcomes (duration groups](#page162),  [marginal structural model)](#page162) . . . . . . . . . . . . . . . . . . . . . 162
2. [Analysis of the eﬀect of time since diabetes diagnosis on employ](#page163)- [ment status and behavioural outcomes (duration groups, fixe](#page163)d  [eﬀects)](#page163) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 163
3. [The eﬀect of time since diabetes diagnosis on employment statu](#page164)s

[and behavioural outcomes (duration groups, random eﬀects)](#page164)  . . 164

1. [Analysis of the eﬀect of time since diabetes diagnosis on over](#page280)- [weight and obesity (duration groups)](#page280) . . . . . . . . . . . . . . . 280

**List of Tables**

* [Summary of direct costs by estimation approach and income sta](#page43)-

[tus in international dollars $ (2011) for prevalence-based studies.](#page43)  43

* [Relationship between direct costs and study characteristics (ro](#page46)-

[bust linear regression).](#page46) . . . . . . . . . . . . . . . . . . . . . . . 46

* Incidence studies on the costs of diabetes . . . . . . . . . . . . . 49
* Incidence studies on the costs of diabetes . . . . . . . . . . . . . 50  [4 Country level costs prediction studies](#page52) . . . . . . . . . . . . . . . 52  [5 Studies estimating the relationship between diabetes and em](#page54)-

[ployment (2001 – 2014)](#page54) . . . . . . . . . . . . . . . . . . . . . . . 54  [6 Studies estimating the relationship between diabetes and othe](#page62)r

[productivity outcomes (2001 – 2014)](#page62)  . . . . . . . . . . . . . . . 62

* [Summary statistics for males and females with and without di](#page80)-

|  |  |  |
| --- | --- | --- |
|  | abetes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 80 |
| 8 | [Impact of diabetes on employment probabilities (probit)](#page86)  . . . . | 86 |

* [Impact of diabetes on employment probabilities (bivariate probit)](#page88) 88

1. [Impact of diabetes on employment probabilities (linear IV)](#page90) . . . 90
2. [Impact of diabetes on employment probabilities by age grou](#page92)p

|  |  |
| --- | --- |
| [(probit)](#page92)  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 92 |
| [12 Impact of diabetes on employment probabilities by wealth grou](#page94)p |  |
| [(probit)](#page94)  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 94 |

1. [Impact of diabetes on employment probabilities by employmen](#page96)t  [status (probit)](#page96) . . . . . . . . . . . . . . . . . . . . . . . . . . . . 96
2. [Inconsistencies in diabetes self-report in MxFLS](#page110) . . . . . . . . . 110
3. [Descriptive statistics for panel and biomarker sample.](#page112) . . . . . . 112
4. [Self-reported diabetes and labour market outcomes.](#page120) . . . . . . . 120
5. [Eﬀect of self-reported diabetes on wages and working hours, b](#page122)y

[type of work.](#page122)  . . . . . . . . . . . . . . . . . . . . . . . . . . . . 122

1. [Relationship between self-reported diabetes and selection int](#page125)o  [types of work.](#page125) . . . . . . . . . . . . . . . . . . . . . . . . . . . . 125
2. [Relationship between self-reported years since diagnosis and em](#page129)- [ployment probabilities using continuous duration and duratio](#page129)n  [splines.](#page129) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 129
3. [Relationship between self-reported years since diagnosis and lo](#page130)g  [hourly wage / weekly working hours using continuous duratio](#page130)n

[and duration splines.](#page130) . . . . . . . . . . . . . . . . . . . . . . . . 130

1. [Number of observations with diabetes (HbA1c](#page132) ≥  [6](#page132)*[.](#page132)*[5%) and self](#page132)- [reported diabetes.](#page132) . . . . . . . . . . . . . . . . . . . . . . . . . . 132
2. Biomarker results . . . . . . . . . . . . . . . . . . . . . . . . . . 134
3. [Self-reported diabetes, biomarkers, diabetes severity and self](#page135)- [reported health and their association with labour market](#page135) outcomes135
4. [Sample means for males and females, by diabetes status](#page156) . . . . . 156
5. [Time variant and invariant predictors of a diabetes diagnosi](#page158)s  [(denominator of stabilized weights)](#page158) . . . . . . . . . . . . . . . . 158
6. [Analysis of the eﬀect of a diabetes diagnosis on employmen](#page159)t  [status and behavioural outcomes using MSM, FE and RE](#page159) . . . . 159
7. [Analysis of the eﬀect of time since diabetes diagnosis on em](#page161)- [ployment status and behavioural outcomes using MSM, FE an](#page161)d

RE . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 161

1. [Household surveys from low- and middle-income countries in](#page193)- [cluding diabetes information as of 2014](#page193) . . . . . . . . . . . . . . 193

|  |  |  |  |
| --- | --- | --- | --- |
| [2](#page210)9 | [Country Code](#page210)s | . . . . . . . . . . . . . . . . . . . . . . . . . . . | 210 |
| [2](#page210)9 | [Country Code](#page210)s | . . . . . . . . . . . . . . . . . . . . . . . . . . . | 211 |

1. [COI study characteristics and cost estimates](#page212) . . . . . . . . . . . 212
2. [COI study costing components](#page239) . . . . . . . . . . . . . . . . . . . 239
3. [Impact of diabetes on employment probabilities (linear IV, 1s](#page249)t

|  |  |  |
| --- | --- | --- |
|  | [and 2nd stage)](#page249)  . . . . . . . . . . . . . . . . . . . . . . . . . . . | 249 |
| [3](#page251)3 | [Impact of diabetes on employment probabilities by age group](#page251)s |  |
|  | [older than 44 (probit)](#page251)  . . . . . . . . . . . . . . . . . . . . . . . | 251 |
| [3](#page253)4 | [Impact of diabetes on employment probabilities by wealth quar](#page253)- |  |
|  | [tile (probit)](#page253)  . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 253 |

1. [IV estimates for the age group 15–44](#page256)  . . . . . . . . . . . . . . . 256
2. [IV estimates for the age group 45–64](#page257)  . . . . . . . . . . . . . . . 257

37 IV results for lower wealth half . . . . . . . . . . . . . . . . . . 259

1. [IV results for upper wealth half](#page260)  . . . . . . . . . . . . . . . . . . 260
2. [Impact of diabetes on employment probabilities by employmen](#page262)t

[status (multinomial logit)](#page262)  . . . . . . . . . . . . . . . . . . . . . 262

1. [IV results for informal employment](#page264)  . . . . . . . . . . . . . . . . 264
2. [IV results for formal employment](#page265)  . . . . . . . . . . . . . . . . . 265

42 Attrition between waves . . . . . . . . . . . . . . . . . . . . . . 266

1. [Summary of stabilized weights](#page267) . . . . . . . . . . . . . . . . . . . 267
2. [Analysis of the eﬀect of time since diabetes diagnosis on employ](#page268)- [ment status and behavioural outcomes using marginal structura](#page268)l  [models (duration groups)](#page268) . . . . . . . . . . . . . . . . . . . . . . 268
3. [Analysis of the eﬀect of time since diabetes diagnosis on em](#page269)- [ployment status and behavioural outcomes using fixed eﬀect](#page269)s  [(duration groups)](#page269) . . . . . . . . . . . . . . . . . . . . . . . . . . 269
4. [Analysis of the eﬀect of time since diabetes diagnosis on em](#page270)- [ployment status and behavioural outcomes using random eﬀect](#page270)s  [(duration groups)](#page270) . . . . . . . . . . . . . . . . . . . . . . . . . . 270
5. [Analysis of the eﬀect of a diabetes diagnosis on employment sta](#page271)- [tus and behavioural outcomes using marginal structural model](#page271)s

[with truncated stabilized weights at 1st and 99th percentile](#page271) . . . 271

1. [Eﬀect of time since diabetes diagnosis on employment statu](#page272)s  [and behavioural outcomes using MSM with truncated stabilize](#page272)d

[weights (1st and 99th percentile; imputed)](#page272) . . . . . . . . . . . . 272

1. [Analysis of the eﬀect of a diabetes diagnosis on employmen](#page273)t  [status and behavioural outcomes using MSM, FE and RE (n](#page273)o  [imputation)](#page273) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 273
2. [Analysis of the eﬀect of time since diabetes diagnosis on employ](#page274)- [ment status and behavioural outcomes using MSM, FE and R](#page274)E  [(non-imputed)](#page274) . . . . . . . . . . . . . . . . . . . . . . . . . . . . 274
3. [Analysis of the eﬀect of time since diabetes diagnosis on employ](#page275)- [ment status and behavioural outcomes using marginal structura](#page275)l  [models (duration groups) (non-imputed)](#page275) . . . . . . . . . . . . . 275
4. [Analysis of the eﬀect of time since diabetes diagnosis on em](#page276)-

[ployment status and behavioural outcomes using fixed eﬀect](#page276)s  [(duration groups) (non-imputed)](#page276) . . . . . . . . . . . . . . . . . 276

1. [Analysis of the eﬀect of time since diabetes diagnosis on em](#page277)- [ployment status and behavioural outcomes using random eﬀect](#page277)s

[(duration groups) (non-imputed)](#page277)  . . . . . . . . . . . . . . . . . 277

1. [Analysis of the eﬀect of a diabetes diagnosis on overweight an](#page278)d  [obesity using MSM, FE and RE](#page278) . . . . . . . . . . . . . . . . . . 278
2. [Analysis of the eﬀect of time since diagnosis on overweight an](#page279)d  [obesity using MSM, FE, RE](#page279) . . . . . . . . . . . . . . . . . . . . 279

**Abbreviations**

**ATE** average treatment eﬀect

**BMI** body mass index

**CHNS** China Health and Nutrition Survey

**CHARLS** The China Health and Retirement Longitudinal Study

**COI** cost-of-illness

**DAG** direct acyclic graph

**FE** fixed eﬀects

**GDP** gross-domestic-product

**HbA1c** glycated hemoglobin

**HIC** high-income country

**ICD** International Statistical Classification of Diseases and Related Health

Problems

**IDF** International Diabetes Federation

**IV** instrumental variable

**LATE** local average treatment eﬀect

**LIC** low-income country

**LMIC** low- and middle-income country

**LPM** linear probability model

**MSM** marginal structural model

**MIC** middle-income country

**MxFLS** Mexican Family Life Survey

**NCD** non-communicable disease

**OLS** ordinary least squares

**OOP** out-of-pocket

**PPP** purchasing-power-parity

**PRISMA** Preferred Reporting Items for Systematic Reviews and Meta-Analyses

**RE** random eﬀects

**UK** United Kingdom

**WHO** World Health Organization

**WTP** willingness to pay

**1 General Introduction**

**1.1 Background to the thesis**

Diabetes, and especially type 2 diabetes, has seen an unprecedented rise in prevalence globally and especially in low- and middle-income countries (LMICs), where rates reached and often surpassed those of high-income countries (HICs) such as the USA, UK or Germany (Hu,  [2011;](#page292) NCD Risk Factor Collaboration,  [2016](#page297)). Today, two-thirds of the over 400 million people with diabetes live in LMICs (International Diabetes Federation,  [2014)](#page292) and in particular in China, India, Brazil, Indonesia, Pakistan, Russia, Egypt and Mexico (NCD Risk Fac-tor Collaboration,  [2016](#page297)). In 2015 diabetes has been responsible for over 5 million death and people with diabetes are estimated to die 6 years earlier due to the disease and increasingly before the age of 60 (International Diabetes Federation,  [2015;](#page292) Seshasai et al.,  [2011](#page302)). This increase is due to a shift in age structure towards older populations and is further spurred by rapid changes in levels of physical activity, nutrition and other lifestyle related factors (Hu,  [2011;](#page292) NCD Risk Factor Collaboration,  [2016](#page297)).

In LMICs the rise of non-communicable diseases  [(NCDs)](#page15) has in many cases led to a double disease burden, where health systems have to deal with high rates of infectious as well as non-communicable diseases (Jamison et al.,  [2013](#page292)). Given the scarce resources in these countries (Mills,  [2014),](#page296) the increasing num-ber of people with diabetes and at risk of the disease are putting an addi-tional burden on these systems (Chan and Luk,  [2016;](#page286) Wareham and Herman,  [2016](#page306)). However, despite the epidemic levels diabetes has reached in LMICs, research on its economic consequences has remained sparse for these countries and mostly limited to HICs. More research is needed to identify how diabetes is aﬀecting individuals in LMICs and what are the groups most adversely af-fected. This could help raise awareness of policy makers of the size and of the potential inequities of the disease burden, and help to design strategies to reduce them.

Currently healthcare systems in LMICs are likely further increasing inequities by providing better care and coverage for those in formal employment and economically better oﬀ (Di Cesare et al.,  [2013;](#page288) Mills,  [2014](#page296)). For Peru, a recent study identified several barriers to care for people with diabetes, and this seems highly relevant for other middle-income countries (MICs). They included a generally low political commitment to improve access to and the quality of diabetes care, little qualified personal to treat diabetes at the primary care level, high out-of-pocket expenditures partly related to the seeking of specialized diabetes care in the private sector, and

few resources in the healthcare budget being allocated to non-communicable-diseases treatment despite its high mortality burden (Cardenas et al.,  [2016](#page286)). Further, it appears that diabetes diagnosis happens often too late to prevent first complications, with a first diagnosis often being made after a patient had been admitted to a hospital emergency department due to diabetes related complications (Cardenas et al.,  [2016](#page286)). Similar observations have been made for other LMICs (Beran,  [2015;](#page284) World Health Organization,  [2014](#page307)).

**1.1.1 Types of diabetes**

Diabetes is a term used to describe various conditions characterised by elevated blood glucose levels. These either occur because the pancreas is not able to produce suﬃcient insulin, or due to insulin resistance, where the body is not able to use the produced insulin eﬀectively (World Health Organization,  [2016](#page307)). The diﬀerent conditions themselves have distinct origins, especially the two most common types called type 1 diabetes and type 2 diabetes.

* **Type 1 diabetes** is an autoimmune disease with an important geneticcomponent and whose triggers still remain largely elusive. It emerges when the insulin producing cells on the pancreas are attacked and de-stroyed by the immune system and insulin has to be provided exoge-nously. About 10% of all global diabetes cases are type 1 diabetes and it is particularly prevalent in Northern European countries such as Finland, though generally exhibits much geographic variation. Its onset is mainly during the first 30 years of life. Symptoms tend to appear rather quickly and can be quite severe leading to a relatively rapid diagnosis or death, if insulin is not given or available. People with type 1 diabetes will need to inject insulin to control their blood glucose levels for their entire life following diagnosis (Tuomilehto,  [2013](#page305)).
* **Type 2 diabetes** results from the body’s ineﬀective use of insulin andaccounts for about 90% of all diabetes cases (World Health Organization,  [2016](#page307)). Albeit there is a considerable genetic component to the develop-ment of type 2 diabetes, there are many known risk factors that favour the development of type 2 diabetes, such as overweight and obesity, un-healthy diet, physical inactivity and smoking, among others (American Diabetes Association,  [2014;](#page281) World Health Organization,  [2016](#page307)). Interest-ingly, the risk to develop type 2 diabetes varies also by ethnicity, with

South-East Asian populations developing diabetes at lower body mass in-dex  [(BMI)](#page14) levels than populations of European decent (Ramachandran, Wan Ma, et al.,  [2010](#page300)). Type 2 diabetes often remains undetected for several years due to its more gradual development compared with type 1 diabetes (American Diabetes Association,  [2014](#page281)). Therefore, even in HICs and especially in LMICs, a proportion of at least 1/4 of the type 2 diabetes population is unaware of the condition (Beagley et al.,  [2014](#page284)).

The onset of type 2 diabetes also appears to be increasingly earlier in life. This has been observed mainly in ethnic minorities in  [HIC,](#page14) such as Mexicans and Asians, while data is limited for  [LMIC](#page14) (Fazeli Farsani et al.,  [2013](#page290)). Also the increasing numbers of obesity in child- and early adulthood are leading to the earlier onset of type 2 diabetes (Chen et al.,  [2012](#page286)). Hence, type 2 diabetes increasingly aﬀects people in the middle of their productive lifespan, extending the time they have to live with the disease and the probability of developing debilitating complications.

**1.1.2 Diabetes complications**

The most common complication for all types of diabetes, and often already present at diagnosis, is retinopathy (35% at diagnosis), being responsible for 2.6% of blindness globally. Further, up to 50% of cases of end stage renal disease are a direct result of diabetes, especially in countries where access to dialysis is restricted. People with diabetes also have a 2–3 times higher risk to experience cardiovascular disease compared to people without diabetes. A fur-ther complication is amputation of lower limps due to impaired wound healing, being 10–20 higher for people with diabetes. In addition to these microvascu-lar complications, diabetes has its greatest health impact as a risk factor for cardiovascular disease and stroke (World Health Organization,  [2016](#page307)). There is also a growing literature suggesting a—potentially bidirectional—relationship between diabetes and depression (Dooren et al.,  [2013;](#page289) Nouwen, Winkley, et al.,  [2010;](#page298) Roy and Lloyd,  [2012](#page301)). In addition, there seems to be a link between diabetes and the development of certain types of cancer, (Nead et al.,  [2015](#page297); Tsilidis et al.,  [2015),](#page305) as well as an array of other of other infectious diseases, intentional self-harm and degenerative disorders diseases (Seshasai et al.,  [2011](#page302)).

**1.1.3 Diabetes prevention**

Diabetes complications are a result of consistently elevated blood glucose levels, and are aggravated if blood pressure is high as well, as is often the case. Hence many complications could be prevented if recommended treatment goals were achieved. However, limited resources and access to healthcare make it diﬃcult to properly treat type 2 diabetes in LMICs (Villalpando et al.,  [2010),](#page305) and even in HICs a large part of the diabetes population does not achieve treatment goals to prevent complications (Diabetes UK,  [2012](#page288)).

Primary prevention of diabetes or at least a delayed onset are further major goals of diabetes research and could be achieved by reducing the prevalence of the known risk factors such as obesity, an unhealthy diet, smoking and sedentary behaviour (World Health Organization,  [2016](#page307)). However, so far most approaches to prevent type 2 diabetes have not had the desired eﬀect and may not always be realistic in very resource constrained settings (White,  [2016](#page306)). In particular eﬀorts to reduce the biggest type 2 diabetes risk factors of obesity and overweight have been unsuccessful (Roberto et al.,  [2015](#page301)).

**1.1.4 The need for further economic research on diabetes**

To design eﬀective interventions and make qualified decisions about the use of primary and secondary prevention strategies of diabetes, researchers and policy makers need information about the current burden of diabetes, both in terms of health and economically. Information on all aspects of economic costs and the quality of the estimates has to be available optimally. In particular, in LMICs equity issues are likely to be of importance if the burden of diabetes varies by socioeconomic groups, ethnicity or sex, potentially widening existing socioeconomic inequities. However, at the start of this thesis, little was known about the economic impact of diabetes in developing countries. There had never been a comprehensive systematic review of studies assessing the costs related to diabetes, both in terms of direct and indirect costs. Only one (non-systematic) review existed (Ettaro et al.,  [2004),](#page290) including cost-of-illness  [(COI)](#page14) studies until the year 2001. Completely absent in this review were studies from LMICs. Further, considerable time had passed since this review and the methodological quality of research published since then needed to be assessed and areas of future research had to be identified. Also missing was a comprehensive overview of studies using quantitative methods to estimate the impact of diabetes on labour market outcomes, such as employment and wages.

**1.2 Objectives of the thesis**

The thesis focuses on three main research questions related to the economics of diabetes in MICs.

1. What is the global economic burden of type 2 diabetes, both in terms of  [COI](#page14) and the labour market eﬀects of diabetes?
2. What is the impact of diabetes on labour market outcomes in MICs?
3. How does a diabetes diagnosis aﬀect behavioural risk factors and Ae the employment eﬀects of diabetes realted to these behavioural risk factors?

These three research questions are answered in Chapters 2, 3,  [4](#page101) and 5. Thereby several sub-themes are explored, including the potential inequities of the economic burden of diabetes, time trends in the impact of diabetes on labour market outcomes and behavioural risk factors, the robustness of the found results to diﬀerent estimation techniques and settings, and hetero-geneities in the impact of diabetes between those aware and those unaware of the condition.

**1.2.1 The global economic burden of diabetes**

Chapter 2: *The Economic Costs of Type 2 Diabetes: A Global Systematic* *Review* provides a first comprehensive global picture of the economic burden oftype 2 diabetes, including both  [COI](#page14) studies and studies on the labour market eﬀects of diabetes. It was expected to find evidence on the economic costs of diabetes in developing countries. Together, the aim was to provide information on the economic costs of diabetes for as many countries as possible. Another goal was the identification of areas, both in terms of methodology and topic, where evidence was lacking and/or current methodologies could be improved upon. This was supposed to guide the subsequent chapters of this thesis as well as other researchers interested in the economics of diabetes. Chapter 2 thereby answers research question one.

**1.2.2 The labour market impact of type 2 diabetes**

The review identified the labour market impact of diabetes in LMICs as a topic that had not received much attention. Apart from the lack of evidence from developing countries, there was also scope for methodological improvements

compared to the existing  [HIC](#page14) evidence. Further, information on the eﬀects on sub-populations, i.e. comparisons between rich and poor and the formal and informal labour market were non-existent.

However, in order to carry out such an analysis, appropriate data needed to be identified. To this end a search for suitable household data from LMICs was carried out, using generalas well as specialized search engines such as the World Bank Central Microdata Catalog  [http://microdata.worldbank](http://microdata.worldbank.org/).  [org](http://microdata.worldbank.org/)/, the Demographic and Health Survey Database  [http://dhsprogram](http://dhsprogram.com/data/).

[com/data](http://dhsprogram.com/data/)/,the Global Health Data Exchange Database  [http://ghdx.healthdata](http://ghdx.healthdata.org/).  [org](http://ghdx.healthdata.org/)/, and the International Household Survey Network Catalog  [http://catalog](http://catalog.ihsn.org/index.php/catalog).  [ihsn.org/index.php/catalo](http://catalog.ihsn.org/index.php/catalog)g. The aim was to identify datasets contain-ing information on self-reported or measured diabetes. Specialized websites providing an overview on household survey data in developing countries were also scoped to identify relevant data (such as  [http://ipl.econ.duke.edu](http://ipl.econ.duke.edu/dthomas/dev_data/index.html)/

dthomas/dev\_data/index.html and  [https://sites.google.com/site/medevecon](https://sites.google.com/site/medevecon/development-economics/devecondata/micro)/

development-economics/devecondata/micro for household survey from de-veloping countries, and an overview on data sets containing biomarker infor-mation provided by The Biomarker Network at  [http://gero.usc.edu/CBPH](http://gero.usc.edu/CBPH/network/resources/studies/)/  [network/resources/studies](http://gero.usc.edu/CBPH/network/resources/studies/)/). An overview of the identified surveys is pro-vided in Table  [28](#page193) in the appendix.

Given the availability of data and the extent of diabetes in MICs compared to low-income countries (LICs), a decision was made to focus on MICs for the remainder of the thesis. In particular, Mexico was chosen to be one of the countries to investigate. The main reason was the availability of suitable data provided by the Mexican Family Life Survey  [(MxFLS](#page15)). It allowed for the in-vestigation of the impact of diabetes on labour market outcomes by providing information on important covariates, including family background and diabetes itself, not available in other surveys. Further, Mexico is a country with partic-ularly high obesity and diabetes rates making it an interesting case to study. Chapter  [3](#page74) therefore investigated the causal eﬀect of diabetes on employment probabilities in Mexico, providing first answers to research question two..

**Identification of the causal eﬀect of diabetes on labour market outcomes**

As is eluded to in Chapter 3, identifying a causal relationship of diabetes with labour market outcomes is being complicated by the possibility of unobserved time-variant and -invariant heterogeneity. In Chapter 3, an instrumental vari-able  [(IV)](#page14) approach was used, as a first step of analyss, to address this research question. However, as is often the case with  [IVs](#page14), the identification strategy is imperfect, and it remains open to debate

whether the instrument used fully satisfies the exclusion restriction, even if formal econometric testing suggests it does, leaving the possibility of biased estimates. Several other strategies potentially exist to identify the true eﬀect of diabetes on labour market outcomes using quasi-experimental econometric approaches (Antonakis et al.,  [2012](#page282)). For example, a natural experiment—that would aﬀect people’s diabetes risk while at the same time have no direct eﬀect on labour market outcomes such as employment probabilities or wages—may be used. However, a setting with exogenously introduced variation is notoriously diﬃcult to find (moreover, it may provide information only for a very—often geographically or economically—specific population that has been exposed to this natural experiment). Another strategy to improve inference is the use of panel data and in particular the fixed eﬀects  [(FE)](#page14) estimation, which does not depend on exogenously introduced variation. Relying only on within-individual variation the strategy allows to fully account for time-invariant factors that may aﬀect diabetes and labour market outcomes simultaneously. This is likely of importance in the case of diabetes and economic outcomes, where the use of  [IVs](#page14) has been motivated by the possibility that unobserved character trades— generally thought to be stable over time—such as motivation as well as early life experiences may be confounding the relationships (Seuring et al.,  [2015](#page303)).

Therefore, part one of Chapter 4, took advantage of a recent addition of data to the  [MxFLS](#page15) to apply a FE estimation approach, testing if the eﬀects of diabetes on employment probabilities found in  [3](#page74) using this alternative identi-fication strategy. Further, it extended the number of investigated outcomes to three, adding wages and working hours.

**Do the eﬀects of diabetes change over time?**

Diabetes is a lifelong disease whose debilitating complications generally appear after several years of elevated blood glucose levels (World Health Organization,  [2016](#page307)). So far, little is known about the exact time after diagnosis diabetes starts exhibiting potential adverse eﬀects on labour market outcomes. How-ever, in order to design strategies to mitigate the economic impact of diabetes this would be important to know as it would help in finding the most eﬃ-cient point in time to intervene. If eﬀects occur immediately after diagnosis, it may be because severe complications are already present at the point of di-agnosis, leaving little possibilities to prevent the economic burden. This would suggest that much could be prevented by an earlier diagnosis and appropriate treatment and lifestyle changes. It could further indicate a potential eﬀect of

the diagnosis itself, for example on psychological health, causing reductions in employment probabilities or wages. However, if eﬀects appear only years after the diagnosis, severe diabetes complications that have developed due to sub-optimal blood glucose management may be causing the reductions in pro-ductivity. This could hint at a possibility to mitigate the negative economic consequences of diabetes by secondary prevention through better diabetes man-agement, even without an earlier diagnoses. The systematic review in Chapter  [2](#page28) showed a lack of evidence in this area. Only one study by Minor  [(2013](#page297)) investigated the long term consequences of diabetes, finding non-linear eﬀects in a USA population. Apart from the need for additional evidence, also sev-eral possibilities for methodological improvements exist. Part two of Chapter  [4](#page101) therefore assessed the impact of the time since diagnosis on labour market outcomes, using both linear and non-linear specifications in a FE framework.

**Measurement of diabetes in household surveys**

There are two possibilities of measuring diabetes in household surveys: (1) asking participants about their diabetes status or (2) trying to identify people with diabetes using biometric exams, such as fasting blood glucose or glycated hemoglobin  [(HbA1c)](#page14) levels. Using self-reported information likely leads to the exclusion of a considerable part of the diabetes population that has not yet received a diagnosis by a health care professional (Beagley et al.,  [2014](#page284)). Using biomarker information, also previously "undiagnosed" cases can be identified. Blood glucose measurements provide information on glucose levels at the time of the blood draw but it is not possible to infer on glucose levels over time. They are also sensitive to food consumption and may lead to false positives if taken in a non-fasted state.  [HbA1c](#page14) levels provide an indication of the aver-age blood glucose levels over the preceding three months and are not sensitive to the glucose level at the time of the blood draw (World Health Organiza-tion,  [2011](#page307)). They are, however, sensitive to an array of disorders such as haemoglobinopathies, anaemias, and disorders associated with accelerated red cell turnover (World Health Organization,  [2011](#page307)). The cut-oﬀ points for dia-betes detection for blood glucose measurement and  [HbA1c](#page14) measurement are 126 mg/dl and 6.5%, respectively (World Health Organization,  [2006,](#page306)  [2011](#page307)).

Unfortunately, and largely due to data limitations, previous research had to rely mainly on self-reported diabetes information. It has therefore remained unclear if the found eﬀects also extended to the diabetes population unaware of its condition. Part 3 of Chapter  [4](#page101) used a relatively large sample of biomarker

data with  [HbA1c](#page14) measurements, made available in wave 3 of the  [MxFLS](#page15) that was released in 2015, to investigate the extent of the undiagnosed population in Mexico and the association of diabetes with labour market outcomes for the entire and undiagnosed diabetes population. This part also addressed the question if current disease severity, as proxied by  [HbA1c](#page14) levels, was related to labour market outcomes.

Overall, the three parts of Chapter  [4](#page101) provide extensive additional evidence to answer research question two, by providing evidence of the eﬀect of diabetes on employment probabilities using an alternative estimation strategy compared to Chapter 3, extending the investigated outcomes to wages and working hours and providing evidence on the eﬀects of diabetes duration. Finally, it investi-gates heterogeneities in the eﬀects of diabetes for the entire diabetes population, i.e., those aware as well as those unaware of their condition.

1. **Diabetes, behavioural risk factors and employment status**

Previous research on the impact of diabetes on employment has assumed a non-dynamic relationship between diabetes and employment chances, with diabetes aﬀecting employment but not employment aﬀecting diabetes. This, however, may be a too restrictive assumption, for example if employment status aﬀects behavioural risk factors such as smoking, alcohol consumption or weight that can aﬀect the likelihood of developing diabetes. However, simply accounting for these risk behaviours in a non-dynamic framework may also lead to biased estimates as it is likely that these risk factors themselves are aﬀected by a diabetes diagnosis as people try to live healthier to prevent further diabetes complications or through the eﬀects of medications. This also makes it impos-sible to account for the potential eﬀect of obesity on labour market outcomes when trying to identify the causal eﬀect of diabetes.

Apart from these methodological reasons to take health behaviours into ac-count in the investigation of the employment eﬀects of diabetes, these be-havioural risk factors themselves represent an important outcome to investi-gate, given that there is evidence that the adverse impact of diabetes could be at least partly prevented by changes in lifestyle and appropriate treatment (Wareham and Herman,  [2016](#page306)). This would require a diagnosis of diabetes, in order to create awareness of the disease. As Chapter  [4](#page101) has shown for Mexico, a large part of the diabetes population is unaware of its condition, whether

in HICs or developing countries (Beagley et al.,  [2014](#page284)). But even once a di-agnosis has been made, appropriate changes towards a healthier lifestyle and medical treatment are required to prevent complications and are only possible if the type of information about ways to achieve this is accessible to and un-derstood by the person with diabetes. This information is typically provided by a healthcare professional at the time of diagnosis and thereafter. Relatively little is known about the extent to which people with diabetes are making such changes after a diagnosis, especially in MICs where healthcare access and health literacy is likely more limited than in HICs (Mills,  [2014](#page296)).

Research study three in Chapter  [5](#page140) therefore investigates both the eﬀect of a di-abetes diagnosis on employment probabilities and health behaviours in China, using six waves of very detailed panel data from the China Health and Nutrition Survey  [(CHNS](#page14)). China, like Mexico, is a country where diabetes rates have increased dramatically over the last decades, now aﬀecting about 100 million people or close to 10% of the adult population (NCD Risk Factor Collabo-ration,  [2016),](#page297) with many remaining unaware of having the condition (Wang, Zhou, et al.,  [2015](#page305)). The study used marginal structural models  [(MSMs),](#page14) which are able to account for time-variant confounding and thereby the potentially intertwined relationships of diabetes, behavioural risk factors and employment status. Alternatively, also a FE and random eﬀects  [(RE)](#page15) approach were used to further investigate the potential sources of bias and robustness of the results. This chapter thereby intended to answer research question three by providing evidence on the eﬀect of a diabetes diagnosis on behavioural risk factors and by taking into account the potential relationship with employment as well. It thereby also provided further evidence to answer research question two, using a diﬀerent estimation strategy and information from a diﬀerent country.

**1.3 Thesis methods and structure**

This research uses systematic review and advanced quantitative methods to answer the research questions that together form this thesis.

A series of four independent research studies form this thesis. Chapters 2 and  [3](#page74) have already been published as journal articles and Chapter  [4](#page101) has been published as a discussion paper and is under review at an international peer reviwed journal at the time of completion of the thesis . Chapter 5 will be submitted within the next months. This is outlined in more detail in the publication and statement of ownership section. Each study addresses diﬀerent research questions, but has the investigation of the labour market

impact of diabetes as a unifying theme. Taken together the studies progressively complement each other, providing a better understanding of the economic impact of diabetes in MICs. Each study is presented in a separate chapter. For Chapters 3,  [4](#page101) and 5, a pre-amble precedes the actual study to contextualize the respective findings with the preceding chapter and the entire thesis.

* **The Economic Costs of Type 2 Diabetes: A Global Systematic Review**

**Abstract**

There has been a widely documented and recognized increase in dia-betes prevalence not only in high-income countries (HICs) but also in low- and middle-income countries (LMICs), over recent decades. It is less clear what is the economic burden associated with diabetes, espe-cially in LMICs. We provide a systematic review of the global evidence on the costs of type II diabetes. Our review seeks to update and con-siderably expand the previous major review of the costs of diabetes by capturing the evidence on overall, direct and indirect costs of type II di-abetes worldwide that was published since 2001. In addition we include a body of economic evidence that has hitherto been distinct from the cost-of-illness  [(COI)](#page14) work, i.e. studies on the labour market impact of diabetes. PubMed, EMBASE, EconLit and IBSS were searched (with-out language restrictions) for studies assessing the economic burden of type 2 diabetes published from January 2001 to October 2014. Costs re-ported in the included studies were converted to international dollars ($) adjusted for 2011 values. Alongside the narrative synthesis and method-ological review of the studies we conduct an exploratory linear regression analysis, examining the factors behind the considerable heterogeneity in existing cost estimates between and within countries. We identified 86  [COI](#page14) and 22 labour market studies.  [COI](#page14) studies varied considerably in both methods and cost estimates, with most studies not using a con-trol group, though the use of either regression analysis or matching has increased. Direct costs were generally found to be higher than indirect costs. Direct costs ranged from $242 for a study on out-of-pocket  [(OOP](#page15)) expenditures in Mexico to $11917 for a study on the cost of diabetes in the USA, while indirect costs ranged from $45 for Pakistan to $16914 for the Bahamas. In LMICs—in much contrast to HICs—substantial part of the cost burden arose to patients from  [OOP](#page15) treatment costs. Our regression analysis revealed that direct diabetes costs are closely and positive associated with a country’s gross domestic product (GDP) per capita, and that the USA stood out as having particularly high costs, even after controlling for GDP per capita. Studies on the labour mar-ket impact of diabetes were almost exclusively confined to HICs and found strong adverse eﬀects, particularly for male employment chances. Many of these studies also took into account the possible endogeneity of diabetes, which was not the case for  [COI](#page14) studies. The reviewed stud-ies indicate a large economic burden of diabetes, most directly aﬀecting patients in LMICs. The magnitude of the cost estimates diﬀers consid-

erably between and within countries, calling for the contextualization of the study results. There remains large scope for adding to the evidence base on labour market eﬀects of diabetes in LMICs. Further, there is a need for future  [COI](#page14) studies to incorporate more advanced statistical methods in their analysis to account for possible biases in the estimated costs.

**2.1 Introduction**

Diabetes is a chronic disease that has spread widely, not only in high-income but also in many LMICs over the last decades. The most recent data from the International Diabetes Federation indicate that diabetes aﬀected 382 million people worldwide in 2013, a number that is expected to grow to 592 million by 2035. The estimated global prevalence in 2013 amounts to 8.3 % among people aged 20–79 years, with the world’s most populous countries India and China reaching prevalence rates between 9 and 10 %, corresponding to 65 and 100 million in absolute numbers, respectively. Particularly high prevalence rates are found in Mexico (12.6%) and Egypt (16.8%), surpassing the rates of most HICs, including the USA (9.2%) and Germany (8.2%).(International Diabetes Federation,  [2014)](#page292) Taken together, in 2013 about two-thirds of all individuals with diabetes lived in LMICs (International Diabetes Federation,  [2014](#page292)). The rising prevalence of diabetes in LMICs appears to be fuelled by rapid urbanization, nutrition transition and increasingly sedentary lifestyles (Hu,  [2011](#page292)). The most prevalent form of diabetes by far is type 2 diabetes, aﬀecting about 90 % of people with diabetes while the remaining 10 % mainly have type 1 diabetes or gestational diabetes (International Diabetes Federation,  [2014](#page292)).

Due to its adverse eﬀect on people’s health diabetes also imposes an eco-nomic burden on individuals and households aﬀected as well as on healthcare systems. The economic burden of diabetes was confirmed by in a review of  [COI](#page14) studies on diabetes mellitus, published in 2004, covering the literature up to the year 2000. The authors concluded that the direct and indirect economic burden of diabetes was "large", and that costs had increased over time. How-ever, the review also noted that significant variation in costing methodologies made it near impossible to directly compare the cost estimates. However, the studies reviewed by Ettaro et al.  [(2004)](#page290) were almost exclusively focused on the USA, with a small part coming from European HICs and none from LMICs.

The aim of this study is therefore to systematically review the literature on the economic costs of diabetes published since 2001 (i.e. the first year not covered by the Ettaro et al.  [(2004)](#page290) review), as we expect a considerable number of new studies, also from LMICs. In addition to the  [COI](#page14) studies we review the litera-ture on labour market outcomes, with a specific interest in the methodological challenges involved. In doing so we substantively update and expand the scope of the Ettaro et al.  [(2004)](#page290) review, allowing us to revisit its findings regarding the evidence base about the economic burden of type 2 diabetes globally.

[COI](#page14) studies generally assess the direct and indirect costs of a particular illness, where the former represent the opportunity cost of resources used for treatment. The indirect costs measure the value of resources lost due the illness, most commonly those caused by losses in productivity due to mortality and morbidity as measured in lost earnings (Segel,  [2006](#page302)). In addition, another approach also focuses on estimating the impact of diabetes on labour market outcomes. However, rather than trying to estimate the monetary losses that arise from a decrease in productivity, these studies typically compare labour market outcomes (e.g. employment probabilities, earnings or lost work days) between people with and without diabetes, while accounting for diﬀerences in age, education and other demographic and socioeconomic variables, that might arise between both groups and that could aﬀect labour market outcomes as well as the chances of developing diabetes. The aim of studies in this field is to obtain a clearer picture of how diabetes causally aﬀects these labour market outcomes, without necessarily monetizing the results. Because of the diﬀerent methodologies and data requirements, these studies tend to diﬀer considerably from traditional  [COI](#page14) studies, which is why we reviewed them separately. To the best of our knowledge this is the first review that systematically assesses the studies in this particular field.

**2.2 Methods**

Preferred Reporting Items for Systematic Reviews and Meta-Analyses  [(PRISMA](#page15)) guidelines were used as a basis for the overall study approach.(Moher et al.,  [2009](#page297))

**2.2.1 Search strategy**

The electronic search was based on the following search terms: "Diabetes Mel-litus"[Mesh] AND ("Costs and Cost Analysis"[Mesh] OR "Cost of Illness"[Mesh] OR "Employment"[Mesh] OR "Labor Market"[All fields] OR "Labour Mar-ket"[All fields] OR "Productivity"OR "Willingness to pay"[All fields]). The above search was run in PubMed and was then adapted for searches in EM-BASE, EconLit and the International Bibliography of the Social Sciences (IBSS). The search was carried out from October 2012 to October 2014 and restricted to studies published between January 2001 and October 2014, as the earlier review had covered  [COI](#page14) studies until 2000 (Ettaro et al.,  [2004](#page290)). No language restrictions were applied. The references were downloaded in RIS format where possible and then transferred to Mendeley. Authors were contacted for further information if clarification was needed after the full text analysis.

**2.2.2 Inclusion and exclusion criteria**

Studies were eligible if a monetary estimate of the direct and/or indirect costs of diabetes was presented in the results section or if studies provided an estimate of the impact of diabetes on labour market outcomes (employment chances, labour income, wages and lost work days). We did not exclude studies with a small sample size as this might have discriminated against studies in LMICs. Studies on types of diabetes explicitly diﬀerent from type 2 diabetes were ex-cluded. However, we included studies that did not explicitly mention the type of diabetes, given that type 2 diabetes accounts for about 90 % of all diabetes cases. Studies exclusively assessing the costs of diabetes complications or the costs of management strategies were excluded as were studies estimating the costs for specific groups with diabetes (e.g. costs for people with poorly con-trolled diabetes), since we were interested in the costs incurred to populations comprising the whole spectrum of people with type 2 diabetes. Editorials, reviews and studies for which the full text could not be retrieved or only an abstract was available were also excluded.

**2.2.3 Data extraction and analysis**

Data extraction was carried out by two investigators (TS and OA). After dupli-cates were removed, titles and abstracts were scanned by one researcher (TS) to identify studies suitable for a full text review. The process was checked

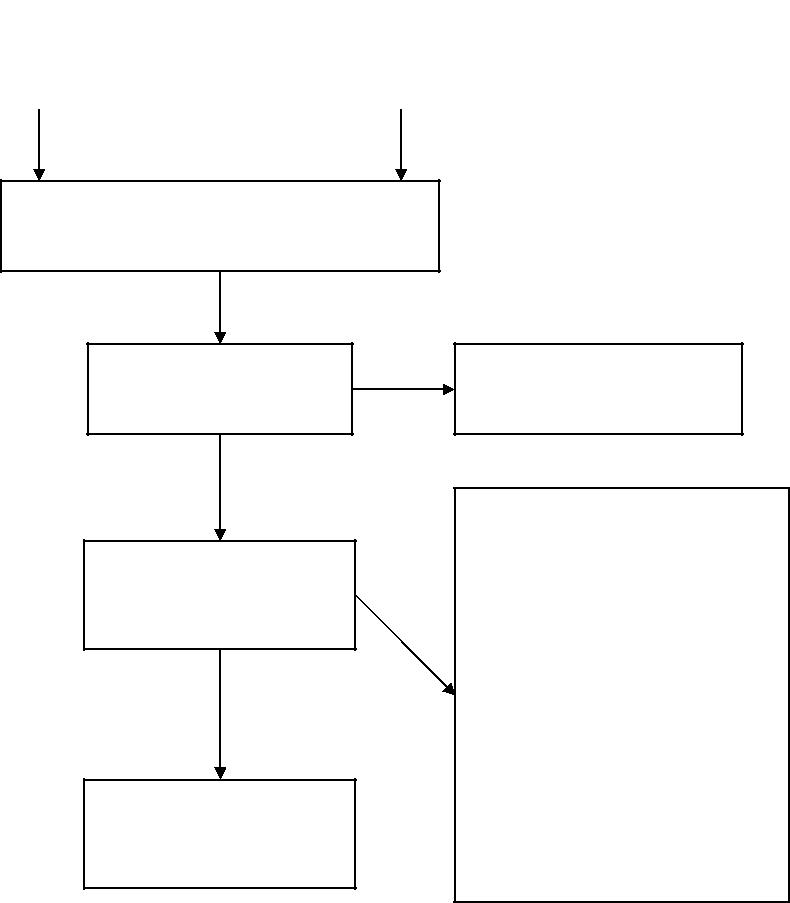
by a second researcher (OA) on a random subsample of 2000 studies of the retrieved references. The full text was subsequently retrieved for the identified studies and they were reviewed by two researchers (TS and OA), with disagree-ments resolved by discussion. Finally, 109 studies were identified (see Figure 1) that fulfilled the inclusion criteria and data extraction was carried out us-ing a pre-defined extraction table. Primary outcomes were the total costs, the direct costs, and the indirect costs of type 2 diabetes and the respective per capita estimates of these outcomes, as well as the impact of type 2 diabetes on employment chances, income, wages and lost work days. Secondary out-comes comprised the methodology used to assess the monetary costs of type 2 diabetes, the range of cost factors included in the analysis, as well as the methodology used to assess the labour market impact of diabetes. Further extracted information included the year of publication, year of data collection, the time horizon, the country or region studied, the data source, sample size and age as well as information on whether the study distinguished between types of diabetes.

We present the  [COI](#page14) study results in per capita values to facilitate compa-rability across countries. For studies presenting overall population level es-timates rather than per capita costs information, we calculated those costs, whenever possible, using the diabetes prevalence mentioned in the respec-tive study. If no total cost estimate was presented but information on direct and indirect costs was available, then direct and indirect costs were added up to produce a total cost estimate. We converted costs into purchasing-power-parity  [(PPP)](#page15) adjusted estimates, also called international dollars and henceforth denoted with the $ sign, in order to further increase compara-bility. Since some studies did not present the data in the country’s local currency but in USA$ or some other major currency, we used the exchange rate given in the article to convert the estimates back into the local cur-rency. If no exchange rate was provided in the study itself, the average ex-change rate (midpoint exchange rate according to OANDA historical exchange rates—[http://www.oanda.com/currency/historical-rates/]) for the re-ported year. The  [PPP](#page15) adjusted estimates for the year 2011 were then calcu-lated using the Campbell and Cochrane Economics Methods Group Evidence for Policy and Practice Information and Coordination Centre (CCEMG-EEPPI Centre) cost converter (Shemilt et al.,  [2010](#page303)). For all additional analyses carried out in the following sections only studies for which a mean cost estimate was presented or could be calculated, were included. Further, in the case of a study

|  |
| --- |
| **Identification** |

Figure 1:  [PRISMA](#page15) flowchart.

|  |  |  |
| --- | --- | --- |
| Recordsidentified through |  | Additional records identified |
| database searching |  | through other sources |
| (n= 8116) |  | (n= 4) |
|  |  |  |



|  |
| --- |
| **Screening** |

|  |
| --- |
| **Eligibility** |

|  |
| --- |
| **Included** |

Recordsafter duplicates removed (n = 7631)

Recordsscreened

(n = 7631)

Full text articles assessed for eligibility (n = 195)

Studies included in qualitative synthesis (n =109)

Recordsexcluded

(n = 7436)

Full text articles excluded, with reasons:

Only abstract available (n=23) Noaccess to study (n=7)

No COI study (n=2)

No cost estimate (n=13) No original research (n=9) Not diabetes (n=2)

Only complication costs (n=2) Only primary care costs(n=2) Specificdiabetes group (n=14) Type 1 Diabetes (n=5)

Review (n=7)

presenting estimates for more than 1 year, only the estimate for the most recent year was used for the analysis. For studies presenting both incremental and total cost estimates, only the incremental cost estimate was taken into account.

Studies were further classified into two groups according to the level of economic development of the investigated country—(1) high-income and (2) LMICs (LMICs)—according to the historical World Bank income group clas-sification of the respective country in the year that data collection for the respective study had taken place (World Bank,  [n.d.](#page306)). Where necessary due to space constraints we used abbreviations for country names, as detailed in Table  [29](#page210).

In order to explore the factors involved in the variation of direct costs re-ported in  [COI](#page14) studies, we first plotted the direct per capita costs in relation to the gross-domestic-product  [(GDP)](#page14) per capita of the respective country and provided an estimate of the relationship using linear regression. We then con-ducted an exploratory regression analysis, with the annual direct cost per pa-tient as the dependent variable to investigate what other factors might explain the variation in direct cost estimates. The set of independent variables com-prised (1) the estimation approach in each study, (2) the year of data used, (3)  [GDP](#page14) per capita of the studied country in international dollars, (4) an indicator of whether the study was conducted in the USA, (5) an indicator of whether the study was deemed to be nationally representative, and (6) a variable in-dicating whether the study had explicitly taken diabetes-related complications into account. The year of the used data was considered because the devel-opment of social security systems and treatment methods may aﬀect how the direct costs evolve over time. We categorized this variable into groups: studies using data from before 1995, 1995 to 1999, 2000 to 2004, 2005–2009 and 2010– 2004. The dummy variable for studies on the USA was included to account for the generally higher healthcare expenditures in the USA compared which other HICs with similar per capita income levels (Laugesen and Glied,  [2011](#page294)). Accounting for national representativeness should cancel out any eﬀects that might be driven by those studies that estimate costs for sub-national, regional-or city-level population samples. Including an estimator for diabetes compli-cations should account for the possible underestimation of diabetes costs in studies excluding complications. We exclude country estimates extracted from multi-country studies in our preferred specification, as their inclusion would lead to an over-statement of the cost eﬀect of the estimation method employed in the given multi-country study.

**2.3 Results**

Due to the diﬀerences in methodologies, we first present the findings on the identified  [COI](#page14) studies and subsequently turn to studies on labour market out-comes.

**2.3.1 Cost-of-illness studies on type 2 diabetes**

**Number of studies**

We identified a total of 86 relevant  [COI](#page14) studies (see Table  [30](#page212) for a detailed description of the included studies), of which 62 focused on HICs, 23 on LMICs, and one multi-country study covered both HICs and LMICs. Studies in LMICs increased over time, with the majority of the  [LMIC](#page14) studies being published between 2007 and 2014. Six of the selected studies were multi-country studies, of which two (Kirigia et al.,  [2009;](#page293) Smith-Spangler et al.,  [2012)](#page303) did not provide detailed cost estimates for every country in the study and one did not provide a year for the estimated costs, so that we could not calculate estimates in international dollars (Boutayeb and Boutayeb,  [2014](#page284)). Therefore, we could not include these particular studies in our country-specific analysis.

**Regional distribution**

In terms of geographic regions, most studies were carried out on countries in Latin America and the Caribbean (n=38) and Europe (n=37), followed by the USA and Canada (n=26), East Asia and Pacific (n=11), the Middle East and North Africa (n=5), South Asia (n=4), Sub-Saharan Africa (n=4) and Australia (n=1). The number of countries studied is higher than the number of articles reviewed due to four multi-country studies (Abdulkadri et al.,  [2009](#page281); Barceló et al.,  [2003;](#page283) Boutayeb and Boutayeb,  [2014;](#page284) Jönsson,  [2002),](#page292) estimating costs for multiple countries. The USA were the most studied country (n=19), followed by Canada (n=7) and Germany (n=5). Mexico (n=6) and China (n=4) were the most frequently studied LMICs.

**Data sources**

Especially in LMICs, self-administered surveys represented a popular method to retrieve data on the cost of diabetes. These were mostly limited regionally, i.e. to a city or hospital, and usually only representative of these regional diabetes populations but not of a national population. In HICs, databases

of insurance and healthcare providers were the main source of information in most studies. These data tended to be representative either at a national or at some sub-national level. As a result, the size of the samples in HICs was mostly between 1,000 and several million. By contrast, studies in low- and lower-middle-income countries were generally characterized by smaller sample sizes, ranging from 35 (Suleiman et al.,  [2006)](#page304) to about 2,433 (Yang, Zhao, et al.,  [2012)](#page307) in the studies reviewed here.

**Variation in costing approaches**

As discussed in more detail in Text Box 1, a range of costing approaches can be found in the  [COI](#page14) literature. Figure  [2](#page39) shows that the most common costing method for the direct costs of diabetes in HICs was the sum-all medical ap-proach for people with diabetes without using control groups (Arredondo and Barcelo,  [2007;](#page282) Arredondo, Zúñiga, and Parada,  [2005;](#page282) Arredondo and De Icaza,  [2011a;](#page282) Arredondo and Zúñiga,  [2004;](#page282) Barceló et al.,  [2003;](#page283) Bjegovic et al.,  [2007](#page284); Boutayeb and Boutayeb,  [2014;](#page284) Brandle et al.,  [2003;](#page285) Camilo González et al.,  [2009;](#page285) Chi et al.,  [2011;](#page287) Condliﬀe and Link,  [2014;](#page287) Horak,  [2009;](#page292) Jönsson,  [2002](#page292); Kirigia et al.,  [2009;](#page293) Lau et al.,  [2011;](#page294) Lee et al.,  [2006;](#page294) Lucioni et al.,  [2003](#page295); Maciejewski and Maynard,  [2004;](#page296) Martin et al.,  [2007;](#page296) Morsanutto et al.,  [2006](#page297); Nakamura et al.,  [2008;](#page297) Nolan et al.,  [2006;](#page298) Ohinmaa et al.,  [2004;](#page298) Oliva et al.,  [2004;](#page298) Peele et al.,  [2002;](#page299) Pohar, Majumdar, et al.,  [2007;](#page299) Redekop et al.,  [2002](#page300); Ringborg et al.,  [2008;](#page300) Zhou, Isaman, et al.,  [2005](#page308)). The disease-attributable costing approach (Abdulkadri et al.,  [2009;](#page281) Ballesta et al.,  [2006;](#page282) Bastida and Pagán,  [2002;](#page283) Buescher et al.,  [2010;](#page285) Dall, Nikolov, et al.,  [2003;](#page288) Davis et al.,  [2006;](#page288) Honkasalo et al.,  [2014;](#page291) Johnson et al.,  [2006;](#page292) Lin et al.,  [2004;](#page295) Mata et al.,  [2002;](#page296) Rodríguez Bolaños et al.,  [2010;](#page301) Simpson et al.,  [2003;](#page303) Solli et al.,  [2010](#page303); Suleiman et al.,  [2006;](#page304) Tunceli, Wade, et al.,  [2010)](#page305) and the attributable-fraction approach were also used widely, though mainly in the USA (Bolin et al.,  [2009](#page284); Dall, Mann, et al.,  [2008;](#page288) Dall, Zhang, et al.,  [2010;](#page288) Dawson et al.,  [2002;](#page288) Hon-eycutt et al.,  [2009;](#page291) Lesniowska et al.,  [2014;](#page294) Schmitt-Koopmann et al.,  [2004](#page302)). The incremental cost approach was applied primarily in studies on HICs (Birn-baum et al.,  [2003;](#page284) Bruno et al.,  [2012;](#page285) Chodick et al.,  [2005;](#page287) Durden et al.,  [2009](#page289); Esteghamati et al.,  [2009;](#page290) Honeycutt et al.,  [2009;](#page291) Köster, Ferber, et al.,  [2006](#page293); Köster, Huppertz, et al.,  [2011;](#page293) Köster, Schubert, et al.,  [2012;](#page293) Linden et al.,  [2009;](#page295) Marchesini et al.,  [2011;](#page296) Norlund et al.,  [2001;](#page298) O’Connell et al.,  [2012;](#page298) Po-har and Johnson,  [2007;](#page299) Ramsey et al.,  [2002;](#page300) Ricordeau et al.,  [2003;](#page300) Rodbard et al.,  [2010;](#page301) Smith-Spangler et al.,  [2012;](#page303) Trogdon and Hylands,  [2008;](#page305) Tunceli,

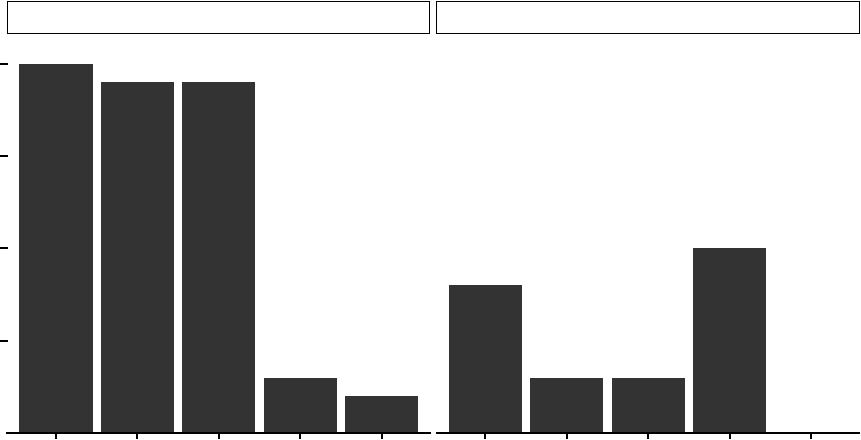
Wade, et al.,  [2010;](#page305) Wiréhn et al.,  [2008;](#page306) Yang, Zhao, et al.,  [2012](#page307)). For LMICs, the survey approach was the most used (Biorac et al.,  [2009;](#page284) Chan, Tsang, et al.,  [2007;](#page286) Chatterjee et al.,  [2011;](#page286) Druss et al.,  [2001;](#page289) Elrayah-Eliadarous et al.,  [2010;](#page289) Javanbakht et al.,  [2011;](#page292) Khowaja et al.,  [2007;](#page293) Al-Maskari et al.,  [2010](#page296); Ramachandran, Ramachandran, et al.,  [2007;](#page300) Tharkar et al.,  [2010;](#page304) Wang, Fu, Pan, et al.,  [2009;](#page305) Wang, Fu, Zhuo, et al.,  [2010;](#page306) Wang, McGreevey, et al.,  [2009](#page306)).

By contrast, almost all indirect cost assessments followed the same method-ology, i.e. the human capital approach. This approach considers all forgone labour earnings of a patient or caregiver that are attributable to diabetes. A minority of three studies (Chang,  [2010;](#page286) Gyldmark and Morrison,  [2001;](#page291) Tharkar et al.,  [2010),](#page304) estimated the indirect costs using the  [WTP](#page15) approach, which tries to measure how much individuals would be willing to pay to reduce the risk of an illness (Segel,  [2006),](#page302) here diabetes (or certain complications associated with it). One of the studies included  [WTP](#page15) estimates in addition to the direct and indirect costs measured by the human capital approach (Tharkar et al.,  [2010](#page304)) but did not include the  [WTP](#page15) estimate in the overall cost estimate, while the other two studies estimated exclusively the  [WTP](#page15) (Chang,  [2010;](#page286) Gyldmark and Morrison,  [2001](#page291)).

**Study perspective**

Studies also varied in their perspective, again compromising direct compara-bility of the cost estimates across studies. Overall, most studies either took a societal (n=32) or healthcare system perspective (n=48). The former gen-erally takes into account the direct and indirect monetary costs that arise to society, including costs to the healthcare system, costs due to lost productivity and sometimes  [OOP](#page15) costs (Segel,  [2006](#page302)). The latter was especially common in HICs where many studies assessed the cost of diabetes to private or public health insurances. In LMICs, studies often took the patient perspective (n=5), estimating  [OOP](#page15) expenditures and in some cases productivity losses, directly arising to the diabetes patient.

Figure 2: Number of  [COI](#page14) studies, by costing approach and income group.



High−income

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 20 | 20 | 19 | 19 |  |  |
|  |  |  |  |
|  |  |  |  |  |  |
| studies | 15 |  |  |  |  |  |
| Number of | 5 10 |  |  | 3 |  |  |
|  |  |  |  | 2 |  |
|  |  |  |  |  |  |

Low− and middle−income

|  |  |
| --- | --- |
|  | 10 |
| 8 |  |
| 3 | 3 |
|  | 0 |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sum All Medical− | Sum Diagnosis Specific− | RB/matching | Survey | WTP | Sum All Medical− | Sum Diagnosis Specific− | RB/matching | Survey | WTP |
|  |  |  |  | Study approach | |  |  |  |  |

*Notes* For LMICs no willingness to pay  [(WTP)](#page15) studyis counted, because the only study(Tharkar et al.,  [2010)](#page304) presenting a  [WTP](#page15) estimate for a  [LMIC](#page14) used primarily a diﬀerent ap-proach to estimate costs, and the  [WTP](#page15) estimate was only presented additionally. Therefore this study was not counted under  [WTP](#page15) here. Two studies are counted twice as they give estimates for a sum-diagnosis specific and a RB/matching approach.

**Text box 1  [COI](#page14) methodologies**

Methodologies for  [COI](#page14) studies can broadly be categorized into two main categories:(1) es-timating the total disease costs and (2) estimating the incremental costs (Akobundu et al.,  [2006](#page281)). Studies can then be divided further according to the specific approach used for esti-mation. Our categorization builds on that by Akobundu et al.  [(2006)](#page281) in their review of  [CO](#page14)I methodologies.

1. Total disease costs
   1. Sum-All Medical: captures all medical expenditures of a person diagnosed with diabetes, irrespective of the relation of the expenditures with diabetes.
   2. Sum-Diagnosis Specific: includes the costs that are related to diabetes. This can be done by using a disease-attributable costing approach, using administrative claims databases to identify the cost of diabetes by respective International Statistical Classification of Diseases and Related Health Problems  [(ICD)](#page14) codes that link the expenditures to a primary or secondary diagnosis of diabetes as the reason for the healthcare utilization. Alternatively, a similar technique used at the population level is the attributable-fraction approach, where the relative contribution of, e.g., diabetes, to the risk of developing another disease (e.g. renopathy or cardiovascular disease) is used to determine how much of the costs of this disease can be attributed to diabetes.
   3. Survey approach: while not specifically mentioned by Akobundu et al.  [(2006)](#page281), for this review we create a separate category capturing studies using surveys of people with diabetes. This category diﬀers from the two approaches a) and b) above in that estimations rely solely on the individual, reported experience of people with diabetes, without use of any diagnostic data at an aggregate level. The survey approach was also used as a separate category in the earlier review on diabetes  [COI](#page14) studies by Ettaro et al.  [(2004](#page290)).
2. Incremental disease costs

There are two main approaches for the estimation of incremental medical costs:

* 1. Regression approach: a statistical technique which can account for observable diﬀerences between the group with diabetes and the control group (i.e. those without diabetes) to find—ideally—the independent eﬀect of diabetes on health-care costs. The diﬀerences typically accounted for are age, region and gender.
  2. Matching approach: uses a control group to directly compare those with diabetes to those without diabetes after matching each person of the ’treatment’ group to a ’similar’ person of the control group, using various categories like age, region and gender to—again—find the independent eﬀect of diabetes on healthcare cost (Akobundu et al.,  [2006](#page281)).

All of the above approaches can be used in prevalence or an incidence based study. In the former case the costs of diabetes are estimated for a certain point in time, typically one year, while the latter approach estimates costs over a person’s lifetime or several years, always starting with the point at which the disease is diagnosed. Both approaches may also be combined in studies estimating the future cost burden of type 2 diabetes by first taking a prevalence approach to calculate current costs and then using predictions about future diabetes incidence rates to arrive at an estimate of diabetes costs at a certain point in the future.

**Costing components**

Of the 75 studies that reported the cost components they used to estimate direct costs, 72 took into account outpatient hospital visits, 70 inpatient hospital visits, 63 physician visits, 58 drug costs, 51 laboratory costs for diagnostic tests and check-ups, 37 equipment costs and 21 non-medical and transportation costs. A total of 46 studies had at least included the costs of hospital, outpatient and physician visits as well as drugs (see Table  [31](#page239) for a detailed description of cost components used in each study).

**Cost estimates of diabetes using a prevalence approach**

Two basic epidemiological approaches exist for the estimation of  [COI,](#page14) and they are not directly comparable. The incidence approach follows people with dia-betes, usually starting with their diagnosis at a common base year, estimating yearly costs for a sample of people at the same disease stage, finally giving an estimate of diabetes costs over a certain time period, such as from diagnosis to death or over a distinct period of, for example, 10 years. This approach can also document how costs of diabetes change and develop over the progression of the disease (Larg and Moss,  [2011](#page293)). By contrast, the prevalence approach estimates the costs of diabetes for a cross-section of people with diabetes at a certain point in time, normally a year, who are at diﬀerent stages of the disease. It is most suitable for assessing the total economic burden of diabetes at a cer-tain point in time. Due to this diﬀerence in time periods and the used data, the estimates of prevalence-based studies are not directly comparable with those of incidence-based studies. Hence, we present the cost estimates separately, starting with the prevalence approach.

Table  [2](#page46) shows the range of direct cost estimates by estimation approach and income status. As can be observed, direct cost estimates varied widely, both between and within the diﬀerent estimation approaches. Cost estimates for direct costs, irrespective of the costing method applied and the cost components included, ranged from $242 for Mexico Arredondo, Zúñiga, and Parada  [(2005](#page282)) in 2010 to $11,917 for the USA Condliﬀe and Link  [(2014)](#page287) in 2007. Also, studies from LMICs generally indicated smaller direct costs than studies from HICs.

For indirect costs, studies using the human capital approach estimated costs ranging from $45 for Pakistan (Khowaja et al.,  [2007)](#page293) in 2006 to $16,914 for the Bahamas (Barceló et al.,  [2003)](#page283) in 2000. Three studies estimated indirect costs by using the  [WTP](#page15) approach and found costs ranging from $191 in a study

on the  [WTP](#page15) for a health insurance for type 2 diabetes in Denmark in 1993 (Gyldmark and Morrison,  [2001),](#page291) a  [WTP](#page15) $4,004 per year for a cure of type 2 diabetes (Chang,  [2010)](#page286) in Taiwan and an annual payment of $4,737 to halt disease progression/prevent future complications of diabetes in India (Tharkar et al.,  [2010](#page304)).

Societal costs of type 2 diabetes, which are estimated by studies combining direct and indirect costs, ranged from $544 in a study on the economic costs of diabetes in Iran (Esteghamati et al.,  [2009)](#page290) in 2001 to $18,224 for the Bahamas (Barceló et al.,  [2003)](#page283) in 2000.

In order to improve the cross-country comparability of the costs of diabetes we plotted the results from studies providing a direct per capita cost estimate against the  [GDP](#page14) per capita estimate of the respective country (we limited this comparison to studies using samples representative of their entire population). Figure  [3](#page45) confirms the expectation that costs do increase with economic wealth:  [GDP](#page14) per capita explains about one-third of the variation in cost estimates (see r2 in Figure 3). Also, studies on the USA seem to estimate costs consistently higher than would be expected on the basis of its  [GDP](#page14) per capita.

The USA, however, spend consistently more than what would be expected on the basis of its  [GDP](#page14) per capita. Again, the wide variation in estimated costs for many countries underscores the point that the studies need to be con-textualized and may not be directly comparable per se. On the whole—though by no means always—the matching and regression as well as the sum-diagnosis specific approaches appear to produce lower cost estimates than especially the total cost results, particularly so for HICs. In an inevitably crude attempt to quantitatively explore the driving factors behind the heterogeneity in cost estimates, we estimated a simple linear regression model with per capita di-rect costs as the dependent variable; explanatory variables included  [GDP](#page14) per capita, the estimation approach employed by the study, the number of included cost components, a dummy for studies carried out in the USA, the year of data collection, the representativeness of the study and if the study included dia-betes complications as explanatory variables. The results, displayed in Table 2, show a strong relationship between  [GDP](#page14) per capita and expenditures for diabetes, with every additional international dollar in per capita  [GDP](#page14) trans-lating into an average increase in direct diabetes expenditures of about $0.04. The estimation approach is not found to matter significantly, nor is the year of study. Estimates from USA studies put the costs at over $3,000 higher (on average) than studies from other countries, indicating that costs in the USA

Table 1: Summary of direct costs by estimation approach and income status in international dollars $ (2011) for prevalence-based studies.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | High-income countries | | |  | Low- and middle-income countries | | | |
|  |  |  |  |  |  |  |  |  |
|  | Sum- | Sum- | RB / | own | Sum- | Sum- | RB / | own |
|  | all | diagnosismatch- | | sur- | all | diagnosismatch- | | sur- |
|  | med- | spe- | ing | vey | med- | spe- | ing | vey |
|  | ical | cific |  |  | ical | cific |  |  |
|  | costs |  |  |  | costs |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Min | 1117 | 907 | 264 | 1495 | 242 | 662 | 443 | 456 |
| Max | 11917 | 9346 | 8306 | 5585 | 4129 | 4672 | 1136 | 3401 |
| N | 25a | 19a | 18 | 3 | 27a | 5a | 2 | 10 |

*Notes* aIncludes country estimates from multi-country studies; RB Regressionbased

may indeed be unusually high. The number of costing components and the inclusion of complications likely also explain some of the variance in estimates, although they are just below and above the 10 % significance level, respectively. Overall, the included independent variables explain about 56 % of the varia-tion in direct cost estimates. In a sensitivity analysis, we included the results from multi-country studies providing country estimates in the regression anal-ysis. The only major diﬀerence to the presented analysis is that the inclusion of complications as well as the number of included cost components were now significant at the 1 and 5 % significance level, respectively. The eﬀect size and significance of the other estimates did not change considerably.

The sensitivity of the cost results to the estimation approach was also ex-amined by two studies that investigated the eﬀect of diﬀerent estimation tech-niques in diabetes  [COI](#page14) studies. Honeycutt et al.  [(2009)](#page291) compared the use of a regression-based and an attributable-fraction approach and found that the cost estimate of the former exceeded the latter by 43 %. Tunceli, Wade, et al.  [(2010)](#page305) compared the matching and the diabetes (disease)-attributable costs approach and found a 14–29 % higher cost estimate using matching, depend-ing on the used assumptions. Both studies concluded that an incremental cost approach results in a higher, and likely more exact, estimate of the direct costs of diabetes than disease-attributable approaches. The authors attributed this to the fact that a regression or matching approach can assign costs to diabetes that cannot be linked to diabetes otherwise. Those approaches are therefore in a position to account for all costs of co-morbidities caused by diabetes, while this is not automatically the case with the other approaches.

**Direct and indirect costs of diabetes**

To assess the relative importance of direct and indirect costs across countries, we plotted direct against indirect costs from studies that provided both esti-mates and drew a 45°line depicting the equal share of direct and indirect costs (see Figure 4).

Most studies found a larger share for direct costs in comparison with indirect costs (observations above the 45°line in Figure 4). This is especially true for HICs, where only a study on Sweden (Bolin et al.,  [2009)](#page284) found a larger share for indirect costs. For LMICs, a study on Colombia (Camilo González et al.,  [2009)](#page285) found considerably higher indirect costs, as did the multi-country study of Barceló et al.  [(2003)](#page283) and a study on various countries in the African region (Kirigia et al.,  [2009),](#page293) which both found higher indirect costs for almost every

Figure 3:  [GDP](#page14) to direct costs ratio by estimation approach.

15000

Y = 732 + 0.075 ⋅ X , R 2 = 0.338

|  |
| --- |
| per capita direct costs ($) |

12000

11000

10000

9000

8000

7000

6000

5000

4000

3000

2000

1000

 Sum−All Medical

 Sum−Diagnosis Specific

RB/matching

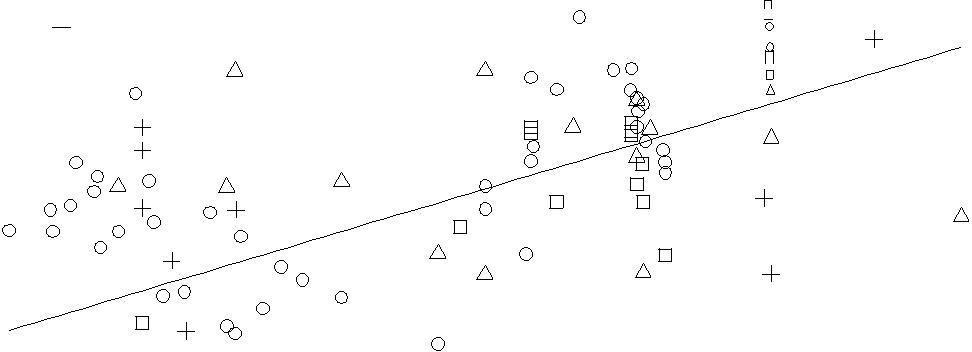
 Survey

best fit

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | MEX |  |  |
|  |  |  | ECU |  |  |  |  |  |
|  |  |  | CHN |  |  |  |  |  |
| GUY | |  | CHN |  |  |  |  |  |
|  | JAM |  | PER | |  |  |
|  | PRY | |  | BHS |  |
|  |  |  |  | BRB |  |
| GTM | | |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |  |
| NIC |  |  | CHN |  | BRA | | IRN |  |
| HTI |  | BOL DOM | |  |  |  |  |
|  | JAM | |  |  | PAN |  |  |
| HND |  | SLV |  |  |  |  |  |
|  | SRB | | |  |  |  |
|  |  |  |  | CUB |  |
|  |  |  |  |  |  | CRI |  |
|  |  |  |  |  |  | CHL |  |
|  |  |  | COL | |  |  | BHS |  |
|  |  |  |  |  |  | URY | |  |
|  |  |  | CHN | THA | | BRB |  |  |
|  |  |  |  | MEX |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ARG |  |
|  |  |  | SRB | | |  |  |  |
| NGA |  |  |  |  |  |  |  |  |
| PAK |  |  |  |  |  |  |  |  |
|  |  |  | COL | |  |  |  |  |
|  |  |  |  |  |  | VEN | |  |
| SDN |  |  |  |  |  | MEX |  |  |
|  |  |  |  |  | IRN |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | MEX |  |  |
|  |  |  |  |  |  | MEX |  |  |



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | TWN |  |  |  |
| ESP |  | BEL DEU | |  |
| ITA |  |  |  |
|  | DEU | CAN |  |
|  | FRA |  |
|  | CAN |  |
|  |  | CAN | SWE |  |
|  | ITA TWN | CAN | AUS |  |
|  | DEU |  |
|  |  |  |
|  | ITA | DEU | SWE |  |
|  | DEU |  |
|  | GBR | IRL |  |
|  | ITA | CAN | NLD |  |
|  | SWE |  |
|  |  | NLD |  |
| ESP |  | CAN |  |
| ESP | FRA | SWE |  |  |
|  |  |  |  |
| ISR |  |  |  |  |
| TTO | JPN | NLD | |  |
| ESP |  | SWE |  |  |



FIN 

TTO

ESP 

USA



USA USA

USA USA

USA 

USA

USA  USA

USA

USA  ARE

USA

USA  USA

USA

USA

USA 

USA

HKG

CHE  NOR

USA



USA

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 5000 | 10000 | 15000 | 20000 | 25000 | 30000 | 35000 | 40000 | 45000 | 50000 | 55000 | 60000 |

GDP per capita ($)

*Notes* The line depicts the best fit based on the linear regression of direct costs on  [GDP](#page14) percapita in international dollars.

Table 2: Relationship between direct costs and study characteristics (robust linear regression).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error |  |
|  |  |  |  |
| Constant | 2133 | 1773.922 |  |
| GDP per capita ($) | 0.045∗∗ | 0.017 |  |
| Estimation Approach |  |  |  |
| Sum-All medical (Ref.) | −413.880 |  |  |
| Sum-Diagnosis Specific | 528.766 |  |
| RB/matching | −719.868 | 526.896 |  |
| Survey | −689.806 | 671.020 |  |
| At least four costing components | 702.966∗ | 403.968 |  |
| USA study | 3111.067∗∗∗ | 533.534 |  |
| Year of study |  |  |  |
| <1995 (Ref.) | −1744.799 |  |  |
| 1995-1999 | 1632.498 |  |
| 2000-2004 | −816.647 | 1586.966 |  |
| 2005-2009 | −1021.685 | 1592.595 |  |
| 2010-2014 | −2744.739 | 1839.689 |  |
| Study representative | −598.670 | 409.070 |  |
| Complications | 666.803 | 414.727 |  |
|  |  |  |  |
| R-squared adj. | 0.559 |  |  |
| N | 70 |  |  |

*Notes* Standard errors in parenthesis. Ref. reference category.∗ *p <* 0*.*10,∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01..

country in the study and also on average for the entire regions, represented as the mean overall study estimate in Figure 4. Both studies used similar approaches to estimate costs, and indirect cost estimates were likely so high because evidence from only a few countries within the region was used as a basis for estimating indirect costs for every other country in the respective study. Further, the studies took the countries’ per capita gross national product as a proxy for earnings, which might have led to an over-estimation of the indirect costs (Kirigia et al.,  [2009](#page293)).

**Studies using the incidence approach**

The four studies that used an incidence approach (see Table  [3](#page49) estimated the cost of diabetes either over a person’s lifetime (Birnbaum et al.,  [2003;](#page284) Camilo González et al.,  [2009)](#page285) or over a certain period after diagnosis Johnson et al.  [(2006)](#page292) and Martin et al.  [(2007](#page296)). Camilo González et al.  [(2009)](#page285) modelled the lifetime (direct and indirect) costs of a typical diabetes patient in Colombia, ar-riving at a mean cost estimate of $54,000. The second study providing lifetime estimates by Birnbaum et al.  [(2003),](#page284) estimated incremental lifetime healthcare costs for USA females with diabetes of $283,000.

Two studies followed patients over a limited time period and found diﬀerent patterns in the development of type 2 diabetes-attributable healthcare costs. In Germany costs increased from $1634 in the first year after diagnosis to $4881 in the seventh year (Martin et al.,  [2007](#page296)). In Canada, Johnson et al.  [(2006)](#page292) found the highest costs in the year of diagnosis with $7635, up from $2755 the year prior to diagnosis. In the year after diagnosis costs decreased to $4273 and then only increased slightly to $4618 in year ten. In Germany and Canada, costs related to complications or hospital visits were the most important components and in Germany increased steadily over time. In Canada costs related to prescriptions increased the most.

Figure 4: Direct and indirect cost relation in studies estimating total costs of type 2 diabetes.

9000

8000

7000

6000

5000

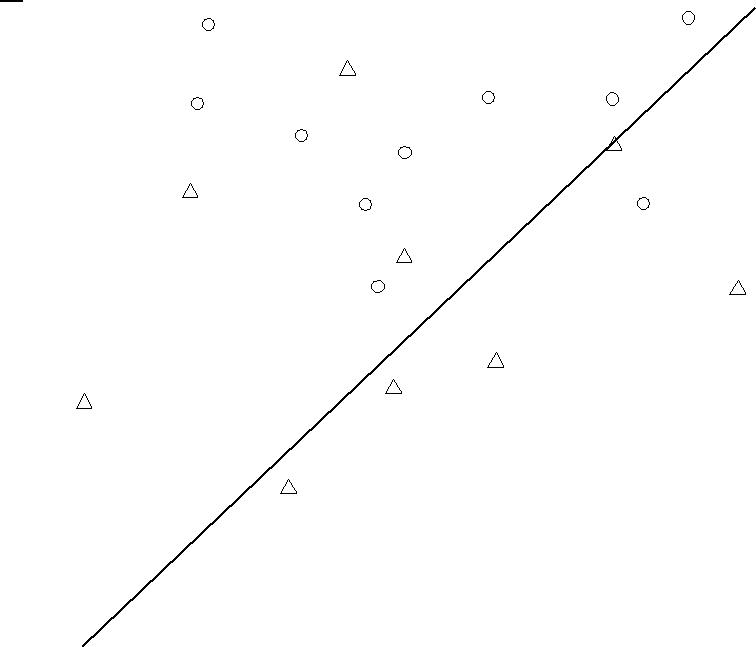
4000

3000

High−income



Low− and middle−income 45° line ITA



CHN

|  |  |  |
| --- | --- | --- |
| NLD | CAN |  |
|  |  |

HKG

USA



USA

USA



ESP

DEU

 SWE

|  |  |  |
| --- | --- | --- |
| ($) |  |  |
| costs | 2000 |  |
|  |  |
| direct | 1000 |  |
|  |  |

SRB

NOR

USA

THA ESP

IRN

SWE

AFR

LAC



PAK



COL

MEX

IRN

MEX



MEX

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1000 | 2000 | 3000 | 4000 | 5000 |

per capita indirect costs ($)

*Notes* The 45°line depicts the points where direct and indirect costs would be equal. Abovethe line direct costs are higher than indirect costs and vice versa. For better visibility both coordinate axes are expressed in log scale

Table 3: Incidence studies on the costs of diabetes

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country | Time horizon | Population |  | Approach |  | Results |
|  |  |  |  |  |  |  |  |
| Johnson et al. | Canada | 1992–2001 | Incidence T2D | patients | Sum-all medi- | Highest | total healthcare |
| [(2006](#page292)) |  |  | from Saskatchewan Health’s | | cal | costs at year of diagnosis | |
|  |  |  | administrative database in | |  | with CAN$7343 ($7635), | |
|  |  |  | Canada |  |  | then increased from a low of | |
|  |  |  |  |  |  | CAN$3880 ($4034) 3 years | |
|  |  |  |  |  |  | after diagnosis to CAN$4441 | |
|  |  |  |  |  |  | 10 years thereafter ($4618). | |
| Camilo | Colombia | 32 years | Hypothetical | average | Sum-all medi- | Total lifetime costs (32 year | |
| González |  |  | Columbian T2D patient | | cal | period) | of average diabetes |
| et al.  [(2009](#page285)) |  |  |  |  |  | patient, including direct and | |
|  |  |  |  |  |  | indirect costs, 57.565 million | |
|  |  |  |  |  |  | Colombian pesos ($54,351). | |
| Martin et al. | Germany | 1995–2003 | Newly diagnosed T2D pa- | | Sum-all medi- | EUR 1,288 ($1635) for the | |
| [(2007](#page296)) |  |  | tients from randomly drawn | | cal | first treatment year after dia- | |
|  |  |  | practices across Germany | |  | betes diagnosis and increased | |
|  |  |  |  |  |  | to EUR 3845 ($4880) in the | |
|  |  |  |  |  |  | seventh year. | |

Table 3: Incidence studies on the costs of diabetes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Country | Time horizon | Population | Approach | Results |
|  |  |  |  |  |  |
| Birnbaum | United States | 1997–1998 | Women employed by nation- | RB / match- | $282973 incremental lifetime |
| et al.  [(2003](#page284)) |  |  | wide operating company and | ing | direct healthcare costs, using |
|  |  |  | hypothetical women above |  | incidence-based, steady-state |
|  |  |  | age 64 receiving Medicare |  | methodology. |
|  |  |  |  |  |  |

**Country level costs prediction studies**

Four studies projected costs of diabetes over a certain period of time (Davis et al.,  [2006;](#page288) Lau et al.,  [2011;](#page294) Ohinmaa et al.,  [2004;](#page298) Wang, McGreevey, et al.,  [2009),](#page306) making assumptions about the future development of diabetes preva-lence and population ageing (see Table 4). For Canada, a 1.7-fold increase from 2000 to 2016 (Ohinmaa et al.,  [2004)](#page298) and a 2.4-fold increase from 2008 to 2035 in diabetes healthcare costs was estimated (Lau et al.,  [2011](#page294)). Taking a health care system perspective, both studies found that the estimated increase would be mostly driven by an ageing population. For Australia, Davis et al.  [(2006)](#page288) estimated a 2.5- to 3.4-fold increase in diabetes attributable healthcare costs from 2000 to 2051, depending on the underlying assumptions about pop-ulation ageing and diabetes prevalence rates. For China, Wang, McGreevey, et al.  [(2009)](#page306) extrapolated total costs of diabetes from the year 2007 to 2030, estimating the costs of diabetes to increase 1.8-fold, solely accounting for the expected increase in prevalence.

1. **The impact of diabetes on employment chances and productivity**

Besides studies that determined the cost of diabetes by costing related expendi-tures, another body of research has investigated—using econometric techniques— the impact of diabetes on ’productivity’, a term used here to comprise outcomes including employment probabilities and lost work days and income or earnings. A recent study systematically reviewed evidence on the impact of diabetes on the ability to work, focusing on studies assessing the impact of diabetes on early retirement, lost work hours, absenteeism and presenteeism (Breton et al.,  [2013](#page285)). We focused particularly on studies exploring the impact of diabetes on employment probabilities and earnings—both issues that were not covered in the mentioned review—and we took a more detailed look at the empirical chal-lenges posed by the issue of endogeneity (see the Appendix for a more detailed discussion of endogeneity).

Tables  [5](#page54) and  [6](#page62) synthesize the relevant information from the 23 identified studies on the eﬀect of diabetes on employment and other labour market out-comes. Almost all studies were conducted on HICs, mainly the USA (n=13) and European countries (n=4). Only one study focused on a  [LMIC.](#page14) investi-gating the eﬀect of diabetes on labour income in China.

Table 4: Country level costs prediction studies

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. |  | Country | Population Approach | | | Time |  | Results | |  |
|  |  |  |  |  |  | horizon |  |  |  |  |
|  |  |  |  | | |  |  | | | |
| Davis |  | Australia | Australian Sum | | | 2000– | If age and sex spe- | | | |
| et | al. |  | popula- | | diagnosis | 2051 | cific prevalence re- | | | |
| [(2006](#page288)) |  |  | tion |  | Specific |  | mains | | unchanged | |
|  |  |  |  |  |  |  | a 2.5-fold increase; | | | |
|  |  |  |  |  |  |  | if age and sex spe- | | | |
|  |  |  |  |  |  |  | cific prevalence al- | | | |
|  |  |  |  |  |  |  | lowed to change as | | | |
|  |  |  |  |  |  |  | well a 3.4-fold in- | | | |
|  |  |  |  |  |  |  | crease. | |  |  |
| Ohinmaa | | Canada | Canadian | | Sum-all | 2000– | 1.7-fold increase. | | | |
| et | al. |  | popula- | | medical | 2016 |  |  |  |  |
| [(2004](#page298)) |  |  | tion |  | costs |  |  |  |  |  |
| Lau |  | Canada | Four |  | Sum-all | 2008– | 2.4-fold increase. | | | |
| et | al. |  | Alberta | | medical | 2035 |  |  |  |  |
| [(2011](#page294)) |  |  | Health | | costs |  |  |  |  |  |
|  |  |  | and |  |  |  |  |  |  |  |
|  |  |  | Wellness | |  |  |  |  |  |  |
|  |  |  | databases | |  |  |  |  |  |  |
| Wang, |  | China | In | pa- | Own sur- | 2007 | Increase from $73 | | | |
| Mc- |  |  | tients | | vey | and 2030 | billion | | in | 2007 |
| Greevey, | |  | and | out- |  | (projec- | to | $132 billion | | |
| et | al. |  | patients | |  | tion) | in | 2030 (1.8 | | fold |
| [(2009](#page306)) |  |  | in | 20 |  |  | increase). | | |  |
|  |  |  | hospitals | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

**Employment chances**

Most studies examined the impact of diabetes on employment probability (n=17), applying a range of econometric techniques. These have evolved over time, and more recent studies took into account the possibility that diabetes might be endogenous: it is conceivable that especially personal traits such as motivation and drive could influence the propensity to develop type 2 diabetes as well as a persons’ job market opportunities. Further, being employed or unemployed could also lead to changes in lifestyles, due to changes in income, stress or leisure time, that could themselves aﬀect the chances of developing diabetes (Brown, Pagán, et al.,  [2005](#page285)). Of the studies that tried to account for this problem (Brown, Pagán, et al.,  [2005;](#page285) Harris,  [2009;](#page291) Latif,  [2009;](#page294) Lin,  [2011](#page295); Minor,  [2011a;](#page296) Zhang, Zhao, et al.,  [2009),](#page308) the majority used an instrumental variable  [(IV)](#page14) technique. This approach allows for the consistent estimation of the eﬀect of diabetes on employment if a variable can be found that is causally related to diabetes without aﬀecting the employment chances through any other unobserved pathway apart from its eﬀect on diabetes (see Text Box 1). In the case of type 2 diabetes all studies used the family history of diabetes as an IV to exploit the fact that the development of type 2 diabetes is much more likely for individuals whose biological parents have also had diabetes. It is argued that, while controlling for education, age and other observable demographic and socioeconomic factors (e.g. wealth, regional and ethnic diﬀerences and the number of children in the household), having a family member with dia-betes should not aﬀect the person’s employment status or other labour market outcomes, while strongly predicting the onset of type 2 diabetes.

Table 5: Studies estimating the relationship between diabetes and employment (2001 – 2014)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref | Survey year | Country | Age | | Eﬀect on employment |
|  |  |  |  |  |  |
|  |  |  |  | Males | Females |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Harris  [(2009](#page291)) | 1999-2000 | | Australia | >24 | Exogenous: | 10.8 percent- |
|  |  |  |  |  | age points reduction to be | |
|  |  |  |  |  | in labour force; endogenous: | |
|  |  |  |  |  | 7.1 percentage points reduc- | |
|  |  |  |  |  | tion and test indicates endo- | |
|  |  |  |  |  | geneneity. |  |
| Zhang, Zhao, | 2001, | 2004- | Australia | 18-64 | 50-64: 11.5 percentage points | |
| et al.  [(2009](#page308)) | 2005 |  |  |  | less likely to be in labour | |
|  |  |  |  |  | force; 18-49: | 3.9 percentage |
|  |  |  |  |  | points less likely, all eﬀects | |
|  |  |  |  |  | increase when other chronic | |
|  |  |  |  |  | diseases are present. | |
| Latif  [(2009](#page294)) | 1998 |  | Canada | 15-64 | Exogenous: | 19 percentage |
|  |  |  |  |  | points less likely to be em- | |
|  |  |  |  |  | ployed; endogenous: not sig- | |

nificant and positive and test indicates endogeneity.

Exogenous: 10 percentage points to be in labour force; endogenous: Nine percentage points reduction and test in-dicates endogeneneity.

No significant eﬀect for dia-betes alone; significant nega-tive eﬀect if other chronic dis-eases are present.

Exogenous: 17 percentage points less likely to be em-ployed, endogenous: not sig-nificant and positive and test indicates exogeneity.

Table 5: Studies estimating the relationship between diabetes and employment (2001 – 2014)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ref |  | Survey year | Country | Age | Eﬀect on employment |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  | Males | Females |
|  |  |  |  |  |  | |
| Kraut | et al. | 1983-1990 | Canada | 18-64 | With complications 2 times less likely to be in labour force; | |
| [(2001](#page293)) |  |  |  |  | no significant eﬀect on employment for those in labour force.a | |
| Norlund et al. | | 1992-1993 | Sweden | >24 | 14.2 percentage points higher retirement rate (22.9 compared | |
| [(2001](#page298)) |  |  |  |  | to 8.7).a |  |
| Alavinia | | 2004 | Sweden, | 50-65 | For whole dataset: no eﬀect of diabetes on being unemployed, | |
| and | Burdorf |  | Denmark, | | but increased odds ratio of 1.33 on being retired. No infor- | |
| [(2008](#page281)) |  |  | Netherlands, | | mation on eﬀects by country.a |  |
|  |  |  | Germany, | |  |  |
|  |  |  | Austria, |  |  |  |
|  |  |  | Switzerland, | |  |  |
|  |  |  | France, | Italy, |  |  |

Spain, Greece

Table 5: Studies estimating the relationship between diabetes and employment (2001 – 2014)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref | Survey year | Country | Age | | Eﬀect on employment |
|  |  |  |  |  |  |
|  |  |  |  | Males | Females |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Lin  [(2011](#page295)) |  | 2005 | Taiwan | 45-64 | Exogenous: | | 9 | percentage | |
|  |  |  |  |  | points less likely to be em- | | | | |
|  |  |  |  |  | ployed; endogenous: 19 per- | | | | |
|  |  |  |  |  | centage points less likely to | | | | |
|  |  |  |  |  | be employed; test on whole | | | | |
|  |  |  |  |  | sample | indicates | | endogene- | |
|  |  |  |  |  | ity. |  |  |  |  |
| Brown, |  |  | USA | >44 | Exogenous: | | 7.4 | percentage | |
| Pagán, | et |  |  |  | points less likely to be em- | | | | |
| al.  [(2005](#page285)) |  |  |  |  | ployed; | endogenous: | | | 10.6 |
|  |  |  |  |  | percentage | | points | less | likely |
|  |  |  |  |  | but test indicates exogeneity. | | | | |
| Minor  [(2011a](#page296)) | | 2006 | USA | >19 at | diag- |  |  |  |  |
|  |  |  |  | nosis |  |  |  |  |  |

Exogenous: 11 percentage points less likely to be em-ployed, endogenous: not sig-nificant and negative.

Exogenous: 7.5 percentage points less likely to be em-ployed; Endogenous: no sig-nificant eﬀect found and test indicates endogeneity.

Exogenous: 25.2 percentage points less likely to be em-ployed, endogenous: 45.1 percentage points less likely to be employed.

Table 5: Studies estimating the relationship between diabetes and employment (2001 – 2014)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref |  | Survey year | Country | Age |  |  | Eﬀect on employment | | | |
|  |  |  |  |  |  |  | |  |  |  |
|  |  |  |  |  |  | Males | |  |  | Females |
|  |  |  |  |  |  | | | | | |
| Vijan | et al. | 1992-2000 | USA | 51-61 | More likely to be retired in 1992 (adjusted OR 1.3). Over 8 | | | | | |
| [(2004](#page305)) |  |  |  |  | years follow up spent 0.14 incremental years in retirement.a | | | | | |
| Bastida | and | 1996-1997 | USA | >44 | 7.5 percentage points | | | | less | No significant eﬀect on em- |
| Pagán  [(2002](#page283)) | |  |  |  | likely to be employed. | | | |  | ployment chances found. |
| Brown, | Perez, | 2008 | USA | 35-64 | Diabetes | negatively | | related | | No significant eﬀect on em- |
| et al.  [(2011](#page285)) | |  |  |  | to employment (5 percentage | | | | | ployment chances found. |
|  |  |  |  |  | points reduction); better di- | | | | |  |
|  |  |  |  |  | abetes management  [(HbA1c](#page14)) | | | | |  |
|  |  |  |  |  | positively |  | aﬀects | employ- | |  |
|  |  |  |  |  | ment probabilities; | | | [HbA1](#page14)c | |  |
|  |  |  |  |  | lowering | of | 10% increases | | |  |
|  |  |  |  |  | employment | | probability | | by |  |
|  |  |  |  |  | 0.44 percentage points. | | | |  |  |

Table 5: Studies estimating the relationship between diabetes and employment (2001 – 2014)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref | Survey year | Country | Age | | Eﬀect on employment |
|  |  |  |  |  |  |
|  |  |  |  | Males | Females |

Tunceli, 1992,1994 USA 51-61 Bradley, et al.

[(2005](#page305))

|  |  |  |
| --- | --- | --- |
| Tunceli, Zeng, 1997-2005 | USA | 20-44 and 45- |
| et al.  [(2009](#page305)) |  | 64 |

|  |  |  |  |
| --- | --- | --- | --- |
| Valdmanis et | 1990-1995 | USA |  |
| al.  [(2001](#page305)) |  |  |  |
| Ng et al. | 1989 | USA | >29 at diag- |
| [(2001](#page297)) |  |  | nosis |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 9 percentage points less likely | | | | 5.9 | percentage | points | less |
| to work without complica- | | | | likely to work without com- | | | |
| tions | controlled | for, | with | plications controlled for, with | | | |
| complications controlled for | | | | complications controlled | | | for |
| 7.1 | percentage | points | less | 4.4 | percentage | points | less |
| likely. | |  |  | likely but not significant. | | |  |

20-44: proportion with work limitations 3.1% higher; 45-64: proportion not working is 8.1% higher; the proportion work disabled is 3.4% higher; proportion with work limitations is 5.7% higher (all compared to similar age group without diabetes).a

Unemployment rate for persons with diabetes was 16% com-pared with 3% among matched comparison group.a

3.6% less likely of being employed (exogenous), 12% for those with complications.a

Table 5: Studies estimating the relationship between diabetes and employment (2001 – 2014)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref | Survey year | Country | Age | | Eﬀect on employment |
|  |  |  |  |  |  |
|  |  |  |  | Males | Females |

|  |  |  |  |
| --- | --- | --- | --- |
| Minor  [(2013)](#page297)  1979-2010 | USA | >14 | Average reduction of employ- |
|  |  |  | ment probability of 28 per- |

centage points; strongest em-ployment penalty in first 5 years after diagnosis.

Average reduction of employ-ment probability of 36 per-centage points; strongest em-ployment penalty in first 15 years after diagnosis.

a No gender diﬀerentiation in study

Because IV estimation has worse asymptotic properties than single equation regression results when endogeneity is not an issue, studies tested for the exis-tence of endogeneity to determine which results to rely on for inference (Brown, Pagán, et al.,  [2005;](#page285) Latif,  [2009;](#page294) Lin,  [2011;](#page295) Minor,  [2011a](#page296)). Interestingly, the re-viewed studies found diabetes to be endogenous for either males (Latif,  [2009](#page294)) or females (Brown, Pagán, et al.,  [2005;](#page285) Minor,  [2011a),](#page296) but never for both. Further, the use of an IV sometimes increased the estimated eﬀect(Lin,  [2011](#page295); Minor,  [2011a)](#page296) whereas in other cases the eﬀect turned insignificant (Brown, Pagán, et al.,  [2005;](#page285) Latif,  [2009](#page294)). As a result, no unambiguous conclusions can be drawn as to how endogeneity aﬀects diabetes and whether or not it causes biased estimates. Most of the relevant studies also explored whether accounting for body mass index  [(BMI)](#page14) or other diabetes-related chronic conditions would substantially alter the result and found this not to be the case (Brown, Pagán, et al.,  [2005;](#page285) Latif,  [2009;](#page294) Minor,  [2013](#page297)).

Overall, studies more commonly found a significant adverse impact of dia-betes on males, ranging from no eﬀect in Canada (Latif,  [2009)](#page294) to a 19 per-centage point reduction in Taiwan (Lin,  [2011](#page295)). Conversely, no eﬀect was found for women in Taiwan (Lin,  [2011),](#page295) Australia (Zhang, Zhao, et al.,  [2009)](#page308) or for Mexican Americans in Texas (Brown, Pagán, et al.,  [2005](#page285)). However, a 45 % decrease in employment chances was observed for women in the USA (Minor,  [2011a](#page296)). Extending the scope and looking at how diabetes duration aﬀected labour market outcomes, using pooled longitudinal data from the USA, one study found that the main adverse eﬀect on employment chances materialized within the first 5 years after diagnosis for men and 11–15 years after diagnosis for women (Minor,  [2013](#page297)).

**Productivity**

For earnings, no eﬀect was found for Mexican-American men in Texas (Bastida and Pagán,  [2002),](#page283) while the highest loss was found for women in the USA ($21392 per year) (Minor,  [2011a](#page296)). Again looking at diabetes duration, a wage penalty was only found for USA men 6–10 years after diagnosis, reducing their wage by about 18 percentage points (Minor,  [2013](#page297)). The only study on a non- [HIC,](#page14) China, tried to tease out the psychological eﬀect of a diabetes diagnosis on subsequent labour income, finding a reduction of 22 % in income for males, but not for females. Further, those with an  [HbA1c](#page14) between 8–10 % experi-enced the most severe income penalty (29 %). The study further showed that the adverse eﬀect of a diabetes diagnosis was concentrated among the poorest

third of the study population (Liu and Zhu,  [2014](#page295)). Another study investigated the eﬀect on earning losses for caregivers of people with diabetes in the United Kingdom  [(UK),](#page15) finding a reduction of $2,609 per year, while the person with diabetes experienced a loss of $1,744 per year (Holmes et al.,  [2003](#page291)). For income, a reduction of $6,250 per year was found for older USA adults who had been followed between the years 1992 and 2000 (Rivera, Barquera, González-Cossío, et al.,  [2004](#page300)). In terms of lost workdays and work hours due to diabetes, the eﬀects ranged from no impact on lost work days on older people (Rivera, Bar-quera, González-Cossío, et al.,  [2004)](#page300) and females in the USA (Minor,  [2011a)](#page296) to 3.2 lost work days in a USA population within a 2-week period if complications were present (Ng et al.,  [2001](#page297)).

In terms of the methodology used, these studies tended to rarely account for endogeneity, and they mostly used standard regression or matching methods to estimate the impact of diabetes. Three studies (Bastida and Pagán,  [2002](#page283); Brown, Perez, et al.,  [2011;](#page285) Minor,  [2011a)](#page296) corrected for the possibility of a sample selection bias, to account for systematic diﬀerences between the working population and the overall population. Only one study additionally applied IV methods and found diabetes to be endogenous, so that its eﬀects on earnings were dramatically understated using naive regression results (Minor,  [2011a](#page296)). For working hours and days missed due to illness, the same study found no indication of endogeneity. Only one study applied an approach other than IV to account for endogeneity, using a diﬀerence-in-diﬀerence model and exploiting a recent diagnosis of diabetes, which was the result of the collection of biomarkers in the survey used, as a natural experiment to measure how income developed between those who were newly diagnosed and those without diabetes in the years following diagnosis (Liu and Zhu,  [2014](#page295)).

Table 6: Studies estimating the relationship between diabetes and other productivity outcomes (2001 – 2014)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. |  |  | Survey year | Country | Age |  | Eﬀect on other productivity outcomes | |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | Males | Females |
|  |  |  |  |  |  |  |  | |
| Kraut | et | al. | 1983–1990 | Canada | 18–64 |  | Eﬀect on earnings only when | |
| [(2001](#page293)) |  |  |  |  |  |  | complications are | present: |
|  |  |  |  |  |  |  | reduced to 72% of total in- | |
|  |  |  |  |  |  |  | come of controls.a |  |
| Liu and Zhu | | | 2009, 2011 | China | not given | | 16.3% decrease in annual income; strongest eﬀect for those | |
| [(2014](#page295)) |  |  |  |  |  |  | in lower income quintiles.a | |
| Herquelot | |  | 1989–2007 | France | Male | 40–50, | 1.7 HR to transition from employed to disabled, 1.6 HR to | |
| et al.  [(2011](#page291)) | | |  |  | females | 35–50 | be retired, 7.3 HR to be dead; between age 35 and 60 each | |
|  |  |  |  |  | in 1989 |  | person with diabetes lost 1.1 years of time in workforce.a | |
| Leijten | et | al. | 2010–2013 | Netherlands | 45–64 |  | Diabetes reduced work ability measured using Work Ability | |
| [(2014](#page294)) |  |  |  |  |  |  | Index (WAI) by 2%. No significant eﬀect on productivity was | |
|  |  |  |  |  |  |  | found.a |  |
| Norlund et al. | | | 1992–1993 | Sweden | >24 |  | 9.4 more sick days.a |  |
| [(2001](#page298)) |  |  |  |  |  |  |  |  |
| Holmes | et | al. | 1999 | UK | <65 |  | GBP 869 lost earnings per year with diabetes; GBP 1300 for | |
| [(2003](#page291)) |  |  |  |  |  |  | carers of people with diabetes.a | |

Table 6: Studies estimating the relationship between diabetes and other productivity outcomes (2001 – 2014)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. |  |  | Survey year | Country | Age | Eﬀect on other productivity outcomes | | |
|  |  |  |  |  |  |  |  | |
|  |  |  |  |  |  | Males | Females | |
|  | | |  |  |  |  |  |  |
| Minor  [(2011a](#page296)) | | | 2006 | USA | >19 at diag- |  | Exogenous: | $2865 loss in |
|  |  |  |  |  | nosis |  | earnings per year, Endoge- | |
|  |  |  |  |  |  |  | nous: $19655; Exogenous: 2 | |
|  |  |  |  |  |  |  | working hours less per week, | |
|  |  |  |  |  |  |  | no significant eﬀect on missed | |
|  |  |  |  |  |  |  | workdays per year, endoge- | |
|  |  |  |  |  |  |  | nous: no significant eﬀect on | |
|  |  |  |  |  |  |  | working hours or workdays | |
|  |  |  |  |  |  |  | missed. |  |
| Vijan | et | al. | 1992–2000 | USA | 51–61 | Lost income of $50004 from 1992–2000 per capita or $6250 | | |
| [(2004](#page305)) |  |  |  |  |  | per year, for whole USA population of same age $85.6 billion | | |
|  |  |  |  |  |  | or $10.7 billion per year; people with diabetes more likely to | | |
|  |  |  |  |  |  | have taken sick days in 1992 (adjusted OR 1.3).a | | |
| Collins | et | al. | 2002 | USA | working age | No significant eﬀect on work days.a | |  |
| [(2005](#page287)) |  |  |  |  |  |  |  |  |
| Bastida |  | and | 1996–1997 | USA | >44 | No significant eﬀect on earn- | Women with | diabetes earn |
| Pagán  [(2002](#page283)) | | |  |  |  | ings. | 84% less. |  |

Table 6: Studies estimating the relationship between diabetes and other productivity outcomes (2001 – 2014)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Ref. |  | Survey year | Country | Age | Eﬀect on other productivity outcomes | |
|  |  |  |  |  |  |  |
|  |  |  |  |  | Males | Females |
|  | |  |  |  |  |  |
| Brown, Perez, | | 2008 | USA | 35–64 | Wages reduced by 0.74% due | No significant eﬀect of dia- |
| et al.  [(2011](#page285)) |  |  |  |  | to diabetes; for every 10% re- | betes on female earnings; no |
|  |  |  |  |  | duction in  [HbA1c](#page14) wages rise | eﬀect of blood sugar manage- |
|  |  |  |  |  | by 0.62 %.  [HbA1c](#page14) >8 was | ment for women,  [HbA1c](#page14) lev- |
|  |  |  |  |  | related to decreasing wages. | els just below 6 to just above |
|  |  |  |  |  |  | 7 were related to lower wages. |
| Lenneman | et | 2005–2009 | USA | >16 | Lost earnings per year of $2146.a | |
| al.  [(2011](#page294)) |  |  |  |  |  |  |
| Tunceli, |  | 1992, 1994 | USA | 51–61 | No significant eﬀect on num- | 2.5 more lost workdays per |
| Bradley, et al. | |  |  |  | ber of work days. | year. |
| [(2005](#page305)) |  |  |  |  |  |  |
| Valdmanis | et | 1990–1995 | USA |  | 71% of the persons with diabetes had an annual income | |
| al.  [(2001](#page305)) |  |  |  |  | of less than $20000 compared with 59% of the matched | |
|  |  |  |  |  | respondents.a |  |

Table 6: Studies estimating the relationship between diabetes and other productivity outcomes (2001 – 2014)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. |  |  | Survey year | Country | Age | Eﬀect on other productivity outcomes | | |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | Males |  | Females |
|  |  |  |  |  |  |  | |  |
| Ng | et | al. | 1989 | USA | >29 at diag- | No significant eﬀect on work | |  |
| [(2001](#page297)) |  |  |  |  | nosis | days for T2D, for those with | |  |
|  |  |  |  |  |  | complications 3.2 | days lost |  |
|  |  |  |  |  |  | within two weeks |  |  |
| Brown, | |  | NA | USA | >45 | For every dollar of labor income lost by adults with diabetes, | | |
| Estrada, | |  |  |  |  | a further income reduction of $0.48 occurs in the community. | | |
| et al.  [(2005](#page285)) | | |  |  |  | Total output reduction for upper bound estimate is $300 mil- | | |
|  |  |  |  |  |  | lion for the local economy.a | |  |
| Minor  [(2013](#page297)) | | | 1979–2010 | USA | >14 | No general eﬀect | of type 2 | No strong evidence found for |
|  |  |  |  |  |  | diabetes on wages; some ev- | | wage penalty for females |
|  |  |  |  |  |  | idence of wage | penalty of |  |

about 18% 6–10 years after diagnosis

a No gender diﬀerentiation in study

**2.4 Discussion**

The objectives of this systematic review were to identify new evidence on the economic impact of type 2 diabetes that emerged since 2001 and extend the scope of the review by including studies on the labour market impact of di-abetes. We identified studies from a great variety of countries, with large diﬀerences in cost estimates across and within countries.

1. **General findings and developments since the 2004 review of diabetes cost-of-illness studies**

An obvious development since the last review is the emergence of  [COI](#page14) studies on LMICs. The economic burden related to diabetes found in these studies in-dicated a strong direct impact on those aﬀected by diabetes. This is reflected in the substantial burden of  [OOP](#page15) treatment costs incurred by patients (Arredondo and Barcelo,  [2007;](#page282) Chatterjee et al.,  [2011;](#page286) Elrayah-Eliadarous et al.,  [2010;](#page289) Es-teghamati et al.,  [2009;](#page290) Khowaja et al.,  [2007;](#page293) Ramachandran, Ramachandran, et al.,  [2007;](#page300) Smith-Spangler et al.,  [2012;](#page303) Suleiman et al.,  [2006;](#page304) Tharkar et al.,  [2010;](#page304) Wang, Fu, Pan, et al.,  [2009;](#page305) Wang, Fu, Zhuo, et al.,  [2010),](#page306) with considerable proportions of the annual income being spent on diabetes care. This relative cost burden was generally higher for people with relatively lower household incomes (Khowaja et al.,  [2007;](#page293) Ramachandran, Ramachandran, et al.,  [2007;](#page300) Tharkar et al.,  [2010](#page304)). Health insurance coverage had some protective eﬀects against  [OOP](#page15) expenditures, but mainly for those with higher incomes, while the poor often lacked coverage (Khowaja et al.,  [2007;](#page293) Ramachandran, Ra-machandran, et al.,  [2007;](#page300) Tharkar et al.,  [2010](#page304)).Nonetheless, once people were covered by health insurance their risk of incurring catastrophic expenditures decreased significantly (Smith-Spangler et al.,  [2012](#page303)). An important cost factor that was predominantly investigated in studies on LMICs were non-medical costs for transportation, informal healthcare or food which were found to con-siderably add to the experienced diabetes cost burden (Chatterjee et al.,  [2011](#page286); Esteghamati et al.,  [2009;](#page290) Tharkar et al.,  [2010;](#page304) Wang, Fu, Pan, et al.,  [2009](#page305); Wang, McGreevey, et al.,  [2009](#page306)).

In terms of the costing methodology applied in  [COI](#page14) studies, the number of studies estimating the excess costs of diabetes increased since the Ettaro et al.  [(2004)](#page290) review. Those studies either used regression analysis or matching to adjust for the diﬀerences between people with diabetes and those without, ac-

counting at least for age and gender, but often also for other socioeconomic, geo-graphic and demographic diﬀerences. Other widely used approaches to estimate direct healthcare costs from the perspective of the healthcare system or private insurance included the disease-attributable and—slightly less frequently—the attributable-fraction approach. For cost assessment in LMICs, studies often either estimated total healthcare costs or carried out self-administered sur-veys. While Ettaro et al.  [(2004)](#page290) recommended the use of disease-attributable approaches to arrive at more exact estimates of the costs of diabetes, the evi-dence found in this review indicates that using an incremental cost approach via matching or regression analysis could provide more accurate results, due to its ability to capture costs otherwise not directly traceable to diabetes. Nonethe-less, the use of the estimation technique always hinges on the availability of appropriate data, with regression or matching analyses requiring information on people without diabetes to be used as a control group. Therefore the esti-mation approach needs to be tailored to the available data.

Compared with the evidence reviewed by Ettaro et al.  [(2004),](#page290) the field has generally advanced with respect to the analysis of costs in diﬀerent ethnic and age groups. Two studies investigated diﬀerences between racial groups in the USA, showing that while ethnic minorities spend less on diabetes healthcare than Whites, this diﬀerence seems to be mainly based on diﬀerences in access to care between Whites and Blacks or Hispanics (Buescher et al.,  [2010;](#page285) Lee et al.,  [2006](#page294)). In terms of age, studies found an increase in healthcare costs with age as well as with, in some cases, the duration of diabetes. A recurring problem was that many studies did not distinguish diabetes types, making it diﬃcult to exactly attribute the costs to the respective diabetes types.

To explore the reasons for the wide heterogeneity in direct cost estimates across studies, we performed a regression analysis, which indicated that an important determinant for the cost variation across countries could be the eco-nomic wealth of the country (proxied by  [GDP](#page14) per capita), similar to what was found in a review of indirect costs of various chronic diseases (Zhao, Xie, et al.,  [2013),](#page308) possibly due to diﬀerences in the availability and aﬀordability of dia-betes care between HICs and LMICs (Cameron, Ewen, et al.,  [2009;](#page285) Cameron, Roubos, et al.,  [2011](#page285)).

Further, studies on the USA seem to estimate consistently higher costs than studies on other countries, even when accounting for diﬀerences in  [GDP](#page14) per capita. The higher direct costs of diabetes estimated for the USA are in line with the generally higher healthcare expenditures in the USA compared with

countries with similar income levels, and could be the result of exceptionally high service fees (Laugesen and Glied,  [2011)](#page294) and prices paid in the USA health-care system (Lorenzoni et al.,  [2014;](#page295) Squires,  [2012](#page304)).

Because of the small sample size on which our analysis was based, these results must be interpreted with caution, and other factors could still be im-portant. For instance, other evidence suggests that diﬀerent costing approaches have a considerable eﬀect on diabetes cost estimates (Honeycutt et al.,  [2009](#page291); Tunceli, Wade, et al.,  [2010](#page305)). Furthermore, the perspective taken, diﬀerent data sources and populations investigated and decisions on the cost compo-nents included are likely important in explaining within-country heterogeneity. In particular, the inclusion of diabetes complications and decisions about which complication(s) to include, as well as the extent to which costs for these dis-eases are attributable to diabetes, can significantly aﬀect the results. Not all studies in the review provide extensive information about how they include complications and some do not include them at all.

Finally, the quality of the data used could have aﬀected the cost estimates. Many studies in LMICs relied on self-reported data from small household sur-veys, limiting their generalizability and leading their results to be prone to recall bias. Further, these studies often identified people with diabetes via their use of healthcare institutions, which excluded a potentially important section of the population in LMICs unable to access formal care, possibly leading to an overestimation of the average diabetes-related costs.

**2.4.2 Labour market studies**

Turning to the eﬀects of diabetes on the labour market, the existing studies showed, almost consistently, with the exception of Canada (Latif,  [2009)](#page294) and one study on the USA (Minor,  [2013),](#page297) that the employment probabilities of men were aﬀected more adversely by the disease than those of women. However, while most studies have tried to tentatively explain these gender diﬀerences, the reasons for this have not been investigated in depth. The studies also showed that, when interpreting this research, it is important to consider whether a study has tried to account for unobservable factors or reverse causality, as otherwise the results might be misleading. Nonetheless, all studies using IV techniques used similar instruments to achieve identification, providing scope for further research using diﬀerent identification strategies to explore how endo-geneity might aﬀect the results. What has been apparent is the lack of research

on labour market outcomes of diabetes in LMICs, with only one study inves-tigating the eﬀect of diabetes on labour income in China (Liu and Zhu,  [2014](#page295)). This deficit might be due to a limited availability of suitable data sources con-taining suﬃcient information to allow for a similar investigation of the topic.

The potential for rich, good-quality data sources to aid the investigation of the economic impact of diabetes can be illustrated by the several studies that used data from the Lower Rio Grande Valley in Texas. These studies demonstrate the evolution of methodology and data from the use of single equation regression models (Bastida and Pagán,  [2002)](#page283) to the use of IV methods (Brown, Pagán, et al.,  [2005)](#page285) and—finally—biometric data on blood glucose values (Brown, Perez, et al.,  [2011](#page285)). While the first two methods allowed the investigation of the general eﬀect of diabetes on employment chances, the latter was able to assess the impact according to how diabetes was managed by the patient, as proxied by the measured biomarkers. The study found that the main adverse eﬀect was due to having diabetes regardless of how it was managed and that improvements in management only had minor positive eﬀects. The authors concluded that investments in the prevention of diabetes would likely be more eﬀective than improved diabetes management.

The latter study and the study by Liu and Zhu  [(2014)](#page295) also show how bio-metric data (e.g. blood glucose values) can be used to arrive at a deeper un-derstanding of the economic eﬀects of diabetes. Biometric information makes it possible to investigate the impact of diabetes according to the severity of the disease and also allows for the consideration of previously undiagnosed people with diabetes, increasing the policy relevance of the research.

1. **Comparison of COI and labour market studies: common themes and lessons learned**

The results of both fields,  [COI](#page14) and labour market studies, show a considerable adverse impact of diabetes in terms of costs to society, health systems, indi-viduals and employers and in terms of a reduction in the productive workforce and productivity in general. Both research strands particularly indicate that the adverse eﬀects of diabetes increase with diabetes duration as well as with the severity of the disease, judged by the high complication costs estimated in  [COI](#page14) studies and the larger employment and income penalties for those with a longer disease duration or higher blood glucose levels.

Nonetheless, several lessons can be learned for each field from advancements

in the other field. Future  [COI](#page14) studies would, for instance, benefit from the more frequent use of biomarker data. This would allow for a more precise analysis of the costs of diabetes according to the severity of the disease and help inform researchers and policy makers about the possible economic eﬀects of achieving certain treatment goals, e.g., a reduction in blood glucose values.

Also, and in contrast to the labour market outcomes literature, the endogene-ity problem has hitherto not been addressed in any form in studies estimating direct healthcare or productivity costs, despite it being an equally important challenge in this domain. A possible bias could arise if some people developed diabetes as a result of an unobserved accident or illness, likely resulting in an overestimation of the costs. Endogeneity could also be introduced if people with diabetes became poorer as a result of the disease and consequently were not able to spend as much on their treatment as they would like to, leading to an underestimation of the true monetary cost of diabetes. Furthermore, an endogeneity bias would be introduced if diabetes was correlated with poverty so that diabetes prevalence would be disproportionately high in subgroups with less resources and consequently less access to care. This would lead to an un-derestimation of the healthcare costs of diabetes. Endogeneity in  [COI](#page14) studies has recently been addressed for the estimation of healthcare costs of obesity, suggesting that direct costs would have been underestimated, had the study not accounted for endogeneity (Cawley and Meyerhoefer,  [2012](#page286)). It appears that, on the basis of the studies identified in our review, a similar—worthwhile— approach could and should be applied to the case of type 2 diabetes.

Yet the labour market studies also stand to gain from adopting certain ap-proaches that are more common in  [COI](#page14) studies. To date, only few labour market studies have used the incidence approach found for  [COI](#page14) studies to follow people with diabetes over a certain time period from their diagnosis on-wards, in order to further explore how the eﬀect of diabetes on employment and productivity measures develops over time.

Some further recommendations may be derived for future  [COI](#page14) and labour market studies on diabetes:

1. For  [COI](#page14) studies the estimation of incremental costs—wherever possible— appears to be most suitable for diabetes, as it more accurately accounts for costs of co-morbidities and for less obviously related disease costs (Honeycutt et al.,  [2009;](#page291) Tunceli, Wade, et al.,  [2010](#page305)). More information that can guide researchers in their choice of methods already exists and should be referred to when performing a  [COI](#page14) study (Akobundu et al.,

[2006](#page281)).

1. If possible, the use of convenience samples of people with diabetes visiting a health care institution should be avoided, particularly in LMICs, as it excludes those not able or willing to visit a clinic for treatment due to economic reasons, leaving out a potentially important proportion of diabetes patients.
2. The interpretation of the  [COI](#page14) results always hinges on the amount of information provided about, among others, the aim of the study, the perspective adopted and the cost components included as well as the estimation approach used. A discussion of how these choices might aﬀect the estimates should also be part of every  [COI](#page14) study. Researchers should therefore consult available guidance from the literature that sets out what information should ideally be included in a  [COI](#page14) study (Larg and Moss,  [2011)](#page293) to increase the transparency and usability of their research.
3. For labour market studies more evidence from LMICs is needed. There is scope for for exploring existing household datasets from LMICs that con-tain information on diabetes (Seuring et al.,  [2014](#page303)). In some cases, panel data are (or may come) available, which would allow the investigation of the eﬀects of diabetes over time as well as to improve the degree of causal inference by controlling for unobserved heterogeneity.
4. As for labour market studies, other ways of achieving identification should be explored to reduce the reliance on IV methods using the family history of diabetes as the sole instrument. The increasing richness of information provided in recent data sets could be used to this eﬀect, also taking into account other quasi-experimental econometric methods (Craig et al.,  [2012](#page288)).

**2.4.4 Limitations**

A possible limitation of this review is the decision to refrain from excluding studies based on certain quality criteria, such as study design, costing method-ology, sample size or reporting standards. This might have resulted in the inclusion of lower quality studies with less reliable estimates, compromising the comparability across countries, particularly between LMICs and HICs, as study designs diﬀered considerably. On the other hand our overarching objec-tive was to ensure a truly globally comprehensive overview of the literature on

the economic impact of diabetes, including evidence from LMICs, which, for reasons often beyond the control of the researchers, may have been of limited quality and thus would have been excluded, had we applied stringent quality benchmarks. Further, any attempt to apply a quality threshold would have faced the challenge of dealing with the absence of a formal checklist to follow in critically appraising the quality of  [COI](#page14) studies. Rather than interpreting it as a limitation, we see the identification and synthesis of  [LMIC](#page14) studies as a unique added value of this review, when compared to the Ettaro et al.  [(2004](#page290)) review.

Notably, we also abstained from any language restrictions, which would have particularly excluded evidence from Spanish speaking and Eastern European countries. Taken together, these factors have resulted in a large number of included studies, allowing for an (albeit exploratory) statistical investigation of the heterogeneity in diabetes cost estimates as a complement to the narrative analysis. We therefore feel that the advantages of refraining from too stringent inclusion criteria more than outweigh the possible negative consequences of including potentially lower-quality studies.

Further, our search was limited to studies after the year 2000. While for  [CO](#page14)I studies a previous review covered the literature until 2000, this is not the case for the literature on labour market eﬀects of diabetes and we therefore cannot exclude the possibility of having missed some relevant (if old) studies. We have checked the references of our included labour market studies for any relevant studies published before 2001. We could find only one relevant study from 1998 investigating how employment chances and family income were aﬀected by diabetes in the USA, comparing samples from 1976, 1988 and 1992 and finding significant adverse eﬀects of diabetes on employment chances but not on family income (Kahn,  [1998](#page292)). The eﬀect for women decreased somewhat between 1976 and 1992, while the eﬀect increased for men. The study did not account for the possible endogeneity of diabetes nor selection bias when estimating the eﬀects on income.

**2.5 Conclusion**

This review has provided an updated and considerably expanded picture of the literature on the global economic impact of type 2 diabetes. The results show a considerable impact of diabetes in terms of costs to society, health sys-tems, individuals and employers and in terms of a reduction in the productive

workforce and productivity in general. Studies on the costs of diabetes now provide evidence from HICs as well as LMICs, using a variety of study designs to estimate the costs of diabetes. The evidence indicates a particularly strong and direct economic impact of type 2 diabetes on people’s livelihoods in lower-income settings. Studies on labour market outcomes so far have been confined, almost exclusively, to HICs, leaving space for further studies in LMICs to pro-vide additional evidence of the eﬀect of diabetes in these countries. An issue not yet covered in diabetes  [COI](#page14) studies—in striking contrast to labour mar-ket outcome studies—has been the possible bias introduced by endogeneity, providing an opportunity for advancing research in this area.

* **The Impact of Diabetes on Employment in Mexico**

**Pre-amble**

The systematic review in Chapter  [2](#page28) identified a paucity of studies on the labour market impact of diabetes in non-high-income countries (HICs). Further, even studies on HICs did not provide much information regarding the heterogeneity of eﬀects accross diﬀerent socioeconomic subgroups. There was no evidence on how diabetes may aﬀect those in the formal compared to the informal labour market or across the wealth distribution. Further, it was unclear what the eﬀects were for people unaware of their disease. Chapters  [3](#page74) and  [4](#page101) therefore investigate the labour market impact of diabetes in a more comprehensive way than previous literature.

This study will use cross-sectional data from a large household survey in Mexico, assessing the impact of diabetes on employment probabilities. An instrumental variable  [(IV)](#page14) strategy inspired by preceding studies from HICs is used to account for the potential endogeneity of diabetes due to unobserved heterogeneity. Especially personal characteristics such as ambition and family background could aﬀect both the probability to develop diabetes, in particular type 2 diabetes, and the probability to be employed. The aim is to investigate if diabetes has a causal eﬀect on employment probabilities and to provide evi-dence for the subgroup of those in the informal labour market and the relatively poor, populations of particular relevance in middle-income countries (MICs).

**Abstract**

This study explores the impact of diabetes on employment in Mex-ico using data from the Mexican Family Life Survey  [(MxFLS)](#page15) (2005), taking into account the possible endogeneity of diabetes via an instru-mental variable estimation strategy. We find that diabetes significantly decreases employment probabilities for men by about 10 percentage points (p<0.01) and somewhat less so for women—4.5 percentage points (p<0.1)—without any indication of diabetes being endogenous. Further analysis shows that diabetes mainly aﬀects the employment probabilities of men and women above the age of 44 and also has stronger eﬀects on the poor than on the rich, particularly for men. We also find some indi-cation for more adverse eﬀects of diabetes on those in the large informal labour market compared to those in formal employment. Our results highlight—for the first time—the detrimental employment impact of di-abetes in a developing country.

**3.1 Introduction**

Diabetes, similar to other conditions that have been coined ”diseases of af-fluence”, has traditionally been seen as mostly a problem of the developed, more aﬄuent countries. Only in recent years the awareness has been grow-ing of the sheer size of the problem in health terms (Hu,  [2011;](#page292) Yach et al.,  [2006](#page307)). Mexico is one example of a middle-income country that has seen dia-betes rates increase sharply over the last years, from about 7.5% in 2000 (Bar-quera, Campos-Nonato, et al.,  [2013)](#page283) to 12.6% in 2013 (International Diabetes Federation,  [2014](#page292)). The high prevalence of diabetes in Mexico reflects an epi-demiological transition from a disease pattern previously characterized by high mortality and infectious diseases to low-mortality rates and non-communicable diseases  [(NCDs)](#page15) aﬀecting predominantly adults (Stevens et al.,  [2008](#page304)). This transition has likely been reinforced by nutritional changes away from a tradi-tional diet towards an energy dense, but nutritionally poor diet with an increas-ing amount of processed foods and sugars (Barquera, Hernandez-Barrera, et al.,  [2008;](#page283) Basu et al.,  [2013;](#page283) Rivera, Barquera, González-Cossío, et al.,  [2004),](#page300) a reduction in physical activity, as well as what appears to be a particular genetic predisposition of many Mexicans to develop type 2 diabetes (Williams et al.,  [2014](#page306)). While many of the high-income countries may be in a position to cope resource-wise with the health care consequences of diabetes, this will be less so the case for Mexico and other low- and middle-income countries (LMICs). The

most recent "cost-of-illness" estimates put the costs of diabetes to the Mexi-can society at more than US$778 million in 2010, with a large part of these costs being paid out-of-pocket (Arredondo and De Icaza,  [2011b](#page282)). While the above includes some estimate of indirect costs, meant to capture the cost bur-den attributable to foregone productivity resulting from diabetes, there exists no rigorous, econometric assessment of the eﬀect of diabetes on employment chances for Mexico, as the research has thus far focused on high-income coun-tries (Bastida and Pagán,  [2002;](#page283) Brown, Pagán, et al.,  [2005;](#page285) Latif,  [2009;](#page294) Lin,  [2011;](#page295) Minor,  [2011a;](#page296) Vijan et al.,  [2004;](#page305) Zhang, Zhao, et al.,  [2009](#page308)).

There are several reasons to expect a significant adverse eﬀect of diabetes on employment chances in Mexico and that this eﬀect might be stronger than in high-income countries. In Mexico type 2 diabetes is increasingly aﬀecting people in their productive age, raising the possibility that a larger share of people with diabetes will have to cope with debilitating complications already relatively early in life (Barquera, Campos-Nonato, et al.,  [2013;](#page283) Villalpando et al.,  [2010](#page305)). Further, only a minority of Mexicans appears to successfully manage their diabetes condition, with as much as 70% of the people with diabetes having poor control over their disease (Villalpando et al.,  [2010](#page305)). In addition, many Mexicans are working in the large informal economy1, possibly limiting their access to quality health care and hence to appropriate treatment options. All these factors are likely to both increase the risk of developing debilitating diabetes complications as well as to reduce productivity as a result. Against this background, the aim of this study is to investigate how diabetes aﬀects employment probabilities in a middle-income country such as Mexico. To the best of our knowledge this is the first such paper on Mexico and indeed on any  [LMIC.](#page14) We also investigate if the impact of diabetes on employment chances diﬀers across age groups and—again for the first time in this field—by wealth, as well as between those formally and informally employed.

The majority of the more recent studies on the labour market impact of diabetes tried to account for the possible endogeneity of diabetes using family history of diabetes as an instrument. Endogeneity might arise due to reverse causality: employment status and its eﬀect on a person’s lifestyle may also influence the odds of developing diabetes. A job with long oﬃce working hours might push a person’s diet or exercise pattern towards a more unhealthy and sedentary lifestyle due to reduced leisure time, increasing the person’s risk

* In 2005 around 58% of the working population in Mexico were employed in the informal sector (Aguila et al.,  [2011](#page281)).

for diabetes. In addition, unobserved factors, such as personal traits, could simultaneously influence a person’s employment as well as his or her diabetes status and introduce an omitted variable bias. A less ambitious person could be less productive in a job, increasing the risk of being laid oﬀ, and he or she could simultaneously have only modest, if any, exercise goals or healthy eating habits, thereby increasing the chances of developing diabetes.

Brown, Pagán, et al.  [(2005)](#page285) estimated the impact of the disease on employ-ment in 1996–1997 in an older population of Mexican Americans in the USA close to the Mexican border, using a recursive bivariate probit model. They found diabetes to be endogenous for women but not for men. The results of the IV estimation suggested no significant eﬀect on women which, compared to the adverse eﬀect found in the probit model, indicated an overestimation of the eﬀect for women when endogeneity was not accounted for. For men, the pro-bit estimates showed a significant adverse eﬀect of about 7 percentage points. Latif  [(2009)](#page294) estimated the eﬀect of the disease on employment probabilities in Canada in 1998. Contrary to Brown, Pagán, et al.  [(2005),](#page285) he found diabetes to be exogenous for females and endogenous for males; taking this into account he obtained a significant negative impact on the employment probabilities for women, but not for men. Because the simple probit model showed a significant negative eﬀect for males, Latif  [(2009)](#page294) concluded that not accounting for endo-geneity resulted in an overestimation of the eﬀect on male employment chances. Minor  [(2011a)](#page296) investigated the eﬀect of diabetes on female employment, among other outcomes, in the USA in 2006. This particular study diﬀered from earlier work in that it not only analysed the eﬀects of diabetes in general, but also of type 1 and type 2 diabetes separately. The study found diabetes to be endoge-nous and underestimated if exogeneity was assumed. In the IV estimates, type 2 diabetes had a significant negative eﬀect on female employment chances. For Taiwan, Lin  [(2011)](#page295) found diabetes to be endogenous, with the IV results show-ing significant changes in the employment eﬀect of diabetes. The impact was found to be significantly negative for men in the IV model indicating an un-derestimation in the standard probit model, where the diabetes coeﬃcient was also significant but much smaller in size. For women, no significant eﬀect was found in the IV estimation after the probit model had indicated a significant and negative impact of diabetes.

Accordingly, at least in some cases, there seems to be the risk of biased esti-mates of the impact of diabetes on employment, when exogeneity is assumed, with an a priori ambiguous bias. Hence, our decision in this study to also as-

sess if diabetes is endogenous and how precisely taking account of endogeneity might aﬀect the estimates. In order to account for this possible endogeneity we use data from the second wave of the Mexican Family Life Survey  [(MxFLS](#page15)) from 2005, which not only provides information on people’s diabetes status and socioeconomic background, but also on parental diabetes, enabling us to construct an instrumental variable similar to what has been used in the previ-ous literature on high-income countries.2 The data also allows the extension of the analysis to test if the inclusion of information on parental education as an additional control variable aﬀects the IV parameter estimates.

The remainder of the paper is structured as follows. Section  [3.2](#page78) provides details about the used dataset and the econometric specification; and section  [4.5](#page119) presents and discusses the empirical results. Section  [4.6](#page136) concludes.

**3.2 Methodology**

**3.2.1 Dataset and descriptive statistics**

The dataset used for the empirical analysis is the Mexican Family Life Sur-vey  [(MxFLS](#page15)). It is a nationally representative household survey which was conducted in 2002 and 2005. We use data from the second wave in 2005, which includes almost 40,000 individuals. Interviews were conducted with all household members aged 15+, and information on a wide range of social, de-mographic, economic and health related topics was collected (Rubalcava and Teruel,  [2008](#page301)). While there are more recent datasets available on Mexico, none of these provide as extensive information on parental characteristics as does the  [MxFLS](#page15) which includes information on parental diabetes and education status, even if parents were not alive anymore or were living in a non-surveyed house-hold at the time of the survey. Diabetes is self-reported and 3.7% of males and 5.1% of females report a diagnosis by a doctor.3 Unfortunately we cannot—

* Studies that have used the family history of diabetes as an instrument for diabetes are Brown, Pagán, et al.  [(2005)](#page285) for a Mexican-American community, Latif  [(2009)](#page294) for Canada, Minor  [(2011a)](#page296) for females in the USA and Lin  [(2011)](#page295) for Taiwan.
* This is well below the estimated prevalence rate for 2013 of almost 12%. This is likely due to the fact that, according to the International Diabetes Federation  [(IDF),](#page14) more than half of the people with diabetes in Mexico are undiagnosed and consequently did not report it (International Diabetes Federation,  [2014](#page292)). Further, the sample in the survey at hand is restricted to people between the age of 15 to 64, which does not match exactly with the population the IDF used for the diabetes prevalence estimates (20 – 79). Hence, our used sample includes a greater share of young people with a very low diabetes prevalence and excludes people above 64 years of age, which likely have a higher than average prevalence rate. Taken together, this—as well as a further increase in prevalence since

with the data at hand—distinguish between the diﬀerent types of diabetes. It can be assumed, however, that about 90% of the reported diagnoses are due to type 2 diabetes, which is by far the most common type of diabetes (Sicree et al.,  [2011](#page303)). The sub-sample used for analysis is limited to the age group of 15 to 64 years, which represents the majority of the working population. To allow for heterogeneity in the coeﬃcients across gender, the sample has been split to estimate the male and female groups separately.

2005—should explain the diﬀerence between the diabetes prevalence in our sample and the one estimated by the  [IDF](#page14).

Table 7: Summary statistics for males and females with and without diabetes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Males |  |  | Females |  |
|  | Mean with diabetes | Mean without diabetes | p (t-test) | Mean with diabetes | Mean without diabetes | p (t-test) |
|  |  |  |  |  |  |  |
| Employed | 0.714 | 0.804 | 0.000 | 0.229 | 0.313 | 0.000 |
| Age | 50.945 | 35.016 | 0.000 | 48.955 | 34.717 | 0.000 |
| Age 15–24 | 0.008 | 0.294 | 0.000 | 0.036 | 0.282 | 0.000 |
| Age 25–34 | 0.043 | 0.232 | 0.000 | 0.076 | 0.250 | 0.000 |
| Age 35–44 | 0.161 | 0.196 | 0.162 | 0.180 | 0.221 | 0.042 |
| Age 45–54 | 0.392 | 0.166 | 0.000 | 0.366 | 0.159 | 0.000 |
| Age 55–64 | 0.396 | 0.111 | 0.000 | 0.342 | 0.089 | 0.000 |
| Rural | 0.337 | 0.399 | 0.047 | 0.391 | 0.399 | 0.723 |
| Small city | 0.082 | 0.126 | 0.038 | 0.144 | 0.123 | 0.204 |
| City | 0.145 | 0.102 | 0.028 | 0.103 | 0.098 | 0.737 |
| Big city | 0.435 | 0.372 | 0.042 | 0.362 | 0.379 | 0.475 |
| Southsoutheast | 0.208 | 0.203 | 0.864 | 0.184 | 0.206 | 0.270 |
| Central | 0.243 | 0.184 | 0.017 | 0.231 | 0.195 | 0.062 |
| Westcentral | 0.173 | 0.213 | 0.124 | 0.191 | 0.210 | 0.343 |
| Northeastcentral | 0.196 | 0.177 | 0.446 | 0.209 | 0.186 | 0.236 |
| Northwestcentral | 0.180 | 0.223 | 0.112 | 0.184 | 0.202 | 0.355 |
| No education | 0.090 | 0.062 | 0.070 | 0.151 | 0.081 | 0.000 |
| Primary | 0.518 | 0.352 | 0.000 | 0.607 | 0.368 | 0.000 |
| Secondary | 0.231 | 0.308 | 0.009 | 0.171 | 0.314 | 0.000 |
| Highschool | 0.059 | 0.158 | 0.000 | 0.043 | 0.138 | 0.000 |
| College or university | 0.102 | 0.120 | 0.379 | 0.029 | 0.098 | 0.000 |
| Indigenous | 0.137 | 0.121 | 0.448 | 0.133 | 0.118 | 0.341 |
| Married | 0.812 | 0.535 | 0.000 | 0.663 | 0.539 | 0.000 |
| Children (under 15) | 1.118 | 1.510 | 0.000 | 1.207 | 1.600 | 0.000 |
| Wealth | 0.179 | -0.010 | 0.003 | 0.004 | -0.003 | 0.885 |
| Diabetes | 1.000 | 0.000 | . | 1.000 | 0.000 | . |
| Diabetes father | 0.180 | 0.071 | 0.000 | 0.146 | 0.079 | 0.000 |
| Diabetes mother | 0.251 | 0.107 | 0.000 | 0.236 | 0.113 | 0.000 |
| Education parents | 0.596 | 0.697 | 0.001 | 0.528 | 0.699 | 0.000 |
| Formal employment | 0.286 | 0.306 | 0.508 | 0.083 | 0.140 | 0.001 |
| Informal employment | 0.529 | 0.560 | 0.342 | 0.191 | 0.220 | 0.155 |
|  |  |  |  |  |  |  |
| N | 255 | 6031 |  | 445 | 7798 |  |
|  |  |  |  |  |  |  |

The descriptive statistics presented in Table  [7](#page80) suggest that the groups of respondents with and without diabetes diﬀer significantly in various aspects. Both males and females with diabetes have a lower employment rate than their counterparts. This would suggest that diabetes has a negative impact on the employment chances of both males and females with diabetes. However, since the groups with diabetes are also significantly older and diﬀer in terms of education, this may be a spurious relationship. As a result, only a multivariate analysis will provide more reliable information on how diabetes truly aﬀects employment probabilities.

**3.2.2 Econometric specification**

We first estimate a probit model with the following specification

|  |  |
| --- | --- |
| *Employedi* = *β*0+ *β*1*Diabetesi* + *β*2*Xi* + *ui* | (3.1) |

where diabetes is assumed to be exogenous. *Employedi* takes the value of 1 if person *i* is employed and 0 if unemployed. Employment status is defined as having worked or carried out an activity that helped with the household expenses for at least ten hours over the last week. This explicitly includes those employed informally, for instance people working in a family business.

*Diabetesi* denotes the main independent variable of interest, taking the valueof 1 if individual *i* has reported a diagnosis of diabetes and 0 otherwise.

*Xi* contains various control variables. Because no information on job historyis available in the data to adequately account for work experience, we need to rely on the combination of age and education to proxy for work experience (Aaronson,  [2010](#page281)). The eﬀect of age is captured through dummy variables for age intervals. Education is taken into account by dummy variables indicating if the highest level of schooling attained was either primary school, secondary school, high school, university or some other form of higher education with no education serving as the reference category, to control for the impact of education on employment and to account for the relationship between diabetes and education (Agardh et al.,  [2011](#page281)).

Since Mexico is a large and diverse country with regional socioeconomic diﬀerences we also include dummies for five diﬀerent Mexican regions4. Apart

4The region variables have been constructed after recommendations on the MxFLS-Homepage. South-southeastern Mexico: Oaxaca, Veracruz, Yucatan; Central Mexico: Federal District of Mexico, State of Mexico, Morelos, Puebla; Central northeast Mexico: Coahuila, Durango, Nuevo Leon; Central western Mexico: Guanajuato, Jalisco, Michoa-

from the more obvious eﬀects economic diﬀerences between regions can have on employment chances and diabetes through their impact on employment opportunities and lifestyles, the dummies should also account for less obvious eﬀects that macroeconomic problems, such as a high unemployment rate, could have on employment chances and diabetes by aﬀecting psychological well-being and sleeping patterns (Antillón et al.,  [2014](#page282)). Because diﬀerences in economic opportunities and lifestyles should also be expected between rural and urban areas, three dummy variables are included to capture the eﬀects these factors might have on employment chances and diabetes, with living in a rural area being the reference category5 (Villalpando et al.,  [2010](#page305)). Further, to control for labour market discrimination and possible diﬀerences in genetic susceptibility to diabetes of indigenous populations (Yu and Zinman,  [2007),](#page307) a dummy for being a member of an indigenous group is included. We also account for for the marital status to control for the impact of marriage on employment chances and lifestyle habits. Further a variable capturing the number of children residing in the household below the age of 15 is inlcuded, to control for their impact on employment chances and for the eﬀect of childbearing and related gestational diabetes on the probabilities of women to develop type 2 diabetes (Bellamy et al.,  [2009](#page284)).

To account for the eﬀect that household wealth might have on diabetes and employment chances, we use the well established method of principal compo-nent analysis of multiple indicators of household assets and housing conditions to create an indicator for household wealth (Filmer and Pritchett,  [2001](#page290)). Our composite wealth index consists of owning a vehicle, owning a house or other real estate, owning another house, owning a washing machine, dryer, stove, refrigerator or furniture, owning any electric appliances, owning any domestic appliances, owning a bicycle and owning farm animals. It further accounts for the physical condition of the house, proxied by the floor material of the house, and the type of water access.

The error term is denoted as *ui*. We do not control for the general health status and other diabetes related chronic diseases as they are likely determined by diabetes itself and, hence, could bias the estimates and compromise a causal interpretation of the eﬀect of diabetes on employment (Angrist and Pischke,  [2009](#page281)).

can; Northwest Mexico: Baja California Sur, Sinaloa, Sonora.

* Rural: < 2,500 inhabitants; Small city: 2,500 to 15,000 inhabitants; City: 15,000 to 100,000 inhabitants; Big city: > 100,000 inhabitants.

As diabetes could be endogenous, the probit model might deliver biased estimates. Therefore we employ an IV strategy, using a bivariate probit model to estimate the following two equations simultaneously:

|  |  |
| --- | --- |
| *Diabetesi* = *δ*0+ *δ*1*Xi* + *δ*2*diabetesmotheri* + *δ*3*diabetesfatheri* + *ηi* | (3.2) |
| *Employedi* = *β*0+ *β*1*Diabetesi* + *β*2*Xi* + *ui* | (3.3) |

In equation  [3.2,](#page83) *Diabetesi* is a dummy variable and is modelled as a function of the same socioeconomic and demographic factors *Xi* as in equation  [3.1](#page81) and of the instrumental dummy variables *diabetesmotheri* and *diabetesfatheri*, in-dicating if the father or the mother had been diagnosed with diabetes. The error term is denoted as *ηi*. Equation  [4.2](#page114) is identical to the probit specification (equation  [3.1)](#page81) and estimates the eﬀect of diabetes on employment, now taking into account the possible endogeneity of diabetes. Diabetes is exogenous if the error terms of both equations are independent of each other (*Cov*(*uiηi*) = 0). Endogeneity is tested using a likelihood ratio test based on the idea that if *Cov*(*uiηi*) = 0, the log-likelihood for the bivariate probit will be equal to thesum of the log-likelihoods from the two univariate probit models (Knapp and Seaks,  [1998](#page293)). If *ui* and *ηi* are correlated, the estimation of equation  [3.1](#page81) using a probit model will not provide consistent estimates of the impact of diabetes on employment. In this case the simultaneous estimation of both equations using the bivariate probit should be preferred. For the estimation of the bivariate probit model it is assumed that *ui* and *ηi* are distributed randomly and bivariate normal. To test the assumption of normality, we use Murphey’s goodness-of-fit score test with the null-hypothesis of bivariate normally distributed errors, as suggested by Chiburis et al.  [(2012](#page287)).6

We choose the bivariate probit model over the linear IV model to account for endogeneity, as there is evidence that it performs better if the sample is relatively small (<5,000) and—more important in our case—when treatment probabilities are low. In such cases the linear IV can produce uninformative estimates while the bivariate probit model has been shown to provide much more reasonable results (Chiburis et al.,  [2012](#page287)). Because only 4% of males

6Murphey’s score test ”. . . embeds the bivariate normal distribution within a larger family of distributions by adding more parameters to the model and checks whether the additional parameters are all zeros using the score for the additional parameters at the bivariate probit estimate.” (Chiburis et al.,  [2012,](#page287) p. 19).

and 5.4% of females report a diagnosis of diabetes, treatment probabilities are indeed low in the given case, providing good justification for the use of the bivariate probit model.

In order to fulfil the conditions of a valid instrument, parental diabetes needs to impact the diabetes risk of the oﬀspring while at the same time being unre-lated to the oﬀspring’s employment chances. It has been shown that there is a strong hereditary component of type 2 diabetes which predisposes the oﬀspring of people with diabetes to develop the condition as well (Herder and Roden,  [2011;](#page291) The Interact Consortium,  [2013](#page304)). This is supported by the notion that genes seem to play a crucial role, besides the recent epidemiological transition and the migration from rural to urban areas, in explaining Mexico’s high di-abetes prevalence according to a recent study by Williams et al.  [(2014](#page306)). The authors identified a specific gene particularly prevalent in Mexican and other Latin American populations with native American ancestry, which is associated with a 20% increase in the risk of developing type 2 diabetes. Furthermore, research has shown that parental lifestyle factors, socioeconomic background as well as parental body mass index  [(BMI)](#page14) can explain but a very small fraction of the increased risk of type 2 diabetes in the oﬀspring, which is why we assume that the increased risk is mainly due to genetic factors unrelated to lifestyle (Herder and Roden,  [2011;](#page291) The Interact Consortium,  [2013](#page304)). This is supported by Hemminki et al.  [(2010),](#page291) who find that adoptees whose biological parents had type 2 diabetes, had an increased risk of developing type 2 diabetes even though they were living in a diﬀerent household, while if their adopted parents had the disease, they had no elevated risk.

Nonetheless, there might still be the chance that parental diabetes decreases the oﬀspring’s employment chances. The additional financial burden of dia-betes or an early death due to diabetes could have prevented the parents from investing in their children’s education the way they would have liked to or it could have led to the child dropping out of school in order to support the family. However, controlling for education should account for these eﬀects if they exist. Therefore parental diabetes should be a valid instrument which predicts diabetes while not aﬀecting employment probabilities through other unobserved pathways. To further improve instrument validity we also account for the possibility that parental education is simultaneously correlated with the parental diabetes status as well as their children’s employment chances, by including a dummy variable indicating if any of the parents had attained more than primary education.

A possible limitation of using parental diabetes as our instrument is that it might directly aﬀect the oﬀspring’s employment decision through other path-ways than education. Conceivably, diabetes might deteriorate parental health in such a way that the oﬀspring has or had to give up its own employment in order to care for its parents or is forced to take up work to financially provide for the parents. With the data at hand we are unable to account for this, but if this eﬀect exists it should be picked up by the overidentification test.

We also estimate the linear IV model as it is consistent even under non-normality (Angrist and Pischke,  [2009](#page281)). The linear IV model takes the following form of a first (Equation  [3.4)](#page85) and a second stage (Equation  [3.5](#page85)).

|  |  |
| --- | --- |
| *Diabetesi* = *π*0+ *π*1*Xi* + *π*2*diabetesmotheri* + *π*3*diabetesfatheri* + *ηi* | (3.4) |
| *Employedi* = *β*0+ *β*1*Diabetesi* + *β*2*Xi* + *ui* | (3.5) |

In the second stage, the potentially endogenous actual diabetes values are re-placed with the predicted values from the first stage. The covariates are the same as in the bivariate probit case described in equations  [3.2](#page83) and  [4.2.](#page114) In the linear IV model the Hausman test is used to identify endogeneity. Validity of the instruments is tested using first stage diagnostics of the linear IV model, as similar tests are not available for the bivariate probit model. Average marginal eﬀects are presented for the probit and bivariate probit models.

**3.3 Results**

This section presents the estimation results using 1) a probit model model that assumes diabetes to be exogenous and 2) IV models with parental diabetes as an instrument for diabetes, to determine if diabetes is endogenous or if instead the results from the probit model can be used.

**3.3.1 Probit results**

Table  [8](#page86) indicates that the eﬀect of diabetes is negative for both sexes. For males, it reduces the probability of being employed by 10 percentage points (p<0.01).

Table 8: Impact of diabetes on employment probabilities (probit)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) |  | (2) |  |
|  | Males |  | Females |  |
|  |  |  |  |  |
| Age 25–34 | 0.124∗∗∗ | (.011) | 0.121∗∗∗ | (.017) |
| Age 35–44 | 0.133∗∗∗ | (.012) | 0.232∗∗∗ | (.018) |
| Age 45–54 | 0.085∗∗∗ | (.014) | 0.170∗∗∗ | (.022) |
| Age 55–64 | −.034 | (.020) | 0.039 | (.026) |
| Small city | −.013 | (.017) | 0.043∗∗ | (.020) |
| City | −.036∗ | (.019) | 0.042∗∗ | (.021) |
| Big city | 0.029∗∗ | (.013) | 0.101∗∗∗ | (.014) |
| Central | 0.027 | (.015) | −.032∗ | (.018) |
| Westcentral | 0.020 | (.015) | −.008 | (.018) |
| Northeastcentral | 0.003 | (.016) | −.053∗∗∗ | (.017) |
| Northwestcentral | −.037∗∗ | (.016) | −.100∗∗∗ | (.016) |
| Primary | 0.056∗∗∗ | (.020) | −.006 | (.022) |
| Secondary | 0.051∗∗ | (.021) | 0.058∗∗ | (.025) |
| Highschool | 0.040∗ | (.023) | 0.126∗∗∗ | (.029) |
| College or university | 0.047∗∗ | (.023) | 0.297∗∗∗ | (.033) |
| Indigenous | 0.005 | (.016) | −.005 | (.020) |
| Married | 0.092∗∗∗ | (.012) | −.231∗∗∗ | (.012) |
| Children (under 15) | 0.010∗∗ | (.004) | −.018∗∗∗ | (.004) |
| Wealth | 0.002 | (.006) | 0.037∗∗∗ | (.007) |
| Education parents | −.007 | (.013) | 0.000 | (.013) |
| Diabetes | −.100∗∗∗ | (.029) | −.045∗ | (.023) |
| Log likelihood | −2897.807 |  | −4508.573 |  |
| N | 6286 |  | 8243 |  |

Average marginal eﬀects; robust standard errors in parentheses. \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01

For females, the eﬀect is also negative but smaller, and shows a reduction in employment probabilities of about 4.5 percentage points (p<0.1).

The other covariates largely show the expected relationships. Employability increases with age and is highest for the 35–44 years age group. Especially for women, living in a more urban environment increases employment chances compared to women living in rural areas. Also, women seem to benefit sub-stantially from higher education in terms of employment chances. For men the eﬀects of education are also positive, though, not as marked as for women. Perhaps surprisingly, being part of an indigenous population does not aﬀect employment probabilities, neither for males or females.

The probit results suggest a significant negative eﬀect of diabetes on the employment probabilities of males and likely also females in Mexico. In light of the concern that diabetes could be endogenous the following section presents the results of the IV estimations.

**3.3.2 IV results**

Using the bivariate probit model, the diabetes coeﬃcient for males increases in size and remains negative whereas for females it decreases but also remains negative. However, standard errors increase in both models and the results turn insignificant, suggesting considerable loss of eﬃciency (see Table 9). The likelihood-ratio test does not reject the null hypothesis of no correlation be-tween the disturbance terms of equations  [3.2](#page83) and  [4.2](#page114) for males and females, suggesting exogeneity of diabetes. The test for normality of the error term does not reject the null hypothesis of normality for the male and the female model, increasing our confidence in the estimates. Nonetheless we also con-sider the results of the linear IV model: the test statistics indicate suﬃciently strong and valid instruments, as shown by the Kleibergen-Paap Wald F statis-tic for weak instruments of 20.48 for men and 27.71 for women, being above the critical value of 19.93 for ten  [%IV](#page14) size and well above the rule of thumb of 10 for weak identification not to be considered a problem (Baum et al.,  [2007](#page283); Staiger and Stock,  [1997](#page304)). The Sargan test does not reject the null hypothe-sis of instruments uncorrelated with the error term and instruments correctly excluded from the estimated equation. The coeﬃcients of the linear IV model are very diﬀerent from the bivariate probit model, turning positive for males and females, but also very imprecise as indicated by the large standard errors (see Table  [10](#page90) displaying the main results and Table  [32](#page249) presenting the complete

Table 9: Impact of diabetes on employment probabilities (bivariate probit)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) |  | (2) |  |
|  | Males |  | Females |  |
|  |  |  |  |  |
| Age 25–34 | 0.125∗∗∗ | (.012) | 0.109∗∗∗ | (.015) |
| Age 35–44 | 0.134∗∗∗ | (.012) | 0.207∗∗∗ | (.016) |
| Age 45–54 | 0.089∗∗∗ | (.016) | 0.149∗∗∗ | (.021) |
| Age 55–64 | −.025 | (.025) | 0.032 | (.029) |
| Small city | −.014 | (.017) | 0.039∗∗ | (.018) |
| City | −.035∗∗ | (.018) | 0.038∗∗ | (.019) |
| Big city | 0.030∗∗ | (.013) | 0.093∗∗∗ | (.013) |
| Central | 0.027 | (.018) | −.030∗ | (.015) |
| Westcentral | 0.019 | (.018) | −.007 | (.016) |
| Northeastcentral | 0.002 | (.018) | −.049∗∗∗ | (.017) |
| Northwestcentral | −.038∗∗ | (.017) | −.091∗∗∗ | (.015) |
| Primary | 0.057∗∗∗ | (.020) | −.006 | (.021) |
| Secondary | 0.052∗∗ | (.023) | 0.052∗∗ | (.022) |
| Highschool | 0.040 | (.025) | 0.113∗∗∗ | (.027) |
| College or university | 0.046∗ | (.025) | 0.273∗∗∗ | (.032) |
| Indigenous | 0.006 | (.017) | −.005 | (.016) |
| Married | 0.093∗∗∗ | (.012) | −.215∗∗∗ | (.011) |
| Children (under 15) | 0.010∗∗ | (.004) | −.016∗∗∗ | (.004) |
| Wealth | 0.002 | (.006) | 0.033∗∗∗ | (.007) |
| Parental education | −.006 | (.013) | 0.000 | (.012) |
| Diabetes | −.185 | (.143) | −.021 | (.108) |
| Instruments |  |  |  |  |
| Diabetes father | 0.048∗∗∗ | (.011) | 0.041∗∗∗ | (.010) |
| Diabetes mother | 0.037∗∗∗ | (.008) | 0.054∗∗∗ | (.008) |
| Log likelihood | −3737.766 |  | −5939.588 |  |
| Score goodness-of-fit (H0=normality of errors) | 12.32 |  | 8.85 |  |
| p value | 0.196 |  | 0.451 |  |
| Endogeneity (H0: Diabetes exogeneous) | 0.443 |  | 0.039 |  |
| p value | 0.506 |  | 0.844 |  |
| N | 6286 |  | 8243 |  |

*Notes* Average marginal eﬀects; robust standard errors in parentheses. The presented coeﬃcients andstandard errors for the instruments result from the estimation of the model specified in Equation II, indicating the eﬀect of parental diabetes on a person’s diabetes risk. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

first and second stage estimates). As mentioned before, Chiburis et al.  [(2012](#page287)) show that the estimates of the linear IV model are likely to be imprecise when low treatment probabilities exist and can diﬀer substantially from the bivariate probit model, which seems to be the case here.7 Since the linear IV models fail to reject exogeneity of diabetes as well, we are confident that the standard probit model provides unbiased and eﬃcient estimates of the eﬀect of diabetes on employment chances in Mexico and should therefore be used for inference.

The next section investigates the eﬀects of diabetes for two diﬀerent age groups, 15–44 and 45–64, to explore whether, and if so, how the eﬀect of dia-betes on employment chances diﬀers between older and younger people. There might be reason to believe that diabetes has a more adverse eﬀect in older age groups, when those suﬀering from diabetes are likely to have accumulated more years lived with diabetes, and hence are more likely to develop complications.

* It could also be the case that the diﬀerence in estimates is due to the fact that while the bivariate probit model estimates the average treatment eﬀect  [(ATE)](#page14) of the variable of interest for the whole sample, the linear IV model estimates the local average treatment eﬀect  [(LATE),](#page14) which estimates the eﬀect of diabetes on employment only for those that have diabetes and whose parents have or have had diabetes as well. Therefore, the estimates of both models can be diﬀerent (Angrist and Pischke,  [2009;](#page281) Chiburis et al.,  [2012](#page287)).

Table 10: Impact of diabetes on employment probabilities (linear IV)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) |  | (2) |  |
|  | Males |  | Females |  |
|  |  |  |  |  |
| Diabetes | 0.098 | (.215) | 0.239 | (.214) |
|  |  |  |  |  |
| R2 | 0.067 |  | 0.120 |  |
| F stat (H0: weak instruments) | 20.483 |  | 27.706 |  |
| Sargan test (H0: valid instruments) | 0.862 |  | 0.295 |  |
| p value | 0.353 |  | 0.587 |  |
| Endogeneity (H0: Diabetes exogenous) | 0.864 |  | 1.796 |  |
| p value | 0.353 |  | 0.180 |  |
| N | 6286 |  | 8243 |  |

*Notes* Robust standard errors in parentheses. Instruments: diabetes of mother, diabetesof father. Other control variables: age, region, urban, education, indigenous, marital status, children, wealth, parental education. Critical values for weak identification test F statistic: 10% maximal IV size 19.93, 15% maximal IV size 11.59, 20% maximal IV size 8.75, 25% maximal IV size 7.25. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**3.3.3 Diﬀerences by age groups**

When divided into an older and younger age group using the cut-oﬀ point of 45 years, the negative eﬀect of diabetes is mainly found in the older age group, for males and females alike (see Table  [11),](#page92) where 12.5% report having diabetes, compared to only 1.7% in the younger age group. The probability of being employed is reduced by about 10 percentage points for men between 45 and 64 years at the 1% significance level, while there is no significant eﬀect on younger men. For women, the employment probability is reduced by about 6 percentage points, with the eﬀect being significant at the 5% level. Similar to men, there is no eﬀect of diabetes on younger women. To investigate in more detail for which age group the eﬀect is strongest, we run separate regressions for both age groups above 44 years. The results (Table  [33)](#page251) show that for men the strongest eﬀect appears in the oldest age group (i.e. 55–64 years), where employment chances are reduced by almost 13 percentage points. For females, a significant eﬀect is found solely for those between 45 and 54 years, where employment chances are reduced by 7.6 percentage points. Hence, there appear to be relevant diﬀerences between males and females in the age at which the biggest adverse eﬀect of diabetes on employment chances occurs.

The use of IV methods in the age stratified samples is compromised due to a reduction in instrument power, sample size and particularly treatment prob-abilities. Especially for the younger age group, where treatment probabilities are close to zero, a meaningful interpretation of the IV results is diﬃcult. Fur-ther, because no endogeneity was found in the pooled samples for males and females presented in section  [3.3.2,](#page87) we would not expect endogeneity of diabetes in the age stratified samples. We nonetheless test for the possibility of diabetes being endogenous using the bivariate probit model and an approach suggested by Lewbel  [(2012),](#page294) to improve instrument strength (see Table  [35](#page256) and Table  [36](#page257)).

Table 11: Impact of diabetes on employment probabilities by age group (probit)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | 15-44 | 45-64 | | |  |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Males | Females |  | Males | Females | |
|  |  |  |  |  |  | |
| Diabetes | −.009 | −.004 |  | −.110∗∗∗ | −.057∗∗ | |
|  | (.062) | (.042) | (.034) | | (.025) |  |
|  |  |  |  |  |  | |
| Log likelihood | −1987.285 | −3354.003 |  | −925.409 | −1167.491 | |
| N | 4415 | 5997 | 1871 | | 2246 |  |

*Notes* Average marginal eﬀects; robust standard errors in parentheses. Forthe younger age group, the model contains the age categories 25–34 and 35– 44 with 15–24 as the reference category. For the older age group, the model contains the age category 55–64 with 45–54 as the reference category. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**3.3.4 Diﬀerences by wealth**

To explore the heterogeneity of the eﬀect of diabetes on employment across diﬀerent levels of wealth, we divide the sample into two wealth groups at the 50th percentile of our constructed wealth index.

We run separate regressions for both groups stratified by gender, finding the strongest negative eﬀect for less wealthy males, where employment chances are reduced by 15 percentage points, and a smaller and less significant eﬀect for less wealthy females (see Table  [12](#page94)). Whereas the coeﬃcients for wealthier males and females have a negative sign, they are not significant at the 10% significance level. This indicates that mainly the less wealthy experience an adverse eﬀect from diabetes. To further explore this, we stratified the sample into wealth quartiles (see Table  [34),](#page253) finding that significant adverse eﬀects for males appear in the first and second wealth quartile, where employment chances are reduced by about 14 percentage points. For females a highly significant and strong eﬀect is only found in the poorest quartile, were employment chances are reduced by 10 percentage points. Together these results indicate that the impact of diabetes on employment chances varies with wealth, with men and women being more aﬀected when being in the lower wealth quartiles.

To consider the possible endogeneity of diabetes in the upper and lower wealth half, we again present the results of the IV models. The stratification into wealth groups significantly reduces instrument power as well as sample size. For none of the wealth groups the bivariate probit model indicates endogeneity (see Table  [37](#page259)). This does not change even when using the Lewbel approach to increase instrument strength and we therefore rely on the probit results for inference.

Table 12: Impact of diabetes on employment probabilities by wealth group (probit)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Poor | |  |  | Rich | |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Males | Females |  | Males | Females | |
|  |  |  |  |  |  | |
| Diabetes | −.150∗∗∗ | −.047∗ |  | −.060 | −.038 | |
|  | (.047) | (.027) | (.038) | | (.035) |  |
|  |  |  |  |  |  | |
| Log likelihood | −1459.235 | −2040.517 |  | −1408.746 | −2421.910 | |
| N | 3140 | 4091 | 3106 | | 4117 |  |

*Notes* Average marginal eﬀects; robust standard errors in parentheses.Othercontrol variables: region, urban, education, indigenous, marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**3.3.5 Diﬀerences by employment type**

To investigate the eﬀect of diabetes on the employment chances in the formal and informal labour market, respectively, we estimate separate models with being employed in the formal and informal sector as the respective dependent variables. We define formal employment on the basis of having a written labour contract. Informal employment is defined as working without a written contract or being self-employed.

For this investigation we use two restricted samples: for the estimation of the eﬀect of diabetes on informal employment we exclude those currently in formal employment and for the eﬀect of diabetes on formal employment we exclude those in informal employment from our sample. We further assume that those who have worked previously and are currently unemployed are looking for employment in the same sector, i.e. if they were previously employed in the informal (formal) labour market they are again looking for an informal (formal) employment. We therefore exclude those previously working in the informal (formal) labour market from our estimation of the eﬀect of diabetes on employment in the formal (informal) labour market. The respective sample thus only contains those currently working in the informal (formal) labour market, those previously employed in the informal (formal) labour market and those that have never worked before. Using this assumption allows the use of a normal probit model and the investigation of a possible endogeneity bias using IV techniques.

Admittedly, the assumption that the currently unemployed look for work in the same labour market they had previously worked in is quite strong and is likely not true for everybody. We therefore additionally estimate a multinomial logit model which is most useful if the decision to work is not binary but there are more than two choices, such as the choice of being either unemployed, employed in the informal or employed in the formal labour market (Wooldridge,  [2002](#page306)). Being unemployed is used as the reference category.

All estimated models (see Tables  [13](#page96) and  [39),](#page262) regardless of the estimation approach, indicate that diabetes significantly reduces the chances of being in informal employment, while it has no eﬀect on formal employment.8 This

* Please note, however, that the coeﬃcients of the multinomial logit and the probit model cannot be directly compared as they are based on diﬀerent assumptions. The former takes into account that a person can choose from more than two employment outcomes (i.e. being unemployed, being formally employed or being informally employed), while the latter only allows for a binary outcome without considering any other options (e.g. being unemployed or informally employed without considering the possibility of formal

Table 13: Impact of diabetes on employment probabilities by employment sta-tus (probit)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Males | |  | Females | | |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Informal | Formal |  | Informal | Formal | |
|  |  |  |  |  |  |  |
| Diabetes | −.063∗∗ | −.041 |  | −.051∗∗ | 0.019 |  |
|  | (.031) | (.043) | (.022) | | (.022) |  |
|  |  |  |  |  |  | |
| Log likelihood | −1780.023 | −1021.771 |  | −3818.588 | −1859.048 | |
| N | 4604 | 2204 | 6983 | | 5652 |  |

*Notes* Average marginal eﬀects; robust standard errors in parentheses.Othercontrol variables: region, urban, education, indigenous, marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

applies to both males and females. This indicates that people with diabetes are less likely to be working in the informal labour market relative to being unemployed, while there is no diﬀerence for those working in the formal labour market. We further find no indication of endogeneity (see Tables  [40](#page264) and  [41](#page265)). Overall, there seem to be strong diﬀerences in terms of the impact of diabetes on people in formal and informal employment, with diabetes having a stronger negative eﬀect for those without a written contract.

**3.4 Conclusion**

The contribution of this paper has been to analyse—for the first time for a  [LMIC—the](#page14) impact of diabetes on employment in Mexico, taking into account the potential endogeneity in the relationship between diabetes and employment chances. The presented results add to the growing literature on the adverse economic eﬀects of diabetes. They indicate that having diabetes substantially reduces the chances to work for men and likely also for women. Hence, diabetes may contribute to a reduction in the pool of the productive workforce available to the Mexican economy.

We have also shown that diabetes reduces employment chances particularly in older people, likely because in this age group people are more common to already have developed diabetes-related complications which reduce their pro-ductivity and eventually force them into unemployment. Further, particularly for men the eﬀects of diabetes on employment chances seem to be particularly strong when they belong to the poorer half of the population. While there might be some self-selection into the poorer group by those who lost their job due to diabetes and as a result descended into the lower wealth group, this finding is indicative of potentially substantial adverse equity impacts. This is also in line with our finding that diabetes reduces employment chances partic-ularly for the informally employed, whereas those in formal employment seem to be less aﬀected. Nonetheless, in order to establish causality more research in this area will be needed.

While in parts of the earlier literature diabetes was found to be exogenous only for either males or females (Brown, Pagán, et al.,  [2005;](#page285) Latif,  [2009),](#page294) our study found diabetes to be exogenous using the samples stratified into males and females, allowing the use of the more eﬃcient probit model to arrive at a consistent estimate of the eﬀect of diabetes on employment chances. Fur-

employment).

ther, we found no endogeneity of diabetes for the sample comprised of the age group above the age of 44, for the samples stratified into an upper and lower wealth half and for the samples stratified by employment type. For the younger age group the bivariate probit model only indicated exogeneity of di-abetes for males, while for females diabetes was shown to be endogenous and showing a significant positive eﬀect of diabetes on employment. This result is rather counterintuitive because there is no obvious reason why diabetes should increase employment chances. Because all samples stratified into age, wealth and employment groups suﬀered from reduced instrument strength which could cause biased IV estimates, we used a method proposed by Lewbel  [(2012)](#page294) to cre-ate additional instruments and increase instrument power. Using this method we no longer found a significant positive eﬀect of diabetes on female employ-ment chances in the younger age group and could not reject the assumption of exogeneity of diabetes in this sample. Also, for all other wealth, age and employment samples, the Lewbel IV method did not reject the assumption of exogeneity. We are therefore confident that we can rely on the probit estimates for inference.

Why was diabetes found to be exclusively exogenous in the Mexican case? We can only speculate on the potential reasons. Diabetes being exogenous seems to indicate that a person’s employment status might not have such a strong eﬀect on his or her diabetes risk through the potential pathways such as lifestyle changes. Rather, the rapid epidemiological transition experi-enced in Mexico over the last decades (Barquera, Hotz, et al.,  [2006;](#page283) Barquera, Hernandez-Barrera, et al.,  [2008;](#page283) Rivera, Barquera, Campirano, et al.,  [2002](#page300)) together with the heightened genetic susceptibility of Mexicans to diabetes (Williams et al.,  [2014),](#page306) seem to have increased the risk of developing diabetes in both employed and unemployed Mexicans.

Taking our results for the older age group and comparing them to those of Brown, Pagán, et al.  [(2005)](#page285) for the USA, whose sample of Mexican Americans 45 years and older might be the best suited for a meaningful comparison, our findings indicate a stronger negative impact of diabetes on males and partic-ularly females residing in Mexico.9 This finding lends some support to our hypothesis that the adverse impact of diabetes on employment could be larger in LMICs than in high-income countries. Comparing the study to Lin  [(2011](#page295))

* This is based on comparing our estimates to the appropriate models in Brown, Pagán, et al.  [(2005)](#page285) based on their test for endogeneity, which indicates the use of the bivariate probit results for women and the probit results for men.

for Taiwan, who also used a sample of people between 45 and 64 years of age, our results are similar in that a larger absolute eﬀect is found for males than for females. However, when compared to other studies in more developed coun-tries, with more advanced health systems and very diﬀerent populations, such as Latif  [(2009)](#page294) for Canada and Minor  [(2011a)](#page296) for women in the US, our results diﬀer in that they do find eﬀects for men and potentially also women.

While the results for women in the main analysis do not reach the levels of statistical significance that those for men do, the negative impact on women is supported by the subgroup analysis. When we take into account the lower overall female employment rates (31%) compared to men (80%), the absolute reduction in employment chances in women translates into a an even larger de-crease in absolute levels of over 16% compared to 12.5% for men. This suggests that diabetes aﬀects employment chances of both sexes were considerable.

A limitation of this study is the use of cross-sectional data, which does not allow for the use of fixed eﬀects and hence for the control of unobserved time-invariant heterogeneity. Data spanning a longer time period would be required to be able to observe changes in the diabetes and employment status which would allow the use of fixed eﬀects. A further limitation is the somewhat old data from 2005, which precedes the main implementation period of the public health insurance scheme called Seguro Popular. This should be taken into account when interpreting our results as the eﬀects might be diﬀerent today, where most Mexicans have access to some sort of health insurance (Knaul et al.,  [2012](#page293)). The presented results rather show the eﬀects of diabetes on employment chances in 2005 in an environment were insuﬃcient healthcare coverage was common for parts of the Mexican population. We nonetheless deliberately chose this particular data as it provided us with a sensible instrument in parental diabetes as well as an array of other socioeconomic information which—as far as we have been able to ascertain—is not provided by any other dataset in LMICs. Finally, due to data limitations, we were not able to investigate the relationship between diabetes duration and employment chances and how long it takes for an employment penalty to develop. Recent research by Minor  [(2013)](#page297) on the US has shown that the eﬀect of diabetes on employment chances changes with the duration of diabetes and is strongest in the first five years after diagnosis for males, whereas for females a strong eﬀect appears only about 11–15 years after diagnosis.

Looking ahead, it would evidently be worthwhile to investigate the eﬀects of diabetes on employment in Mexico using more recent data. In light of

the recently completed implementation of Seguro Popular—which increased its coverage from about 10 million people in 2005 to over 50 million in 2012 and now provides almost all previously uninsured Mexicans with access to healthcare (Knaul et al.,  [2012](#page293))—the results of this paper might be used as a baseline to judge the success of Seguro Popular in reducing the adverse eﬀects of diabetes on employment. In addition, the reasons for the diﬀerences between males and females in the estimated eﬀects remain a matter of speculation and more research is needed to explore the underlying pathways. This information would be valuable in the design of more eﬀective measures to reduce the negative eﬀects of diabetes for both males and females.

In conclusion, this paper shows that diabetes represents a large burden for people in Mexico and likely in other LMICs, not only due to the associated disease and medical cost burden but also because of its eﬀect on employment chances. This is particularly a problem for the poor who are more adversely aﬀected by diabetes than the more aﬄuent. To alleviate some of the negative eﬀects of diabetes, Seguro Popular may provide an opportunity to further im-prove the prevention and treatment of diabetes in the poor, especially if the health system adapts to the challenges presented by chronic diseases (Samb et al.,  [2010](#page302)). Evidence of possible cost-eﬀective interventions for secondary prevention in the context of Seguro Popular already exists (Salomon et al.,  [2012](#page301)). There remains, however, an evidence gap on cost-eﬀective strategies for the primary prevention of diabetes.

* **The Impact of Diabetes on Labour Market Outcomes in Mexico: a Panel Data and Biomarker Analysis**

**Pre-amble**

This study builds on the results of the preceding chapter. Instead of using an instrumental variable  [(IV)](#page14) approach to address the issue of endogeneity, it takes advantage of the recently released third wave of the Mexican Family Life Survey  [(MxFLS)](#page15) to allow the construction of a longitudinal data set contain-ing three waves. This enables the use of panel data methods to arrive at a causal interpretation of the estimates, without having to rely on the untestable assumptions underlying the IV approach.

Further, the study provides additional novel evidence for the eﬀect of self-reported diabetes on wages and working hours in a developing country. Finally it addresses another area identified by the systematic review in  [2](#page28) investigat-ing in how far self-reported diabetes can be used to draw conclusions about the entire diabetes population, including those unaware of the condition us-ing biomarker information. This area has hitherto received little research but is of great importance due to the large unaware diabetes population in high-income countries (HICs) and low- and middle-income countries (LMICs). Using biomarker data it investigates in how far self-reported diabetes identifies the en-tire diabetes population and if findings based on self-reports can be extended to those unaware of the condition. This should help to better interpret estimates using self-reported diabetes as provided in Chapter 3.

**Abstract**

There is limited evidence on the labour market impact of diabetes, and existing evidence tends to be weakly identified. Making use of Mexican panel data to estimate individual fixed eﬀects models, we find evidence for adverse eﬀects of self-reported diabetes on employment probabilities, but not on wages or hours worked. Complementary biomarker infor-mation for a cross section indicates that a large diabetes population is unaware of the disease. When accounting for this, the negative rela-tionship of self-reported diabetes with employment remains, but does not extend to those unaware of their diabetes. Further analysis sug-gests that this diﬀerence stems from worse general health among the self-reports rather than more severe diabetes.

**4.1 Introduction**

Diabetes, and particularly its most common variant, type 2 diabetes, has in-creased worldwide and is expected to continue to rise over the next decades (NCD Risk Factor Collaboration,  [2016](#page297)). It has become a problem for middle-income countries (MICs) and HICs alike, with over two-thirds of people with diabetes living in the developing world (International Diabetes Federation,  [2014](#page292)). Mexicans and Mexican-Americans appear to be particularly aﬀected by diabetes, also in comparison to other Latino populations living in the USA (Schneiderman, Llabre, et al.,  [2014](#page302)). In Mexico itself, diabetes prevalence has been estimated to have grown from 6.7% in 1994 to 14.4% in 2006, includ-ing both diagnosed and undiagnosed cases (Barquera, Campos-Nonato, et al.,  [2013),](#page283) and is expected to increase further over the next decades (Meza et al.,  [2015](#page296)). Already now, diabetes is the number one cause of death in Mexico (Barquera, Campos-Nonato, et al.,  [2013](#page283)).

The observed trend has been attributed to a deterioration in diet and a re-duction in physical activity (Barquera, Hernandez-Barrera, et al.,  [2008;](#page283) Basu et al.,  [2013),](#page283) while genetic predisposition among Mexicans with pre-hispanic ancestry may also have played a role (Williams et al.,  [2014](#page306)). Recent evidence indicates that the onset of diabetes has been occurring at an ever earlier age in Mexico (Villalpando et al.,  [2010](#page305)). With treatment as ineﬀective as it cur-rently is—only a minority achieves adequate blood glucose control (Barquera, Campos-Nonato, et al.,  [2013](#page283))—the earlier onset will increase the likelihood of complications during the productive lifespan.

Diabetes is a term used to describe various conditions characterized by high blood glucose values, with the predominant disease being type 2 diabetes ac-counting for about 90 %of all diabetes cases (Sicree et al.,  [2011](#page303)). The el-evated blood glucose levels that are a result of the body’s inability to use insulin properly to maintain blood glucose at normal levels, can entail a range of adverse health eﬀects for the individual concerned. However, via eﬀective self-management of the disease much if not all of the complications can be avoided (Gregg et al.,  [2012;](#page290) Lim et al.,  [2011](#page295)). In the absence of eﬀective self-management—or in the case of inadequate treatment—diabetes has been docu-mented to lead to conditions such as heart disease and stroke, blindness, kidney problems, and nerve problems which together with impaired wound healing can lead to the loss of limbs (Reynoso-Noverón et al.,  [2011](#page300)). These conditions can be seriously debilitating and may therefore reduce an individual’s economic activity, including its productivity and labour market participation.

The eﬀect of diabetes on labour market outcomes has been studied predomi-nantly in HICs—with the exception of a study on Mexico (Seuring et al.,  [2015](#page303)) and one on China (Liu and Zhu,  [2014)](#page295) each. In the  [HIC](#page14) studies diabetes has been found to be associated with reductions in employment probabilities as well as wages and labour supply (Brown, Pagán, et al.,  [2005;](#page285) Brown, Perez, et al.,  [2011;](#page285) Brown,  [2014;](#page285) Latif,  [2009;](#page294) Minor,  [2011a,](#page296)  [2013;](#page297) Minor and MacEwan,  [2016;](#page297) Seuring, Archangelidi, et al.,  [2015](#page303)).

While these studies have provided useful evidence on the potential labour market eﬀects of diabetes, many of the complexities of the relationship have not been comprehensively addressed in any given study. First of all, unob-served heterogeneity presents a challenge to estimate the relationship between diabetes and labour outcomes. Especially time-invariant unobserved individual characteristics, e.g. health endowments—often related to health during uteru, infant and child years, and to low household income or adverse health shocks during these early years—as well as risk preferences have been shown to ad-versely aﬀect health in general and the propensity to develop type 2 diabetes more specifically (Ewijk,  [2011;](#page290) Li, He, et al.,  [2010;](#page294) Sotomayor,  [2013](#page303)). These and other unobserved personal characteristics (e.g. ability) may also aﬀect em-ployment probabilities, wages or working hours directly through their eﬀects on contemporaneous productivity (Currie and Vogl,  [2013)](#page288) and indirectly by limiting educational attainment and human capital accumulation (Ayyagari et al.,  [2011](#page282)). Further, only focusing on the overall eﬀect of a self-reported dia-betes diagnosis does not reveal when potential labour market penalties appear,

given the dynamic aspect of diabetes and the potential diﬀerences in its eﬀects over time. Additionally, apart from its health impact diabetes might also aﬀect labour market outcomes through other channels. For instance, people aware of their condition may be less inclined to continue working if this interferes with their disease management or be suﬀering from psychological consequences (depression, anxiety) of becoming aware of the disease; they may also use the diagnosis as a justification for decreasing their labour supply, leading to a po-tential justification bias in the estimated eﬀect of diabetes (Kapteyn et al.,  [2009](#page292)). Importantly, for these reasons the labour market eﬀects may also be distinct for people with self-reported versus those unaware of their condition, potentially leading to biased estimates if the analysis is solely based on self-reports.

The objective of this study is to provide new evidence on the impact of diabetes on labour outcomes, while improving upon previous work by paying close attention to the above challenges. We use three waves of panel data from Mexico covering the period 2002–2012, provided by the  [MxFLS.](#page15) The  [MxFLS](#page15) is particularly useful for the analysis of diabetes as it allows us to account for the above complexities in a more refined way than has been the case so far. Using individual level fixed eﬀects  [(FE)](#page14) analysis for the first time in this literature, we take account of time-invariant heterogeneity when assessing the impact of self-reported diabetes and self-reported diabetes duration on labour market outcomes.1 Further, we add to the current literature in exploring the role of undiagnosed diabetes, using novel and rich biomarker data—an issue of considerable importance in light of the large prevalence of undiagnosed diabetes (see Beagley et al.  [(2014))](#page284) that remained unaccounted for in most earlier studies which typically rely on self-reported information. Doing so sheds light on the issue of measurement error and the potentially diﬀerential eﬀects of self-reported and undiagnosed diabetes.

Our results using self-reported diabetes suggest an economically important decrease in the employment probability of people aware of their disease. Wages and working hours, however, do not appear to be negatively associated with self-reported diabetes. We further find that employment probabilities are re-duced with each additional year since diagnosis, with some evidence for an even larger eﬀect per year after the initial 10 years.

The biomarker analysis indicates that self-reported diabetes entails a sig-

1We are not aware of any other evidence on the eﬀect on wages and working hours in a  [MIC](#page14).

nificant employment penalty, while biometrically measured diabetes does not. Overall, undiagnosed diabetes does not appear to aﬀect any of the labour mar-ket outcomes examined here, suggesting that adverse eﬀects mainly occur to those self-reporting a diagnosis. We argue that, nonetheless, the eﬀects found for self-reported diabetes in this study are largely unbiased as long as inference is not extended to the unobserved undiagnosed population, and are economi-cally important in light of the sheer size of the diagnosed population in Mexico.

1. **Diabetes and labour outcomes—existing evidence**

Several studies have investigated the eﬀects of diabetes on labour market out-comes.

For the USA, Brown, Pagán, et al.  [(2005)](#page285) estimate the impact on employment in 1996–1997 in an elderly population of Mexican Americans living close to the Mexican border, using a bivariate probit model. The study finds diabetes to be endogenous for women but not for men. For the latter, the estimates show a significant adverse eﬀect of 7 percentage points. For women, the negative eﬀect becomes insignificant when using IV estimation. In another study, again for a cross-sectional sample of Mexican-Americans, Brown, Perez, et al.  [(2011](#page285)) look at how diabetes management, inferred from measured glycated hemoglobin  [(HbA1c)](#page14) levels, is associated with employment chances and wages. The authors detect a linear negative association between  [HbA1c](#page14) levels and both employment chances and wages for men.

Two further studies also examine the impact of diabetes on employment and productivity for the USA: Minor  [(2011a)](#page296) focuses on the eﬀect of diabetes on female employment, earnings, working hours and lost work days in 2006, find-ing diabetes to be endogenous and its eﬀect underestimated if exogeneity is assumed. In the IV estimates, diabetes has a significant negative eﬀect on fe-male employment as well as annual earnings but not on working hours. In a later study Minor  [(2013)](#page297) investigates the relationship of diabetes duration and labour market outcomes using a cross-sectional analysis, providing evidence of a non-linear relationship, with employment probabilities declining shortly after diagnosis for men and after about 10 years for women; wages are not aﬀected by duration. Finally, a recent study by Minor and MacEwan  [(2016)](#page297) investi-gates the association of self-reported diabetes and undiagnosed diabetes with

employment probabilities and working hours in an adult USA population, us-ing cross-sectional data. This study indicates a reduction in the coeﬃcient size of diabetes if undiagnosed diabetes cases are included in the diabetes indicator instead of only self-reported diabetes. Further, they find that there is no asso-ciation of undiagnosed diabetes with employment probabilities itself. However, the results of the study, particularly those for undiagnosed diabetes, are based on a very small number of cases, warranting further investigation.

For Canada, Latif  [(2009)](#page294) estimate the eﬀect of the disease on employment probabilities using an IV strategy similar to Brown, Pagán, et al.  [(2005](#page285)). His results suggest diabetes to be exogenous for females, and both endogenous and overestimated for males in the univariate model, with the estimates of the bivariate model indicating a significant negative impact on the employment probabilities for women, but not for men. For Australia, Zhang, Zhao, et al.  [(2009)](#page308) analyse the eﬀects of diabetes on labour force participation using a multivariate endogenous probit model. Their results demonstrate reduced labour market participation for males and females as a result of diabetes, with the eﬀects appearing overstated if the endogeneity of diabetes is unaccounted for.

To the best of our knowledge only two studies exist for non-HICs. Liu and Zhu  [(2014)](#page295) investigate the eﬀect of a diabetes diagnosis on labour income in China, exploiting a natural experiment to identify causality and find a signif-icant reduction in income for those with a recent diagnosis. An earlier study for Mexico explored the eﬀect of self-reported diabetes on the probability of employment using only cross-sectional data from the 2005 wave of the  [MxFLS](#page15), and found a significant (p<0.01) reduction in employment chances for males by about 10 percentage points and for females by about 4.5 percentage points (p<0.1), using parental diabetes as an IV (Seuring et al.,  [2015](#page303)). The scarcity of evidence for LMICs is also documented in a recent systematic review of the economic cost of diabetes (Seuring, Archangelidi, et al.,  [2015](#page303)).

Overall, the majority of existing studies, including those on high income countries, tend to suﬀer from at least four key limitations:

1. They rely exclusively on cross-sectional data, limiting the possibilities to account for unobserved individual characteristics.
2. The use of the family history of diabetes, which has been the sole in-strumental variable employed so far, relies on the genetic and herita-ble component of type 2 diabetes that could theoretically provide valid

identification of the true eﬀect of diabetes. However, it remains unclear whether the variable fully satisfies the exclusion restriction, as it may also proxy for other genetically transferred traits, including unobserved abili-ties that impact labour outcomes directly. This traditional identification strategy also abstracts from intrahousehold or intergenerational labour supply eﬀects (Seuring et al.,  [2015](#page303)).2

1. The use of self-reported diabetes can introduce non-classical measurement error due to systematic misreporting which has been shown to cause esti-mates of economic impacts to be potentially biased and overstated (Caw-ley, Maclean, et al.,  [2015;](#page286) O’Neill and Sweetman,  [2013;](#page298) Perks,  [2015](#page299)).
2. A final potential limitation lies in the selection into diagnosis as a result of disease severity: those who are more severely ill are more likely to have visited a medical doctor and be diagnosed.

To overcome some of these limitations, this paper applies an individual level FE panel estimation strategy and makes use of biomarker data. We also es-timate models for diﬀerent types of employment, i.e. non-agricultural wage employment, agricultural employment and self-employment, as ill health may have distinct eﬀects across these activities.

**4.3 Data**

We use the Mexican Family Life Survey  [(MxFLS),](#page15) a nationally representative, longitudinal household survey, which has three waves conducted in 2002, 2005– 2006 and 2009–2012. All household members aged 15 and above were inter-viewed, covering information on a wide range of social, demographic, economic and health characteristics of the individuals and their families (Rubalcava and Teruel,  [2013](#page301)). Apart from self-reported diabetes information that is available in all rounds, we also use information on the self-reported year of diagnosis as well as biomarker data including  [HbA1c](#page14) levels for a subsample of respondents. Our main analysis uses all three waves taking advantage of the large amount of observations and the panel structure of the data. Our variable of interest is self-reported diabetes, which is based on the survey question: "Have you ever been diagnosed with diabetes?".

* It is conceivable that diabetes might deteriorate parental health in such a way that the oﬀspring either has to give up their employment to provide care, or has to increase labour supply to compensate for lost income.

Because the response to this question may well suﬀer from measurement error due to recall bias, we investigate and try to increase the consistency of the self-reported diabetes variable, using disease information from earlier and ensuing waves to infer on the current, missing or inconsistent, diabetes status. One of the key advantages of panel data is the repeated measurement giving more than one data point for many of the individuals, thereby allowing to uncover inconsistencies for those with at least two observations. While we are not aware of any literature investigating the issue of inconsistencies in self-reported diabetes over time, a study by Zajacova et al.  [(2010),](#page307) on the consistency of a self-reported cancer diagnosis over time in a USA population, found that 30% of those who had reported a cancer diagnosis at an earlier point did report at a later point that they never had received a cancer diagnosis. They also found that a more recent diagnosis was reported with greater consistency possibly due to increasing recall problems and/or reduced salience as time since diagnosis progresses.

We also find inconsistencies in the diabetes self-reports over the three waves of the  [MxFLS](#page15) data, with between 10–20% of those reporting diabetes in one wave not doing so in one of the subsequent waves. In order to reduce the amount of inconsistencies, we were interested in the validity of diabetes self-reports. While we could not find a study assessing the validity of self-reported diabetes in Mexico, a study from China has shown that specificity of self-reported diabetes, i.e. those who self-report a diabetes diagnosis actually have diabetes, was very high (>98% for China), while sensitivity, i.e. how many people with diabetes, diagnosed or undiagnosed, actually self-report the disease, was low (40% for China) (Yuan et al.,  [2015](#page307)). This indicates that people who report a diabetes diagnosis are likely to indeed have the condition while many of those not reporting a diabetes diagnosis are unaware of their diabetes.

We assess the validity of self-reported diabetes in our data by using  [HbA1](#page14)c levels and the self-reports of diabetes related medicine use from wave three. We find that 90% of those self-reporting a diabetes diagnosis had an  [HbA1](#page14)c ≥ 6*.*5% or did report taking diabetes medication, indicating relatively high specificity in our data as well.

We used this information to infer the "true" diabetes status for those with inconsistent reports. For those with two waves, we assumed that if a diabetes diagnosis had been reported in a prior wave they also had diabetes in the ensuing wave, even if then it was not reported. For people where we had data from all three waves, we used that additional information to make a decision

on how to deal with inconsistencies using the rules outlined in Table  [14](#page110).

This approach should add more consistency to the self-reported diabetes in-formation by using all available information. We tested if this approach was supported by the  [HbA1c](#page14) values provided in wave 3. Of those with inconsis-tencies in their diabetes elf-reports 95 were present in the biomarker sample (46 with two and 49 with one self-report of diabetes). We therefore Using a t-test we compared the mean  [HbA1c](#page14) for the two groups and found a significantly (p<0.001) higher mean  [HbA1c](#page14) (9.7%) for those with two self-reports compared to for those with only one self-report of diabetes (7.0%). Further, of those with one self-report, for only 30% the  [HbA1](#page14)c≥ 6*.*5% compared to 87% of those with two self-reports. Based on these results we are reassured that the way we have dealt with the inconsistencies in the data minimizes misclassification of people into diabetes or no-diabetes and has reduced some of the measurement error in the diabetes data. Unfortunately we cannot use a similar method for dealing with inconsistencies in the self-reported year of diabetes diagnosis, as it has only been reported once. Hence, the results from duration analysis should be interpreted with care.

A further, and no less important, source of measurement error is the omission of those with undiagnosed diabetes. In order to investigate how this may aﬀect estimates of the labour market impact of diabetes we use information from a subsample of the 2009-2012 wave containing over 6000 respondents (everybody aged 45+ and a random subsample of those aged 15–44 (Crimmins et al.,  [2015))](#page288) that have biometrically measured blood glucose values, allowing for the identification of those with undiagnosed diabetes. Throughout our analysis the samples we use are restricted to the working age population (15–64). To prevent pregnant women from biasing our results due to the increased diabetes risk during pregnancy and its eﬀects on female employment status, we have dropped all observations of women reporting to be pregnant at the time of the survey (N=764). We further exclude everybody currently in school.

Table 14: Inconsistencies in diabetes self-report in MxFLS

Inconsistency Assumption Number of observations

replaced

Diabetes self report in 2002, 2005 but not in 2009

Diabetes self report in 2002, 2009 but not in 2005

Diabetes self report only in 2002, but not in 2005 and 2009 Diabetes self report only in 2005, but not in 2002 and 2009 Diabetes self report in 2002, but not in 2005. Not in survey in 2009 Diabetes self report in 2005, but not in 2009. Not in survey in 2002

|  |  |
| --- | --- |
| Has diabetes in 2009 as | 19 |
| well |  |
| Has diabetes in 2005 as | 63 |
| well |  |
| Has no diabetes in 2002 | 66 |
| either |  |
| Has no diabetes in 2005 | 52 |
| either |  |
| Has diabetes in 2005 as | 44 |
| well |  |
| Has diabetes in 2009 as | 23 |
| well |  |

The detailed information in the  [MxFLS](#page15) allows us to consider the following outcome variables of interest: employment3, hourly wage and weekly working hours.4 For the pooled data of all three waves (Table  [15),](#page112) diabetes was self-reported by 5% of men and 6% of women, respectively. This is consistent with other prevalence estimates of self-reported diabetes for this time period in Mexico.5 About half of the respondents in the sample live in rural areas. Looking at our outcome variables, 86% of men report some form of employment compared to 37% of women. Interestingly, men do not report considerably higher hourly wages than women but work more hours per week. Also, men are working more often in agricultural jobs while women are more likely to be self-employed or in non-agricultural wage employment. Women also have lower educational attainment on average.

Turning to the biomarker subsample of the third wave (2009-2012), respon-dents are somewhat older on average than in the pooled sample, as it includes everybody above the age of 44 but only a random subsample of those aged 44 or below (Crimmins et al.,  [2015](#page288)). Also, self-reported diabetes is higher than in the pooled sample6. Regarding the other control and outcome variables, the sample is fairly similar to the pooled sample. Remarkably, a relatively large

3Employment status is defined as having worked or carried out an activity that helped with the household expenses the last week and working for at least four hours per week. This explicitly includes those employed informally, for instance people working in a family business. The number of working hours needed to be considered as working is lower than in Chapter 3. We took this decision because we wanted to assess the impact of diabetes on driving people out of work completely. Any eﬀect on working hours should be captured in the respective working hours models. We also tested if changing the definition of being employed to having worked at least ten hours per week as in Chapter 3. This only led to marginal changes in the coeﬃcients and standard errors, not aﬀecting the interpretation of the results.

* Hourly wage was calculated by adding up the reported monthly income from the first and second job (if any) and dividing it by the average number of weeks per month. This gave us the average earnings per week which were then divided by the weekly working hours to arrive at an hourly wage estimate. Labor income was either reported as the total amount for the whole month or more detailed containing information on the monthly wage, income from piecework, tips, extra hours, meals, housing, transport, medical benefits and other earnings. Over 80% of respondents reported the total amount instead of a detailed amount. Respondents were also asked for their annual income and we used that information to arrive at an hourly wage if information for monthly labour income was missing. Finally, we adjusted the calculated wage for inflation from the year of the interview up to 2013 and took the log of those values. Due to a considerable

number of missing or zero income reports the sample used for the wage estimation is smaller than the sample for working hours. Working hours were calculated summing up the self-reported working hours of the first and—if applicable—the second job.

* Barquera, Campos-Nonato, et al.  [(2013)](#page283) show that the prevalence of diagnosed diabetes in Mexico was 7.5% in 2006, only somewhat above our results, which may be the result of the slightly diﬀerent age groups considered.

6As well as in the full sample of wave 3.

Table 15: Descriptive statistics for panel and biomarker sample.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Panel | |  | Biomarker | | |  |
|  |  |  |  |  |  |  |  |
|  | Males | Females |  | Males | Females |  |  |
|  |  |  |  |  |  |  |  |
| *Dependent variables* |  |  |  |  |  |  |  |
| Employed | 0.86 | 0.37 | 0.86 | | 0.34 |  |  |
|  | (0.34) | (0.48) | (0.35) | | (0.47) |  |  |
| Hourly wage (Mexican Peso) | 42.47 | 40.49 | 36.30 | | 35.23 |  |  |
|  | (485.87) | (142.08) | (53.69) | | (43.63) |  |  |
| Weekly working hours | 46.82 | 38.99 | 46.00 | | 38.15 |  |  |
|  | (16.79) | (18.90) | (16.89) | | (19.65) |  |  |
| Agricultural worker | 0.22 | 0.04 | 0.25 | | 0.03 |  |  |
|  | (0.41) | (0.20) | (0.43) | | (0.18) |  |  |
| Self-employed | 0.19 | 0.28 | 0.21 | | 0.32 |  |  |
|  | (0.39) | (0.45) | (0.41) | | (0.47) |  |  |
| Non-agricultural worker or employee | 0.59 | 0.68 | 0.53 | | 0.64 |  |  |
| *Diabetes variables* | (0.49) | (0.47) | (0.50) | | (0.48) |  |  |
|  |  |  |  |  |  |  |
| Self-reported diabetes | 0.05 | 0.06 | 0.09 | | 0.12 |  |  |
|  | (0.22) | (0.24) | (0.29) | | (0.32) |  |  |
| Diabetes duration if self-reported diabetes (years) | 7.49 | 7.83 | 7.48 | | 7.99 |  |  |
|  | (6.01) | (7.83) | (6.07) | | (7.03) |  |  |
| Glycated hemoglobin (HbA1c) |  |  | 6.46 | | 6.58 |  |  |
| HbA1c ≥ 6*.*5% |  |  | (1.89) | | (2.02) |  |  |
|  |  | 0.26 | | 0.28 |  |  |
|  |  |  | (0.44) | | (0.45) |  |  |
| Undiagnosed diabetes |  |  | 0.18 | | 0.18 |  |  |
| *Education and demographic variables* |  |  | (0.39) | | (0.39) |  |  |
|  |  |  |  |  |  |  |
| Age | 36.03 | 36.29 | 42.78 | | 42.79 |  |  |
|  | (13.62) | (13.17) | (14.28) | | (13.94) |  |  |
| Rural village of < 2,500 | 0.44 | 0.43 | 0.50 | | 0.46 |  |  |
|  | (0.50) | (0.50) | (0.50) | | (0.50) |  |  |
| Married | 0.54 | 0.54 | 0.60 | | 0.56 |  |  |
|  | (0.50) | (0.50) | (0.49) | | (0.50) |  |  |
| Number of children (age < 6) in household | 1.48 | 1.57 | 1.18 | | 1.22 |  |  |
|  | (1.45) | (1.47) | (1.29) | | (1.32) |  |  |
| Indigenous group | 0.19 | 0.19 | 0.19 | | 0.18 |  |  |
|  | (0.39) | (0.39) | (0.39) | | (0.39) |  |  |
| Secondary | 0.30 | 0.30 | 0.26 | | 0.26 |  |  |
|  | (0.46) | (0.46) | (0.44) | | (0.44) |  |  |
| High school | 0.16 | 0.13 | 0.14 | | 0.12 |  |  |
|  | (0.36) | (0.34) | (0.34) | | (0.33) |  |  |
| Higher education | 0.11 | 0.09 | 0.12 | | 0.09 |  |  |
|  | (0.32) | (0.29) | (0.32) | | (0.28) |  |  |
|  |  |  |  | |  |  |  |
| Observations | 21388 | 27341 | 2785 | | 3623 |  |  |

*Notes* Mean values, standard deviations in parenthesis. Results for the other variables, i.e.the Mexican states, log hourly wage and wealth, are omitted to save space.

share of people have an  [HbA1c](#page14) indicative of diabetes, defined by the World Health Organization  [(WHO)](#page15) as levels above or equal 6.5% (World Health Or-ganization,  [2011](#page307))7: 18% of males and females are unaware of their diabetes. This suggests that relying on self-reported diabetes as a measure for diabetes in Mexico might considerably understate the true extent of diabetes, potentially leading to biased estimates of its economic impact.

**4.4 Estimation strategy**

Strauss and Thomas  [(1998)](#page304) provide a useful framework to think about the relationship between health and labour outcomes:

|  |  |
| --- | --- |
| *L* = *L*(*H, pc, w*(*H*; *S, A, B, I, α, ew*)*, S, A, B, V, ξ*) | (4.1) |

where *L* is labour supply or labour market participation, *pc* is a vector of prices for consumer goods, *w* is the real wage; *H* is an array of measured health status ; *S* is education; *A* is a vector of demographic characteristics; *B* is the family background of the individual; *I* captures the local community infrastructure; *α* is an array of unobservables (e.g. ability), *ew* represents the measurementerror, *V* is non-labour income and *ξ* is the taste parameter.

The equation showcases the joint eﬀect of health on both wages and labour supply or labour market participation. Health aﬀects labour supply and par-ticipation directly by impacting the ability to work and indirectly by changing wages.

There are several ways diabetes may aﬀect *H*. First of all, diabetes can deteriorate health if it remains untreated, with the adverse eﬀects potentially increasing over time. Second, a diagnosis of diabetes and ensuing treatment may lead to better health compared to the undiagnosed state. However, com-pared to healthy people even those receiving treatment for their diabetes may still have worse health outcomes. Third, there is also evidence that the di-agnosis itself may aﬀect one’s own health perception and could lead to worse self-perceived health (Thoolen et al.,  [2006](#page304)). We therefore expect diabetes to adversely aﬀect health and consequently labour market outcomes.

When estimating Eq.  [4.1](#page113) empirically with observational data, unobserved heterogeneity may bias the results. As mentioned in section  [4.1](#page102) unobserved

* In one of the first analyses of these new biomarker data, Frankenberg et al.  [(2015)](#page290) show that the rates of elevated  [HbA1c](#page14) levels in Mexico are very high when compared to  [HbA1](#page14)c data from similar surveys in the USA and China.

factors captured in *α* such as early childhood investments, innate ability and risk preference could aﬀect wages as well as the probability to develop diabetes. Further, changes in lifestyle due to changes in wages or employment status may also aﬀect the probability to develop diabetes through changes in diet and physical activity. Finally, measurement error *ew* may be an important issue due to the large undiagnosed population with diabetes, particularly if being diagnosed is related to employment or wages via better access to healthcare through employment benefits and higher income.

The following section describes our estimation strategy for the diﬀerent parts of the data.

**4.4.1 Panel data on self-reported diabetes**

We investigate the relationship between self-reported diabetes and three labour market outcomes: employment, wages and labour supply, respectively, using a FE model. While using individual level FE does not allow to fully identify a causal relationship, this strategy does improve on the degree of causal in-ference, compared to a simple cross-sectional analysis.8 In particular it does allow controlling for unobserved personal characteristics that could bias the estimates, without the drawbacks of an at least debatable IV strategy that has been widely applied in this literature. We have also estimated random eﬀects models but do not present them here as the Hausman test suggested the use

|  |  |
| --- | --- |
| of the FE model throughout.9 |  |
| We estimate the following model: |  |
| *Yit* = *β*0+ *β*1*Diabetesit* + *β*2*Xit* + *ci* + *γt* + *uit.* | (4.2) |

where *Yit* is a binary variable taking a value of 1 if respondent *i* reports being in employment at time *t* and 0 otherwise, *Diabetesit* is a binary variable taking a value of 1 at time *t* if the respondent reports having ever received a diagnosis of diabetes10, *Xit* is a vector of control variables, *ci* represents an individual fixed eﬀect, *γt* represents a year dummies, and *uit* is the error term.

For the relationship of self-reported diabetes with wages and working hours

8Other forms of unobserved heterogeneity could also aﬀect our estimates—for instance time-variant unobserved heterogeneity or omitted variables simultaneously driving labour outcomes and health.

9See the respective table for the results of the cluster robust Hausman test

10We are not able to distinguish between type 1 diabetes and type 2 diabetes using this data. Other studies that tried to assess the eﬀect of type 1 diabetes on labour market outcomes have found no association (Minor,  [2011a;](#page296) Minor and MacEwan,  [2016](#page297)). Including type 1 diabetes therefore likely attenuates any adverse relationship we may find.

our empirical models are estimated conditional on having positive wages and being employed, respectively. In these models *Yit* represents the log hourly wage of respondent *i* at time *t* or the weekly working hours over the last year.

The control variables in both FE specifications include dummy variables to capture the eﬀects of the living environment, of living in a small, medium or large city with rural as the reference category, and state dummies. We also include a marital status dummy and the number of children residing in the household below the age of 6 to control for the impact of marriage and children on labour market outcomes and the eﬀect of childbearing and related gesta-tional diabetes on the probability of developing type 2 diabetes (Bellamy et al.,  [2009](#page284)). To account for the eﬀect of changes in household wealth on diabetes and employment probabilities, we use standard principal component analysis of multiple indicators of household assets and housing conditions to create an indi-cator for household wealth11 (Filmer and Pritchett,  [2001](#page290)). Finally, a quadratic age term and calendar year dummies are included to capture the non-linear eﬀect of age and any trends over time, respectively.

Before moving on, it bears emphasizing that despite our eﬀorts to reduce any bias in our estimates, the estimated coeﬃcients do not reflect true causal eﬀects since time-variant unobserved heterogeneity may still bias the estimates. With respect to employment status, one potential issue would be that job loss aﬀects lifestyle choices that increase the probability to develop diabetes, which could then in turn negatively aﬀect labour market outcomes. So far, no strong adverse eﬀects of job loss as a result of diabetes self-reports have been reported in the literature (Bergemann et al.,  [2011;](#page284) Schaller and Stevens,  [2015),](#page302) but this has so far only been researched in a high-income country context. Another example relates to stress at work, which has been linked to the development of type 2 diabetes (Eriksson et al.,  [2013;](#page289) Heraclides et al.,  [2012](#page291)). However, while stress levels may change over time, a person’s coping mechanisms to deal with stress are likely time-invariant (Schneiderman, Ironson, et al.,  [2005](#page302)). While we cannot exclude the role of these time variant unobserved factors, it seems that the role of time-invariant variables, e.g. genetic predisposition and relatively stable personality traits, is predominant. The applied FE approach should then limit the bias resulting from these time-invariant confounding factors.

11Our composite wealth index consists of owning a vehicle, a second house, a washing ma-chine, dryer, stove, refrigerator or furniture, any electric appliances, any domestic appli-ances, a bicycle or farm animals. It further accounts for the physical condition of the house, proxied by the floor material of the house, and the type of water access.

**4.4.2 Self-reported diabetes duration**

To explore the role of the duration of diabetes for labour outcomes, we estimate the following model using a self-reported measure of the years since diagnosis:

|  |  |
| --- | --- |
| *Yit* = *β*0+ *β*1*Dyearsit* + *β*2*Xit* + *ci* + *uit,* | (4.3) |

where *β*1*Dyearsit* is a continuous variable indicating years since first diabetes diagnosis.

In an eﬀort to capture possible non-linearities in the relationship of interest we then use a spline function that allows for the eﬀect of an additional year with diabetes to vary over time.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Yit* = *δ*0+ *g*(*Dyearsit*) + *δ*2*Xit* + *ci* + *uit.* | |  |  |  |  |  | (4.4) | |
| with *g*(*Dyearsit*) = | *nN*=1 *δn* · *max*{*Dyearsit* − *ηn*−1}*Iin* and *Iin* | | | = 1[*ηn*−1 ≤ | | | | |
| *η* | *n* | *n* |  |  | *,* |  | *, . . . , N* |  |
| *Dyearsit < ηn*], withP*n* being the place of the -th node for | |  | = 1 | |  | 2 |  | . |

We choose three nodes that—based on visual inspection (see Figures 5,  [6](#page127) and 7 in Section  [4.5.2](#page126))—best captured any possible non-linearity in the relationship between diabetes duration and labour outcomes. These are located at 4, 11 and 20 years after diagnosis. The first four years should capture any immediate eﬀects of the diagnosis, the years five to eleven should capture any eﬀects of adaptation to the disease. After 11 years it is conceivable that many of the debilitating complications of diabetes would appear that could deteriorate health and lead to adverse eﬀects on labour market outcomes. The coeﬃcient *δn* captures the eﬀect of diabetes for the *n*-th interval. The eﬀects are linear if

*δ*1= *δ*2=*, . . . ,* = *δn*.

Because the year of diagnosis was only reported in the third wave, duration of diabetes (or time since diagnosis) for the earlier waves was only calculated for those that had also been interviewed in the third wave, reducing the com-parability of the results to those using the binary diabetes indicator.12

One caveat of using FE is that, when year dummies are included, any vari-able that varies by one unit in each time period, is not separately identified (Wooldridge,  [2012](#page306)). Because this is also the case for diabetes duration, in Eq.  [(4.3)](#page116) and Eq.  [(4.4),](#page116) identification of this variable relies on the presence of people without diabetes in the sample, for which diabetes duration does not

12To obtain the time passed since diagnosis, the year of diagnosis was subtracted from the year of the interview.

increase at the same rate as time.13 As a further robustness check, we also estimate two models that only use between-individuals variation, i.e. a linear probability model  [(LPM)](#page14) that uses only data from the third wave, the only wave where year of diagnosis was originally reported, and a pooled  [LPM](#page14) that used data from all three waves.14

**4.4.3 Cross-section: biomarker and self-reported data**

Self-reported diabetes only captures part of the diabetes population as many individuals remain undiagnosed; it may also contain cases of people who mis-report having diabetes. Estimations based on self-reports may therefore suﬀer from selection bias in at least three ways:

1. Systematic overreporting of diabetes: people without diabetes may re-port a diabetes diagnosis, unintentionally—for instance due to misdiag-nosis, either from a health professional or because of self-diagnosis, or intentionally—for instance with a view to justifying some other adverse event or status in their life (e.g. being unemployed).
2. Systematic underreporting of diabetes: people with diabetes may also underreport because they are concerned about negative stigma associated with the condition. Furthermore, diabetes often remains undiagnosed leaving people unaware of their condition.
3. Diagnosis is more likely for those who are more likely to have visited a doctor, for instance because they are more aﬀected by the condition, wealthier, or hypochondriac.15

Overreporting may attenuate the eﬀect of diabetes if those falsely reporting a diabetes diagnosis are in fact in good health; it may also lead to overes-timation of the impact if some of those misreports reflect other factors that negatively aﬀect labour outcomes (e.g. other illnesses or general ill health), or

1. Consequently, those that reported a diagnosis in the year of the interview were counted as ’one year since diagnosis’. From this follows that if the respondent reported to having

been diagnosed in the year before the interview he or she was counted as ’two years since diagnosis’ and so on.

14Models excluding the calendar year dummies provide similar results.

15More formally, assume that the true model of the eﬀect of diabetes on labour market outcomes is *y* = *X*∗*β* + . Because we do not observe the true values of *X*∗ we have to use self-reported measures that contain errors: *X* = *X*∗ + *u*. Since *u* may be correlated with - in contrast to classic measurement error which is randomly distributed, we cannot sign the bias of *β*.

if they are used to justify other adverse events that may negatively aﬀect labour outcomes. Similarly, underreporting may lead to overestimation if those with undiagnosed diabetes are generally healthier, hence more likely to have posi-tive labour market outcomes than those with self-reported diabetes. However, if the undiagnosed and the diagnosed groups are similar in terms of health, then this would lead to an underestimation of the eﬀect of diabetes.

The health information received at a diabetes diagnosis may also have an eﬀect in itself. It may for instance aﬀect an individual’s psychology which in turn may influence economic behaviour. Two studies found a diabetes diagno-sis and subsequent treatment to increase the odds of psychological problems, including depression and anxiety (Paddison et al.,  [2011;](#page298) Thoolen et al.,  [2006)](#page304), while similar results have not been found for people with undiagnosed diabetes (Nouwen, Nefs, et al.,  [2011](#page298)). Looking at behavioural change, health informa-tion has been shown to aﬀect behaviour after the diagnosis of not only diabetes (Slade,  [2012)](#page303) but also of other chronic diseases (see Baird et al.  [(2014),](#page282) Gong  [(2015),](#page290) Thornton  [(2008),](#page304) and Zhao, Konishi, et al.  [(2013)](#page308)). However, little is known about the eﬀects of health information on labour market outcomes. For diabetes, only Liu and Zhu  [(2014)](#page295) investigate the eﬀect of receiving a diabetes diagnosis on labour income in Chinese employees. This study finds a reduc-tion in labour income which was attributed to the psychological eﬀects of the diagnosis.16

The use of biomarker data allows to explore the relationship of measured diabetes with labour outcomes which can then be compared to the estimated eﬀect of self-reported diabetes. The biomarker data also enables us to look at diabetes severity, as measured by  [HbA1c](#page14) values. Since this data is only available for a subsample of one wave—the most recent one—our analysis here is limited to cross-sectional data no longer directly comparable to the panel-based results in this paper. Nonetheless, it allows for a first exploration of the relationships of measured diabetes and disease severity with labour market outcomes.

Our analysis of the biomarker sample consists of three steps. We first es-timate Eq.  [4.5](#page119) to assess the association of self reported diabetes with labour outcomes, as before, but this time for the biomarker sample only, using the

1. In a very diﬀerent context Dillon et al.  [(2014),](#page289) using a randomized intervention, find that the news stemming from diagnosis of malaria aﬀects productivity and income, but not labour supply among sugar cane cutters in Nigeria.

following specification:

|  |  |
| --- | --- |
| *Yi* = *β*0+ *β*1*Dsri* + *β*2*Xi* + *ci* + *ui* | (4.5) |

We then estimate the relations between diabetes, as defined by our biomarker, and labour outcomes, via the following equation:

|  |  |
| --- | --- |
| *Yi* = *β*0+ *β*1*Dbioi* + *β*2*Xi* + *ci* + *ui* | (4.6) |

Here *Dbioi* is equal to 1 if  [HbA1c](#page14) ≥ 6*.*5%.

To find the eﬀect of undiagnosed diabetes we include both variables at the

|  |  |
| --- | --- |
| same time and estimate: |  |
| *Yi* = *β*0+ *β*1*Dsri* + *β*2*Dbioi* + *β*3*Xi* + *vi* + *ui.* | (4.7) |

For the biomarker analysis we rely on within-household variation *vi* for iden-tification to account for unobserved community characteristics, such as the access to healthcare and the quality of healthcare in the community, poverty and unemployment levels in the community or the amount of public green space and recreational possibilities available. These factors potentially aﬀect both the propensity to develop diabetes and to receive a diagnosis; they may also be related to labour market outcomes.17

**4.5 Results**

**4.5.1 Incidence of self-reported diabetes**

Table  [16](#page120) presents the estimation results of the FE model using Eq.  [4.2,](#page114) which indicate significant and substantial reductions in the probability of employment for men and women with self-reported diabetes. The coeﬃcients are similar for both sexes, showing a reduction in employment probabilities of over 5 percent-age points. In relative terms—taking into account the lwoer employment rates for women compared to men—these percentage points reductions translate into a reduction of 14% for women and of 6% for men, suggesting a stronger impact of diabetes on female employment chances.

17We did not account for fixed household characteristics as the average number of observa-tions per household was close to one, i.e. for most households only one member provided biomarker information in our subsample, significantly limiting the variation within house-holds that would be needed for identification.

Table 16: Self-reported diabetes and labour market outcomes.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Employment | |  | Log hourly wages | |  | Weekly working hours | | |
|  |  |  |  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  | (5) | (6) |  |
|  | Males | Females |  | Males | Females |  | Males | Females | |
|  |  |  |  | |  |  |  |  | |
| Self-reported diabetes | −.054∗∗ | −.059∗∗ | 0.054 | | 0.081 |  | −.524 | −1.955 | |
|  | (.025) | (.024) | (.067) | | (.158) | (1.499) | | (2.517) |  |
|  |  |  |  | |  |  | |  |  |
| Hausman test | 255.260 | 388.822 | 1084.317 | | 91.096 | 967.007 | | 106.455 |  |
| p-value | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | | 0.000 |  |
| N | 21388 | 27341 | 13828 | | 7068 | 17616 | | 9112 |  |

*Notes* Individual level fixed eﬀects. Robust standard errors in parentheses. Reference category: de-pendent non-agricultural worker or employee. Other control variables: state dummies, urbanization dummies, education dummies, married dummy, number of children < 6, wealth, health insurance sta-tus, age squared and calender year dummies. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

The results in Columns 3–6 show no significant relationship between self-reported diabetes and wages or working hours. One may expect this rela-tionship to diﬀer by the type of work, as those with diabetes working in an agricultural job that requires strenuous, physical eﬀorts may see their produc-tivity more adversely aﬀected than those engaged in more sedentary work. We therefore estimate a model including interaction terms between self-reported diabetes and agricultural employment and between self-reported diabetes and self-employment, respectively, using non-agricultural wage employment as the comparison group, and restricting our sample to those employed only.

Table 17: Eﬀect of self-reported diabetes on wages and working hours, by type of work.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Log hourly wage | |  | Weekly working hours | | |  |
|  |  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |  |
|  | Males | Females |  | Males | Females | |  |
|  |  |  |  |  |  | |  |
| Agricultural worker | −.078∗ | −.280 |  | −3.577∗∗∗ | −4.473∗ | |  |
|  | (.044) | (.186) | (.800) | | (2.702) |  |  |
| Self-employed | 0.028 | −.144∗ |  | −1.452∗∗ | −4.713∗∗∗ | |  |
|  | (.043) | (.087) | (.704) | | (1.388) |  |  |
| Self-reported diabetes | 0.105 | 0.064 | 0.617 | | −.524 | |  |
| Self-reported diabetes x | (.076) | (.169) | (1.606) | | (2.252) |  |  |
| −.242 | −.409 |  | −5.495∗ | −3.535 | |  |
| agricultural worker |  |  |
| Self-reported diabetes x | (.188) | (.373) | (2.833) | | (22.300) |  |  |
| −.105 |  |  |  | −4.149 | |  |
| self-employed | 0.125 | 0.306 | |  |
|  | (.192) | (.326) | (2.503) | | (4.739) |  |  |
|  |  |  |  | |  |  |  |
| Hausman test | 280.491 | 912.537 | 4086.461 | | 995.171 |  |  |
| p-value | 0.000 | 0.000 | 0.000 | | 0.000 |  |  |
| N | 13828 | 7068 | 17616 | | 9112 |  |  |

*Notes* Individual level fixed eﬀects. Robust standard errors in parentheses. Refer-ence category: non-agricultural worker or employee. Other control variables: state dummies, urbanization dummies, education dummies, married dummy, number of children < 6, wealth, health insurance status, age squared and calender year dum-mies. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

The results in Table  [17](#page122) show that while male agricultural workers have lower wages in general, the relationship with diabetes does not depend on the type of work, as none of the interaction terms show up as significant. In the working hours regression one interaction term is significant, suggesting that those with self-reported diabetes working in agriculture supply 5 hours less relative to non-agricultural workers and employees. However, because we have more than two work types we cannot draw conclusions solely on the basis of the t-statistic. We therefore perform a Wald test for the overall significance of the interaction term which does not reject the null of no interaction eﬀects (*p* = *.*15), indicating that the eﬀect of diabetes on working hours does not vary significantly by type of work.

In summary, we find no evidence for an association between self-reported diabetes and wages or working hours. This lack of eﬀects may be explained by selection: potentially, only those with "mild" or asymptomatic diabetes are still in the same job continuing to earn similar wages. Only once complications become increasingly severe would they switch activity (or drop out of the labour market), without going through a notable phase of reduced productivity and labour supply.

To explore whether diabetes aﬀects the selection into certain types of work we estimate FE models of the probability of being in non-agricultural wage employment, agricultural employment or self-employment using three dummy variables indicating the respective type of work as the left hand side variables. The results in Table  [18](#page125) indicate a negative association with self-employment, though the estimates are quite imprecise. For women, those who self-report diabetes are less likely to work in agriculture and potentially self-employment. This may suggest that having diabetes drives people out of self-employment and agricultural jobs, for instance because these jobs are physically more demanding and possibly also because they provide less protection in terms of insurance and employment duration. We also estimated a pooled multinomial logit model augmented with the within-between approach (Bell and Jones,  [2015),](#page284) based on the work of Mundlak  [(1978),](#page297) which allows interpreting the coeﬃcients of all time-varying variables as within-eﬀects by including individual means of all time-varying covariates18. The results indicate a very similar pattern both in size and significance (results available on request).19

1. Several other studies in economics have used this approach recently, e.g., Boll et al.  [(2016)](#page284), Geishecker and Siedler  [(2011),](#page290) and Wunder and Riphahn  [(2014](#page307))
2. Using the same methods, we also investigated the impact of diabetes on changes in the type of work for those already employed, finding no evidence that diabetes leads to changes in

the type of work. These results are also available on request.

Table 18: Relationship between self-reported diabetes and selection into types of work.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Males |  |  |  | Females |  |  |
|  |  |  |  |  |  |  |  |  |
|  | (1) | (2) | (3) |  | (4) | (5) | (6) |  |
|  | Non-agric. | Agric. | Self-employed |  | Non-agric. | Agric. | Self-employed | |
|  |  |  |  |  |  |  |  | |
| Self-reported diabetes | −.006 | −.008 | −.043 |  | −.001 | −.022∗∗ | −.029 | |
|  | (.029) | (.022) | (.026) | (.018) | | (.009) | (.018) |  |
|  |  |  |  |  | |  |  |  |
| Hausman test | 2196.390 | 2005.383 | 1249.080 | 1126.933 | |  | 86.400 |  |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 | |  | 0.000 |  |
| N | 20719 | 20719 | 20719 | 26577 | | 26577 | 26577 |  |

*Notes* Individual level fixed eﬀects. Robust standard errors in parentheses. Other control variables: statedummies, urbanization dummies, education dummies, married dummy, number of children < 6, wealth, health insurance status, age squared and calender year dummies. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

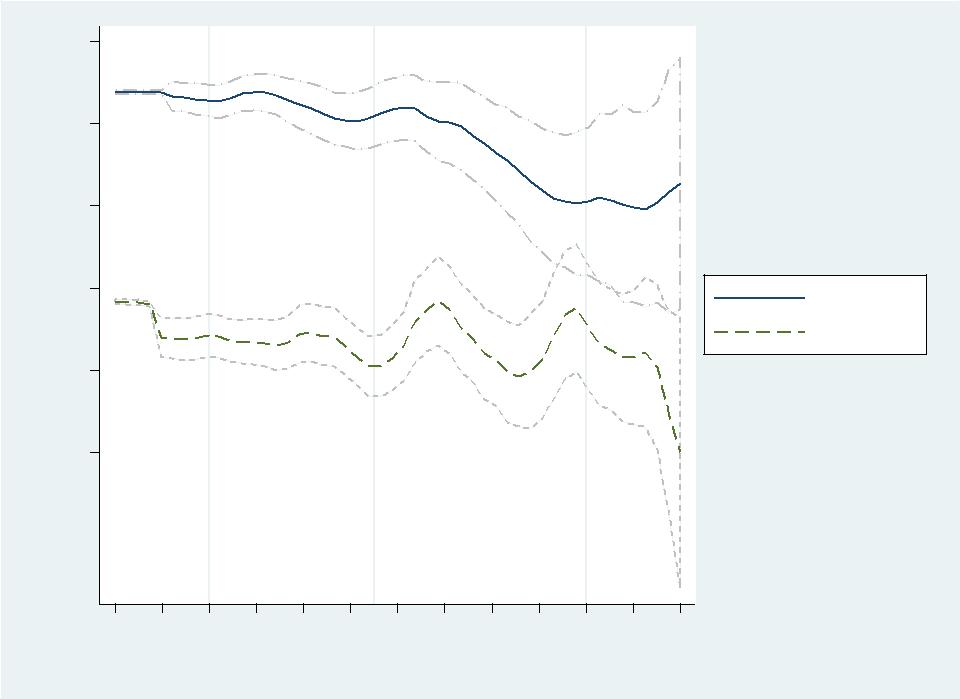
**4.5.2 Duration of self-reported diabetes**

Because diabetes is a chronic and generally life-long disease, we investigate how soon after the first diagnosis diabetes may aﬀect labour market outcomes. Given that complications of diabetes develop over time, the eﬀect may increase linearly as the years go by. Non-linear relationships are also plausible: health problems that have led to the diagnosis as well as psychological eﬀects after the diagnosis may aﬀect labour market outcomes immediately after having been diagnosed with diabetes. Similarly management of the disease may be successful only after some initial period. It is also possible that after some time complications start to appear, again reducing health and leading to reductions in labour supply and productivity.

To obtain an initial idea of the relationship between our outcome variables and diabetes duration we use a non-parametric kernel-weighted local polyno-mial regression. As Figure  [5](#page127) shows, the relationship between diabetes duration and the probability of employment for men shows a more or less steady decline that becomes more pronounced as time progresses. For women, a first drop-oﬀ occurs right after diagnosis; thereafter no consistent pattern is observed.20 A similar analysis for wages shows somewhat more erratic relationships, although there seems to be a long term negative trend for women but not for men (see figures  [6](#page127) and 7). A similar negative trend can be observed for working hours for women, but not for men.

1. Since long run estimations suﬀer from large standard errors—as the sample size is strongly reduced—this limits its interpretation and we therefore truncate the graphs at a disease duration of 24 years.

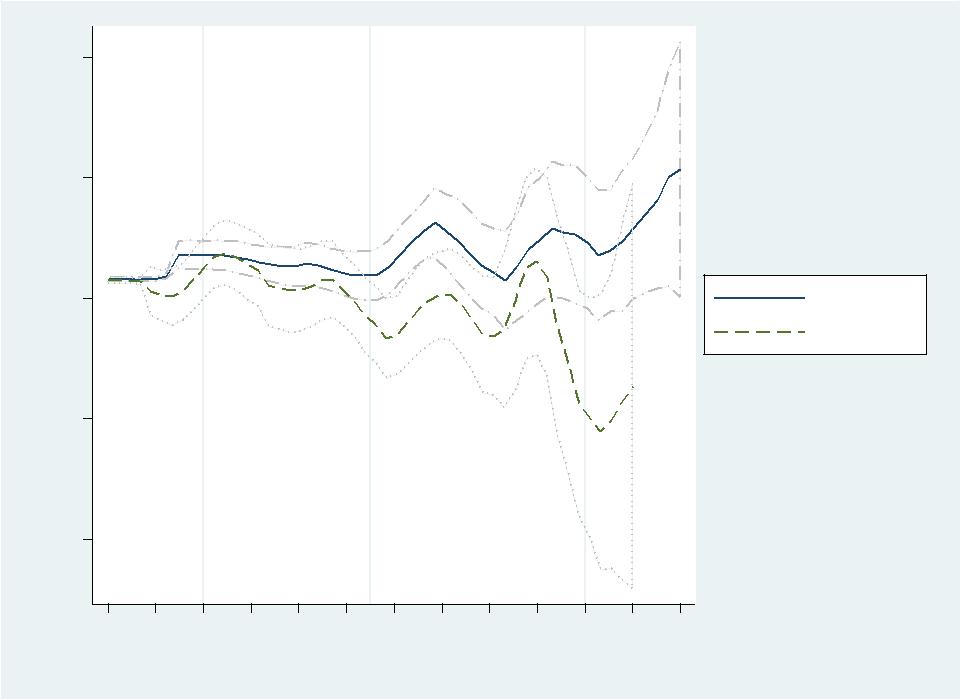
Figure 5: Kernel-weighted local polynomial regression of employment status on diabetes duration.



|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | .8 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | .6 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Employment | .4 |  |  |  |  |  |  |  |  |  |  |  | Males |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | Females |  |
| .2 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 0 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |  |
|  |  |  |  |  | Years since diagnosis | | | | |  |  |  |  |  |

*Notes* The dotted lines around the main line show 95% confidence intervals.

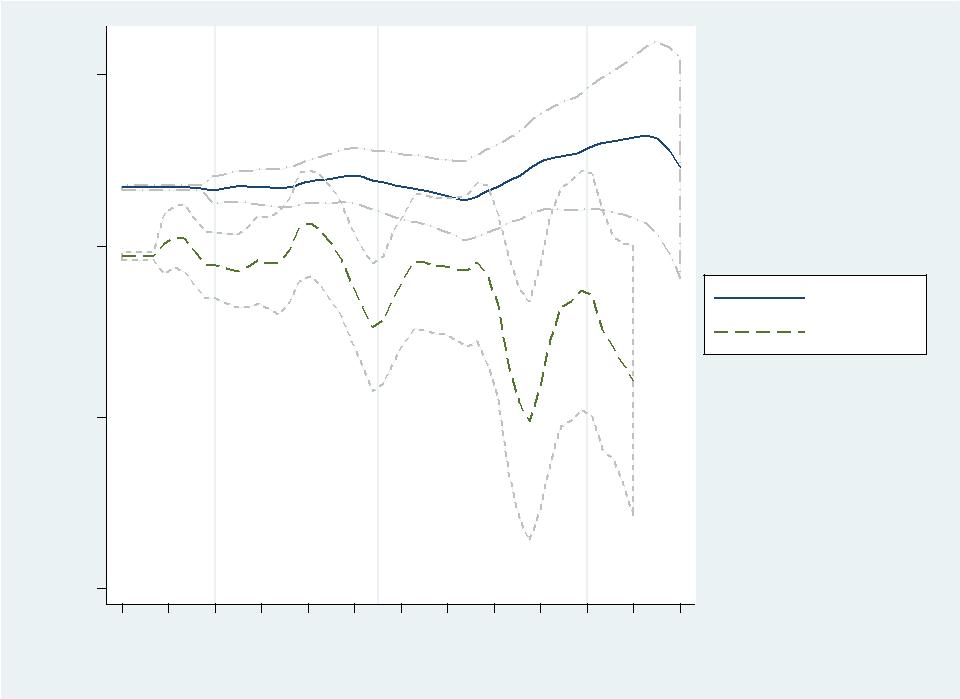
Figure 6: Kernel-weighted local polynomial regression of log hourly wages on diabetes duration.



|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| wage |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Log hourly | 3 |  |  |  |  |  |  |  |  |  |  |  | Males |  |
|  |  |  |  |  |  |  |  |  |  |  |  | Females |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |  |
|  |  |  |  |  | Years since diagnosis | | | | |  |  |  |  |  |

*Notes* The dotted lines around the main line show 95% confidence intervals.

Figure 7: Kernel-weighted local polynomial regression of working hours on di-abetes duration.



|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| hours | 40 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| working |  |  |  |  |  |  |  |  |  |  |  |  | Males |  |
|  |  |  |  |  |  |  |  |  |  |  |  | Females |  |
| Weekly | 20 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 0 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |  |
|  |  |  |  |  | Years since diagnosis | | | | |  |  |  |  |  |

*Notes* The dotted lines around the main line show 95% confidence intervals.

Tables  [19](#page129) and  [20](#page130) presents the results of the linear and non-linear duration models (for which we created the following splines to capture the immediate, intermediate and long-term relationships: 0–4, 5–11, 12–19 and 20+), starting with the results of the cross-sectional  [LPM,](#page14) followed by the pooled  [LPM](#page14) and then the FE model as specified in Eq.  [(4.3)](#page116) and Eq.  [(4.4](#page116)).

For employment probabilities (Table  [19)](#page129) the results indicate a yearly reduc-tion in male employment probability throughout. For women the coeﬃcient shows a reduction of up to almost 1 percentage points per year, though the association is not as strong in the FE model. The coeﬃcients in the spline models provide some evidence for an immediate eﬀect of diabetes, which then levels oﬀ for some time after which it becomes stronger again. Nonetheless, for males and particularly females, the coeﬃcients are quite imprecisely measured.

Turning to wages (Table  [20),](#page130) the FE model indicates a reduction in female wages of about 7% per year with diabetes. For men we find no consistent ef-fect. The results of the non-linear specification indicate that there may be a reduction in wages 5–11 years after the initial diagnosis. We also find asso-ciations for women with more than 20 years of diabetes, but these estimates may be spurious due to the considerably reduced number of observations in

Table 19: Relationship between self-reported years since diagnosis and employ-ment probabilities using continuous duration and duration splines.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Males |  |  |  | Females |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | (1) | (2) | (3) |  | (4) | (5) | (6) |  |  |
|  | OLS | OLS | FE |  | OLS | OLS | FE | |  |
|  | (wave 3) | (pooled) |  |  | (wave 3) | (pooled) |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Panel A: linear | −.008∗∗∗ | −.007∗∗∗ | −.017∗∗∗ |  | −.005∗∗∗ | −.004∗∗∗ | −.009∗ | |  |
| Diabetes duration |  |  |
|  | (.002) | (.002) | (.006) | (.002) | | (.001) | (.005) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Hausman test |  |  | 153.024 |  |  |  | 200.073 |  |  |
| p-value |  |  | 0.000 |  |  |  | 0.000 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Panel B: splines |  |  |  |  |  |  |  |  |  |
| Diabetes duration | −.007 | −.007 | −.026∗ |  | −.010 | −.015∗∗ | −.017 | |  |
| 0–4 |  |  |
|  | (.007) | (.006) | (.014) | (.007) | | (.006) | (.016) |  |  |
| 5–11 | 0.000 | −.003 | −.003 |  | −.004 | 0.004 | −.003 | |  |
|  | (.009) | (.006) | (.009) | (.008) | | (.006) | (.008) |  |  |
| 12–20 | −.030∗∗ | −.017∗ | −.029∗ | 0.005 | | −.004 | −.014 | |  |
|  | (.012) | (.010) | (.016) | (.008) | | (.006) | (.011) |  |  |
| > 20 | 0.011 | 0.007 | −.046∗ |  | −.010∗ | −.003 | −.015 | |  |
|  | (.016) | (.014) | (.028) | (.006) | | (.003) | (.018) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Hausman test |  |  | 161.953 |  |  |  | 198.692 |  |  |
| p-value |  |  | 0.000 |  |  |  | 0.000 |  |  |
| N | 8217 | 16292 | 16292 | 10467 | | 22407 | 22407 |  |  |

*Notes* The table presents the results of three estimation methods. Panel A presents the results of the linearspecifications. Panel B presents the results of the non-linear specifications. Robust standard errors in paren-theses. Other control variables: state dummies, urbanization dummies, education dummies, married dummy, number children < 6, wealth, age squared and calendar year dummies. The OLS and pooled OLS models additionally control for age. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 20: Relationship between self-reported years since diagnosis and log hourly wage / weekly working hours using continuous duration and duration splines.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Males |  |  |  | Females |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | (1) | (2) | (3) |  | (4) | (5) | (6) |  |  |
|  | OLS | OLS | FE |  | OLS | OLS | FE | |  |
|  | (wave 3) | (pooled) |  |  | (wave 3) | (pooled) |  |  |  |
|  |  |  |  | | |  |  |  |  |
|  |  |  | **Log hourly wages** | | |  |  |  |  |
| Panel A: linear |  |  | −.019 |  | −.014∗ | −.009 | −.073∗∗ | |  |
| Diabetes duration | 0.001 | 0.010∗∗ |  |  |
|  | (.006) | (.005) | (.018) | (.008) | | (.008) | (.029) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Hausman test |  |  | 838.213 |  |  |  | 93.232 |  |  |
| p-value |  |  | 0.000 |  |  |  | 0.000 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Panel B: splines |  |  |  |  |  |  |  |  |  |
| Diabetes duration |  |  |  |  |  |  |  |  |  |
| 0–4 | 0.034∗ | 0.046∗∗∗ | 0.033 | 0.027 | | 0.030 | 0.015 |  |  |
|  | (.017) | (.016) | (.055) | (.031) | | (.026) | (.138) |  |  |
| 5–11 | −.041∗ | −.037∗∗ | −.055∗ |  | −.039 | −.034 | −.101∗ | |  |
|  | (.021) | (.018) | (.033) | (.030) | | (.024) | (.056) |  |  |
| 12–20 | 0.015 | 0.044 | 0.062 |  | −.032 | −.071∗ | −.051 | |  |
|  | (.033) | (.029) | (.056) | (.042) | | (.039) | (.047) |  |  |
| > 20 | 0.053 | 0.014 | −.111 |  | −.007 | 0.041∗∗∗ | −.204∗∗∗ | |  |
|  | (.054) | (.040) | (.104) | (.028) | | (.015) | (.053) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Hausman test |  |  | 1037.290 |  |  |  | 96.266 |  |  |
| p-value |  |  | 0.000 |  |  |  | 0.000 |  |  |
| N | 5509 | 10767 | 10767 | 2874 | | 5741 | 5741 |  |  |
|  |  |  |  | | |  |  |  |  |
|  |  |  | **Weekly working hours** | | |  |  |  |  |
| Panel A: linear |  |  |  |  | −.020 | −.124 |  |  |  |
| Diabetes duration | 0.069 | 0.048 | 0.181 |  | 0.208 |  |  |
|  | (.124) | (.102) | (.330) | (.187) | | (.127) | (.652) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Hausman test |  |  | 704.904 |  |  |  | 107.709 |  |  |
| p-value |  |  | 0.000 |  |  |  | 0.000 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Panel B: splines |  |  |  |  |  |  |  |  |  |
| Diabetes duration | −.033 | −.233 |  |  |  |  |  |  |  |
| 0–4 | 0.709 | 0.739 | | 0.470 | 2.014 |  |  |
|  | (.421) | (.325) | (.938) | (.645) | | (.586) | (2.947) |  |  |
| 5–11 | 0.269 | 0.338 | −.218 |  | −.410 | −.479 | −.508 | |  |
|  | (.539) | (.399) | (.568) | (.728) | | (.553) | (1.020) |  |  |
| 12–20 | 0.209 | 0.137 | 0.698 |  | −.164 | −.051 | −.402 | |  |
|  | (.730) | (.538) | (.945) | (.995) | | (.700) | (1.207) |  |  |
| > 20 | −1.300 | −.768 | 0.039 |  | −.499 | −.418 | 8.117∗∗∗ | |  |
|  | (.944) | (.930) | (2.184) | (.930) | | (.305) | (1.612) |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Hausman test |  |  | 724.225 |  |  |  | 112.627 |  |  |
| p-value |  |  | 0.000 |  |  |  | 0.000 |  |  |
| N | 6807 | 13581 | 13581 | 3591 | | 7383 | 7383 |  |  |

*Notes* The table presents the results of three estimation methods for the two dependent variables: loghourly wages and weekly working hours. Panel A presents the results of the linear specifications. Panel B presents the results of the non-linear specifications. Robust standard errors in parentheses. Other control variables: state dummies, urbanization dummies, education dummies, married dummy, number children < 6, wealth, age squared, calendar year dummies, type of work (agricultural and self employed with dependent non-agricultural wage employment as the base) and health insurance status. The OLS and pooled OLS models additionally control for age. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

this group.21. There appears to be no consistent relationship between working hours and time since being diagnosed with diabetes.

Overall these results suggest a fairly constant decrease in the probability of employment for both men and women and in earnings for women, which con-trast with estimates for the USA (Minor,  [2013),](#page297) where no such linear relation-ship is observed. Minor  [(2013)](#page297) finds a reduction in employment probabilities of 82 percentage points for females after 11 to 15 years and a reduction of 60 percentage points for males after 2-5 years, indicating very large employment penalties, in particular in comparison to our results for Mexico. However, our non-linear results are not directly comparable to these estimates as Minor used pooled cross-sectional data, constructed dummy variables instead of splines and used diﬀerent duration groups.22

**4.5.3 Cross-sectional biomarker analysis**

In this section we gain additional insights from using the biomarker data col-lected in the third wave of the  [MxFLS.](#page15) As noted in section  [4.3,](#page107) these data enable us to identify respondents with  [HbA1c](#page14) levels equal to or above the internationally recognized diabetes threshold of 6.5%. This will allow the in-vestigation of the direction of bias introduced when relying on self-reported diabetes only and when it is not possible to identify those unaware as well.

We first present a cross tabulation of self-reported diabetes and the results of the biomarker analysis (Table  [21](#page132)). The table indicates that 27% of the sample have  [HbA1c](#page14) levels indicative of diabetes and 81% of those self-reporting a diabetes diagnosis also have  [HbA1c](#page14) levels equal to or above the diabetes threshold. Overall, of the people with diabetes according to biomarker analysis, 32% self-report a diagnosis, while 68% do not.

1. There are only 9 and 3 observations for male and female wages with more than 20 years since diagnosis in wave 3, respectively, and similarly 17 and 7 in the pooled sample, respectively. For male and female working hours there are 12 and 7 observations with more than 20 years since diagnosis in wave 3, respectively, and 20 and 12 for the pooled

sample, respectively.

22We estimated a comparable model to that of Minor  [(2013)](#page297) using dummy variables and find a significant reduction in employment chances throughout, regardless of whether we use our duration groups to construct the dummies or the duration groups used by Minor  [(2013](#page297)). For men, we find a significant reduction of about 6 to 12 percentage points, depending on the used specification, in the first 2 and 4 years after diagnosis, respectively. In the following years the eﬀect size tends to increase somewhat. For women, we find less evidence for an immediate eﬀect of diagnosis, but eﬀects do emerge after about 2 years of living with the disease and also increase somewhat over time. These results are available on request.

Table 21: Number of observations with diabetes (HbA1c ≥ 6*.*5%) and self-reported diabetes.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *HbA*1*c <* 6*.*5% | HbA1c ≥ 6*.*5% | Total |
| No self-reported diabetes | 4544 | 1181 | 5725 |
|  | 79% | 21% | 100% |
|  | 97% | 68% | 89% |
| Self-reported diabetes | 129 | 554 | 683 |
|  | 19% | 81% | 100% |
|  | 3% | 32% | 11% |
| Total | 4673 | 1735 | 6408 |
|  | 73% | 27% | 100% |
|  | 100% | 100% | 100% |

*Notes* The first row of each category presents absolute values, the second rowrow percentages and the third row column percentages.

To further investigate the relationship of self-reported and biomarker tested diabetes, we estimate the models presented in section  [4.4.3.](#page117) The results in columns 1 and 2 of Table 22 show that the earlier results are robust for the biomarker sample. The coeﬃcients in column 3 and 4 indicate that the asso-ciations with employment probabilities are much weaker when using diabetes defined by the biomarker instead of self-reported diabetes.23 In columns 5 and 6, obtained from estimating Eq.  [4.7,](#page119) the coeﬃcient for the biomarker diabetes population *Dbioi* now reflects the eﬀect of undiagnosed diabetes, as the regres-sion includes a control for self-reported diabetes, revealing that undiagnosed diabetes is not associated with any of the labour outcomes. The coeﬃcient for self-reported diabetes is marginally bigger in size for men and somewhat smaller for women compared to column 1 and 2, respectively. However, these diﬀerences are not statistically significant (p>0.1) using a Z-test, suggesting that not accounting for undiagnosed diabetes will likely leave the estimates of self-reported diabetes unbiased.

As discussed earlier, diﬀerences in eﬀects between self-reported diabetes and those undiagnosed are likely to stem from selection into the diagnosed popula-tion, for instance those in worse health or higher  [HbA1c](#page14) levels are more likely to go to the doctor and be diagnosed as well as to lose their job because of their diabetes. To further explore this, we first estimate models additionally controlling for self-reported health status to capture diﬀerences in subjective individual health. Secondly, we investigate in how far diﬀerences in measured  [HbA1c,](#page14) as a proxy for diabetes severity, may explain diﬀerences in employment eﬀects of self-reported and undiagnosed diabetes. To this end we estimate Eq.  [4.7](#page119) additionally controlling for  [HbA1c](#page14) levels.

When additionally controlling for subjective health status, we find that for men and women the diﬀerence between self-reported diabetes and undiagnosed diabetes is reduced due to a smaller coeﬃcient for self-reported diabetes (Ta-ble  [23,](#page135) Panel A). Especially for females, the point estimates for self-reported diabetes and undiagnosed diabetes are now virtually the same size, suggesting that diﬀerences can be almost exclusively explained by self-reported health. For men, factors not captured by self-reported health may still play a role. Additionally accounting for measures of overweight and obesity, self-reported

23We also created a dummy variable that additionally to measured diabetes accounted for those with a self-reported diabetes diagnosis but biomaker levels below the diabetes threshold. This allowed us to investigate the eﬀect for the entire diabetes population. The coeﬃcients and their statistical significance are only marginally diﬀerent to those presented in columns 3 and 4 of Table  [22,](#page134) which is why we do not present them here.

Table 22: Biomarker results

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Self-reported diabetes | |  | HbA1c ≥ 6.5 | |  | HbA1c ≥ 6.5 and self-reported d. | | |  |
|  | (1) | (2) |  | (3) | (4) |  | (5) | (6) |  |  |
|  | Males | Females |  | Males | Females |  | Males | Females | |  |
|  | | |  |  |  |  |  |  |  |  |
| **Dependent variable: Employment** | | |  |  |  |  | −.053∗∗ | −.032 | |  |
| Self-reported diabetes | −.051∗∗ | −.044∗ |  |  |  |  |  |
| HbA1c ≥ 6.5 | (.026) | (.023) |  | −.012 | −.031∗ | (.026) | | (.026) |  |  |
|  |  |  | 0.003 | | −.022 | |  |
|  |  |  | (.016) | | (.018) | (.017) | | (.019) |  |  |
|  |  |  |  | |  |  | |  |  |  |
| N | 2785 | 3623 | 2785 | | 3623 | 2785 | | 3623 |  |  |
|  | | | | |  |  |  |  |  |  |
| **Dependent variable: Log hourly wages** | | | | |  |  |  |  |  |  |
| Self-reported diabetes | −.010 | −.040 |  |  |  |  | −.006 | −.010 | |  |
| HbA1c ≥ 6.5 | (.065) | (.113) |  | −.007 | −.057 | (.078) | | (.119) |  |  |
|  |  |  |  | −.006 | −.055 | |  |
|  |  |  | (.044) | | (.070) | (.049) | | (.075) |  |  |
|  |  |  |  | |  |  | |  |  |  |
| N | 1803 | 884 | 1803 | | 884 | 1803 | | 884 |  |  |
|  | | | | |  |  |  |  |  |  |
| **Dependent variable: Weekly working hours** | | | | |  |  |  |  |  |  |
| Self-reported diabetes | −.293 | −.751 |  |  |  |  | −.286 | −1.566 | |  |
| HbA1c ≥ 6.5 | (1.305) | (2.178) |  | −.088 |  | (1.419) | | (2.351) |  |  |
|  |  |  | 1.153 |  | −.012 | 1.525 |  |  |
|  |  |  | (.844) | | (1.462) | (.925) | | (1.565) |  |  |

*Notes* Community level fixed eﬀects. Robust standard errors in parentheses. Other control variables: age,age squared, state dummies, urbanization dummies, education dummies, married dummy, number children < 6 and wealth. Calender year dummies are included as data collection for the third wave was stretched out over several years. The wage and working hour models additionally control for type of work (agricultural and self employed with non-agricultural wage employment as the base) and for health insurance status. ∗ *p <* 0*.*10,∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01..

Table 23: Self-reported diabetes, biomarkers, diabetes severity and self-reported health and their association with labour market outcomes

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Employment | |  | Log hourly wages | |  | Weekly working hours | | |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  | (5) | (6) |  |  |
|  | Males | Females |  | Males | Females |  | Males | Females | |  |
|  | | |  |  |  |  |  |  |  |  |
| **Panel A (self-reported health)** | | |  |  |  |  |  | −2.191 | |  |
| Self-reported diabetes | −.036 | −.023 | 0.002 | | 0.060 | 0.123 | |  |
| Hba1c ≥ 6*.*5% | (.026) | (.027) | (.079) | | (.121) | (1.433) | | (2.386) |  |  |
| 0.003 | −.023 |  | −.004 | −.051 |  | −.066 | 1.829 |  |  |
|  | (.017) | (.019) | (.049) | | (.075) | (.926) | | (1.569) |  |  |
| Self-reported health status | |  |  |  | −.115 |  | −1.131 |  |  |  |
| good | 0.023 | 0.057∗ | 0.061 | |  | 3.521 |  |  |
|  | (.025) | (.034) | (.074) | | (.124) | (1.376) | | (2.499) |  |  |
| fair | −.007 | 0.006 | 0.025 | | −.157 |  | −1.606 | 4.646∗ | |  |
|  | (.026) | (.034) | (.076) | | (.128) | (1.424) | | (2.607) |  |  |
| bad | −.127∗∗∗ | −.024 |  | −.016 | −.371∗ |  | −6.190∗∗ | 6.918∗ | |  |
|  | (.043) | (.046) | (.135) | | (.189) | (2.521) | | (3.858) |  |  |
| very bad | −.165 | 0.117 |  | −.331 | 0.316 |  | −1.869 | −17.400∗ | |  |
|  | (.110) | (.116) | (.300) | | (.439) | (6.433) | | (9.005) |  |  |
|  |  |  |  | |  |  | |  |  |  |
| N | 2785 | 3621 | 1803 | | 883 | 2302 | | 1143 |  |  |
|  | |  |  |  |  |  |  |  |  |  |
| **Panel B (HbA1c levels)** | | −.027 |  | −.007 |  |  |  | −1.440 | |  |
| Self-reported diabetes | −.056∗ |  | 0.002 | 0.076 | |  |
|  | (.031) | (.025) | (.068) | | (.114) | (1.362) | | (2.382) |  |  |
| HbA1c ≥ 6*.*5% | −.005 | −.005 |  | −.010 | −.019 | 1.032 | | 1.887 |  |  |
|  | (.023) | (.026) | (.060) | | (.099) | (1.279) | | (2.490) |  |  |
| HbA1c | 0.003 | −.006 | 0.001 | | −.012 |  | −.364 | −.122 | |  |
|  | (.005) | (.006) | (.013) | | (.021) | (.279) | | (.514) |  |  |
|  |  |  |  | |  |  | |  |  |  |
| N | 2785 | 3623 | 1803 | | 884 | 2302 | | 1144 |  |  |

*Notes* Community level fixed eﬀects. Robust standard errors in parentheses. Other control variables:age, age squared, state dummies, urbanization dummies, education dummies, married dummy, number children < 6 and wealth. Calender year dummies are included as data collection for the third wave was stretched out over several years. The wage and working hour models additionally control for type of work (agricultural and self employed with non-agricultural wage employment as the base) and for health insurance status. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

hypertension, heart disease and depression does not further aﬀect the interpre-tation of the diabetes coeﬃcient (results available on request).

Turning to Panel B, we do not find an indication that diﬀerences in  [HbA1](#page14)c levels are driving the diﬀerent employment eﬀects of diabetes for the aware and unaware. We therefore conclude that current diabetes severity is likely not associated with any labour outcome and does not explain the diﬀerence in eﬀects between diagnosed and undiagnosed diabetes.

To the best of our knowledge only one study has previously used biomarkers to analyze the relationship with labour market outcomes in a comparable popu-lation. Brown, Perez, et al.  [(2011)](#page285) use data for a Mexican American population in a broadly comparable way to this paper, though stopping short of investi-gating the labour market impact of undiagnosed diabetes. In concordance with our results this study also finds that once diabetes is diagnosed, current man-agement plays a minor role in determining labour market outcomes. This is not surprising given that  [HbA1c](#page14) levels only provide a picture of blood glucose levels over the last three months. They therefore may not be representative of blood glucose levels in the years before and after the diabetes diagnosis which ultimately determine how soon complications appear and how severe they will be.

**4.6 Conclusion**

Diabetes has become one of the most common chronic diseases in middle-and high-income countries, with the potential to severely impact the health and economic well-being of those directly (and possibly indirectly) aﬀected. Yet there remains only limited ’hard’ evidence on the economic consequences, especially for these countries. Moreover, what evidence does exist at best partially tackles the econometric challenges involved.

This paper improves on existing work by addressing several methodological challenges that arise due to the nature of the disease and types of data available, using rich longitudinal panel data from Mexico, a  [MIC](#page14) for which the biomarker data used in this paper indicates that diabetes, including undiagnosed diabetes, has reached alarming levels.

Apart from providing unique evidence for a developing country, the paper makes methodological contributions for the estimation of labour market eﬀects of diabetes. By estimating individual fixed eﬀects the analysis provides an improved accounting for the endogeneity of self-reported diabetes, as this allows

cancelling out the potential role of unobserved individual traits that may aﬀect both labour market outcomes and propensity to self-report (or suﬀer from) diabetes. Using further information on the year of diagnosis enables us to investigate the potential heterogeneity in the eﬀect of self-reported diabetes on labour market outcomes over time. Finally, taking advantage of biomarker data to identify the entire diabetes population, i.e. including those with undiagnosed diabetes, allows for an assessment of the potential bias in estimates relying on self-reported diabetes (which is still the most frequent measure in the previous literature).

The first part of our results confirms a considerable gap in employment prob-abilities for both men and women reporting a diabetes diagnosis, compared to those that do not report the condition. Especially women have to deal with a considerable relative reduction in their employment probabilities. We also find some evidence that diabetes is more likely to reduce the probability of employment in the agricultural and self-employment sector, characterized pre-dominantly by informal arrangements, compared to the rest of the workforce. Those who remain employed do not suﬀer any wage or labour supply eﬀects, possibly because they are still relatively healthy or are able to resort to a type of work that does not entail their diabetes status limiting their work-related performance. More research will be needed to confirm and further investigate this finding as well as its interpretation.

Regarding the heterogeneity in the eﬀects of diabetes over time, our results indicate an adverse impact of self-reported diabetes on employment chances, with the impact growing in magnitude especially after the first 10 years post-diagnosis. This is plausible in that as time lived with diabetes evolves, compli-cations associated with diabetes tend to become more frequent and more severe (Adler et al.,  [2003](#page281)). Looking at wages as our labour market outcome, we un-cover some adverse eﬀects for females, indicating a sizeable reduction with time since diagnosis. Interestingly, theses reductions in wages appear more or less where no employment eﬀects are found, suggesting that after the initial em-ployment shock fo the diagnosis, reductions in productivity are more levelled, leading only to reductions in wages but not to job loss, at least until further more debilitating complications appear after additional years with the disease. These findings may bode ill for countries were diabetes has started appearing at an increasingly younger age, causing people to live with the disease for larger parts of their productive lifespan, possibly exacerbating the economic eﬀects of reduced employment due to diabetes (Hu,  [2011;](#page292) Villalpando et al.,  [2010](#page305)).

The second part of our results indicates that only relying on self-reported diabetes can lead to an overestimation of the relationship between diabetes and labour market outcomes. We find that a negative relationship only exists for those with self-reported, but not for those with undiagnosed diabetes. This perhaps surprising, notable diﬀerence, is at least mediated by the subjective health status being worse for those self-reporting compared to the undiagnosed. Current disease severity, as proxied by  [HbA1c](#page14) levels, does not appear to play an important role in this context.

Our findings bear several implications. First, when interpreting labour mar-ket impact estimates relying on self-reported diabetes, one cannot assume that the results extend to those with undiagnosed diabetes. However, the strategy of simply merging self-reported and undiagnosed in one diabetes category may not be ideal, as doing so will fail to account for the heterogeneity between the groups in the amount of health information they possess, the time they have already been exposed to elevated blood glucose levels and consequently their subjective as well as true health status, leading to a potentially important loss of information. If, by contrast, both groups are separately accounted for in the model, thereby acknowledging their inherent diﬀerences, this allows us to gain information about the distribution of the economic burden across the two groups.

Further, the results of the biomarker analysis also reveal that the coeﬃcient of self-reported diabetes is not strongly aﬀected when accounting for biomarker diagnosed diabetes, suggesting that using self-reported diabetes still provides largely unbiased estimates. The latter estimates should then of course only be used to draw conclusions about the eﬀect of self-reported diabetes, not of diabetes overall. In the case of Mexico, given that more than 7% of the Mexi-can population have been diagnosed with diabetes, the identified reduction in employment probabilities still amounts to a significant overall economic burden being associated with (diagnosed) diabetes.

Our results add further weight to the case for reducing the incidence and progression of diabetes. On top of the well-documented health benefits, it ap-pears there are considerable potential gains to be had in terms of increasing the productive lifespan of people. This is of particular importance in LMICs, where parental health shocks, related job loss and increasing health expenditures can have repercussions across the entire household. Other family members, in-cluding children, may be forced to increase their labour supply and to reduce non-health expenditures in order to prevent deterioration of the household’s

economic situation. This can lead to forgone investments into child education, showcasing the potential for adverse long-term eﬀects of health shocks due to diabetes (Bratti and Mendola,  [2014](#page285)). Moreover, the large proportion of undi-agnosed people indicates that diagnosis—at least in Mexico—happens too late or not at all, thereby significantly reducing the possibility to prevent complica-tions via appropriate treatment and self-management, which has repercussions by increasing the risk of severe complications appearing early. Hence, much of the health and economic burden may be prevented by earlier diagnosis and, given the generally limited success in achieving good control in Mexico, bet-ter treatment of those already diagnosed with diabetes. Ultimately of course, there will be a need to invest in the prevention of diabetes cases in the first place. Taxation of sugar sweetened beverages may be one promising way for-ward (Colchero et al.,  [2016),](#page287) though the long-term eﬀects in terms of diabetes prevention remain to be demonstrated.

**5 The relationship between diabetes, employment status and behavioural risk factors: An application of marginal structural models and fixed eﬀects to Chinese panel data**

**Pre-amble**

Chapters  [3](#page74) and  [4](#page101) provided evidence of the adverse impact of self-reported di-abetes on employment probabilities in Mexico. However, if this is also the case in other middle-income countries (MICs) is unclear. Chapter  [5](#page140) intents to provide further evidence using panel data covering a period of rapid economic transition in China. It further provides information about the ability of peo-ple with diabetes achieving changes in behavioural risk factors important for the prevention of diabetes complications, as studies have shown that smoking cessation and weight loss after a diagnosis can have beneficial eﬀects on blood glucose control and the risk of complications.

This study again faces the problem of the potential endogeneity of diabetes. It uses an already established approach with the fixed eﬀects  [(FE)](#page14) estimator. However, it adds a further identification strategy by making use of marginal structural models  [(MSMs),](#page14) a strategy widely applied in epidemiology to ac-count for time-variant confounding, where prior outcomes aﬀect the current treatment, namely diabetes. This potential source of bias has been assumed to not exist in previous applications, but could potentially have biased the es-timate of the eﬀect of diabetes on labour market outcomes. Accordingly, the

study makes several contributions: It provides information about the robust-ness of the identified relationship of diabetes on employment status by using an alternative estimation strategy in a diﬀerent setting, thereby also taking into account the potential eﬀect of behavioural risk factors, and it gives first evidence in how far people with diabetes in China are able to change their behavioural risk factors after a diabetes diagnosis.

**Abstract**

A diabetes diagnosis entails important consequences for its recipi-ents. Diagnosed patients obtain health information but also face the challenge of having to manage the condition via lifestyle adjustments, with potential consequences for—among other things—their economic activity. We investigate the causal eﬀect of a diabetes diagnosis on employment status and behavioural risk-factors, two potentially inter-twined factors, using longitudinal data from the China Health and Nu-trition Survey  [(CHNS)](#page14) that cover the years 1997 to 2011. Two com-plementary statistical techniques—marginal structural models and fixed eﬀects panel estimation—are used for the statistical analysis, and gen-erate very similar results despite their diﬀerent underlying assumptions. Both strategies find distinct patterns for males and females. They sug-gest a decrease in female employment chances after a diagnosis (over 11 percentage points) and further show that women are mostly unable to positively change their behavioural risk factors by loosing weight and reducing energy intake. Men, however, do not see their employment probabilities aﬀected by diabetes and also respond to a diagnosis by los-ing weight and reducing energy intake as well as their intake of alcohol in ways that are sustained over time. These results suggest important inequities in the impact of diabetes between sexes in China and point to the potential of reducing behavioural risk factors for women to narrow these inequities.

**5.1 Introduction**

The eﬀect of diabetes on employment status has received relatively little at-tention in MICs, including China. The scarce existing evidence indicates that diabetes can aﬀect labour market outcomes in high-income countries (HICs), but also in MICs (Seuring, Serneels, et al.,  [2016](#page303)). This is of growing relevance especially with diabetes appearing increasingly earlier in a person’s productive lifespan, among others due to increasing obesity at earlier ages. Importantly, once diagnosed, the onset of diabetes, and diabetes complications, strongly depend on the patient’s behaviour. Behavioural risk factors like alcohol con-sumption, smoking, caloric consumption and weight gain are all related to the onset of diabetes as well as ensuing diabetes complications. Research shows for instance that behaviour changes after a diabetes diagnosis can have positive health eﬀects and reduce the risk of subsequent cardiovascular events (Long et

al.,  [2014)](#page295) and may help in eﬀectively managing blood glucose levels and achiev-ing further treatment goals (Zhou, Ji, et al.,  [2016](#page308)). Consequently, if these risk factors can be reduced it may be possible to prevent some of the health and economic burden of diabetes. Thus, it seems that a diabetes diagnosis may present an important opportunity to reduce risk factors for diabetes compli-cations (De Fine Olivarius et al.,  [2015)](#page288) and hence also reduce the economic burden of diabetes to the individual. This raises the question how diabetes diagnosis aﬀects both labour outcomes and health behaviour over time.

However, one of the challenges of determining a causal relationship between diabetes, employment status and changes in behavioural risk factors is their potential interrelatedness. For example, employment status might by aﬀecting weight status by reducing the time spend on physical activity due to reduc-tions in available leisure time, or it may promote risk factors such as smoking behaviour or energy intake that can both aﬀect the probability of developing diabetes as well as diabetes related complications, for instance by increasing stress levels. In an eﬀort to investigate the dynamic impact of unemployment on health behaviours, Colman and Dave  [(2014)](#page287) found heterogeneous eﬀects of unemployment, with it leading to slight weight gain, a decrease in smoking and decreases in fast-food consumption. Macroeconomic evidence also indi-cates that job loss can lead to changes in health, especially in mental health (Charles and Decicca,  [2008),](#page286) which may have further downstream eﬀects on health behaviours.

Research on the impact of diabetes on labour market outcomes has so far ignored the potentially simultaneous relationship of diabetes with employment and behavioural diabetes risk factors. Using regression techniques such as ordi-nary least squares  [(OLS)](#page15) or FE it is assumed that the investigated independent variables are unaﬀected by prior values of the dependent variable. However, if prior changes in employment status are causally related to a diabetes diagnosis or aﬀect the risk factors for diabetes complications, not accounting for this can lead to biased estimates.1 Similarly, studies investigating the impact of a diabetes diagnosis on behavioural risk factors while not taking into account the eﬀect of employment status on both diabetes and these risk factors, may pro-

1One solution is to include lagged values of the dependent variable on the right hand side, but this raises challenges of its own, including diﬃculty of interpretation, but also potentially biased estimates. The lagged dependent variable will be correlated with the time-invariant part of the error-term, violating the assumption of exogeneity of the right-hand side variables. Further, if the other covariates are correlated with the lagged-dependent variable, they will also be biased (Anderson and Hsiao,  [1982;](#page281) Nickell,  [1981](#page298)).

duce biased estimates. Moreover, apart from time-varying confounding due to observed covariates, unobserved variable present a further challenge. In partic-ular time-invariant confounders, such as poor early life conditions or personal trades, may simultaneously increase the probabilities to develop diabetes, be unemployed and engage in unhealthy behaviour.

The goal of this study is therefore to assess the impact of a diabetes diagnosis on both employment probabilities and behavioural risk factors while account-ing for the potentially intertwined relationships between diabetes, employment and health behaviours. This is done via the use of  [MSMs,](#page14) an estimation strat-egy that is increasingly common in epidemiology and is able to account for time-dependent confounding across time (Robins et al.,  [2000)](#page301) when estimating the impact of a treatment, here a diabetes diagnosis, on the outcome of inter-est. This is, by our knowledge, the first time this estimation strategy is used to estimate the impact of diabetes on an individual’s employment status or behavioural risk factors. We complement this strategy and test the robustness of the  [MSM](#page14) estimates to the potential violation of one of its crucial assump-tions, namely that unmeasured confounding factors are not important. To do this, we compare them with FE models which, although unable to account for the potentially bidirectional relationship account for unobserved time-invariant confounding factors in addition to confounding due to observed variables. Very diﬀerent results to the  [MSM](#page14) would suggest a violation of the assumption of no unobserved confounding. To further investigate and understand the role of confounding factors, we also estimate random eﬀects  [(RE)](#page15) models and com-pare the results. also provides unique analytical insights. It further extends the evidence base for the impact of diabetes on labour outcomes in MICs, where currently empirical information is only available for Mexico (Seuring, Serneels, et al.,  [2016](#page303)). At the same time the study provides, as far as we are aware, the first longitudinal evidence for the eﬀect of a diabetes diagnosis on behavioural risk factors in any developing country.

More information about the eﬀects of a diabetes diagnosis may be particu-larly important for low- and middle-income countries (LMICs) such as China, where diabetes prevalence has surged from 1% in the early 1980s to about 10% in recent years (Hu,  [2011;](#page292) NCD Risk Factor Collaboration,  [2016](#page297)). Confronting this diabetes epidemic puts a strain on healthcare systems (Seuring, Archange-lidi, et al.,  [2015),](#page303) increasing the need to find highly cost-eﬀective prevention and treatment options in very resource constraint settings (Silink et al.,  [2010](#page303)). However, to do this it is important to assess how successful people with dia-

betes currently are in preventing adverse economic eﬀects and reducing their risk factors for diabetes complications.

The literature trying to identify a causal relationship between diabetes and employment has relied on instrumental variable  [(IV)](#page14) strategies (Brown, Pagán, et al.,  [2005;](#page285) Latif,  [2009;](#page294) Seuring et al.,  [2015)](#page303) and individual FE models (Seur-ing, Serneels, et al.,  [2016](#page303)). However, while an IV approach could potentially account for all forms of confounding, the validity of the used instruments is at least questionable (see discussion in Chapter 4). The FE model, as discussed above, also relies on important assumptions that may be violated. Turning to the relationship between a diabetes diagnosis and behavioural risk factors, only one study has intended to causally relate a recent diabetes diagnosis with changes in health behaviours in the USA, finding positive behaviour changes shortly after diagnosis. The study that the eﬀects were mostly short lived and tended to dissipate over time, particularly considering weight loss (Slade,  [2012](#page303)). To isolate the causal eﬀect Slade  [(2012)](#page303) created an "at risk" control group without diabetes that intended to be similar to the treatment group with diabetes, apart from not having received a diagnosis. He used informa-tion on diabetes biomarkers to estimate the propensity score of those without a diabetes diagnosis to be above a specific at risk threshold, so that everybody above a certain propensity score was used to form the control group. He then estimated dynamic population average models, including the lagged dependent variable on the right hand side, as well as FE models to identify a causal rela-tionship. While this approach likely improves the control group by increasing its similarity in the diabetes risk profile to the diagnosed population, the use of a lagged dependent variable may have biased the estimates due to unobserved time-invariant variables being correlated with the lagged dependent variable, violating the exogeneity assumption and potentially introducing bias in the other covariates. This is also true for the FE model (Anderson and Hsiao,  [1982;](#page281) Nickell,  [1981](#page298)). Further, the study did not account for employment status as one of the control variables.

A diﬀerent identification approach was used by Zhao, Konishi, et al.  [(2013](#page308)) when investigating the eﬀects of a hypertension diagnosis on nutritional out-comes in China. They used a regression-discontinuity design and biomarker information on blood pressure. A crucial assumption in the study was that people above the hypertension threshold were indeed informed about their hy-pertension while those just below the threshold were not. These two groups were then compared to isolate the particular eﬀect of the additional health

information on food consumption in the following wave. The results indicated that a diagnosis leads to reductions in fat consumption, but no other nutri-tional outcomes, and only for those economically better oﬀ. Several caveats exist for this study and the used approach. According to Zhao, Konishi, et al.  [(2013)](#page308) it was not always clear to what extent participants where informed about their hypertension status and whether they had received just the actual blood pressure measurement information, leaving the interpretation to the par-ticipants, or whether they were made explicitly aware of their hypertension (or also pre-hypertension) status. Further, the results may have limited general-isability, since the measured treatment eﬀect was a very local one, applying only to the population around the hypertension threshold. Finally, the study only provides information for a relatively short period until the first wave af-ter diagnosis, unable to capture any changes further away from the point of diagnosis.

Accordingly, there is a need to provide new evidence on the eﬀects of a di-abetes diagnosis on employment status as well as behavioural risk behaviours that could aﬀect the development of diabetes complications, using longitudinal data and alternative estimation strategies. Thereby this study adds in several ways to the existing literature. First, it shows the impact of diabetes diagnosis on labour outcomes in China, not only over the short term, but for a period covering the entire decade of the 2000s, allowing for a more long term investi-gation of the eﬀects. This both confirms and extends earlier evidence for other settings and using diﬀerent methods. Second, it provides information on the eﬀect of a diabetes diagnosis on health behaviours. Third, by considering the eﬀects over time on both employment and health behaviour, the results shed light on potential pathways through which the impact on employment may work. Fourth, the study provides a methodological innovation by using both  [MSM](#page14) and FE estimation methods, oﬀering insights not only on the robustness of the  [MSM](#page14) results, but also on the validity of some of its assumptions.

**5.2 Methods**

**5.2.1 Study sample**

The  [CHNS](#page14) is an international collaborative project led by the Carolina Popu-lation Center at the University of North Carolina at Chapel Hill investigating nutrition and health behaviours in nine provinces of China (Zhang, Zhai, et al.,

[2014](#page307)). We use data from 1997 onwards, which was the first time survey par-ticipants provided diabetes information. In total we use six waves (1997, 2000, 2004, 2006, 2009 and 2011) obtained from the longitudinal dataset released in 2015. The data provide extensive information on nutrition and health, includ-ing anthropometric measures of weight and height, reducing potential measure-ment issues. It further provides socioeconomic information, most importantly for this study about employment. The sample is limited to the adult popula-tion from age 18–64. The sample is not nationally representative and as such does not provide sampling weights (Popkin et al.,  [2010](#page299)).

Overall, between 84% to 90% of the survey participants are followed up in the consecutive wave, with attrition being highest after 2006. Attrition in the  [CHNS](#page14) due to mortality is around 1% (Popkin et al.,  [2010](#page299)). Other reasons mentioned by Popkin et al.  [(2010)](#page299) are loss in follow up due to migration, natural disasters and redevelopment of housing in the urban centres leading to relocations. We analysed if any of our variables of interest was significantly related to attrition at any wave and did only find lower calorie consumption and being unemployed to exhibit an association. Having diabetes was not related to attrition. Further, attrition was strongly related to urbanization, a higher level of education, being of younger age and having lower family income, suggesting that mostly participants of younger age, more urbanized but from less well-oﬀ households tended to leave the survey. Attrition rates between the waves are shown in Table  [42](#page266).

**5.2.2 Assessment of diabetes**

We used self-reported information on a diabetes diagnosis to construct our diabetes indicator. We only relied on incident cases of self-reported diabetes, excluding individuals with self-reported diabetes at baseline. Given the chronic nature of diabetes, we assumed that after the initial diagnosis diabetes persists for the rest of one’s life. This is a reasonable assumption given the medical evidence (Steven et al.,  [2016](#page304)).2 To construct a measure of diabetes duration for incidence cases we used self-reported information on the year of diagnosis. If we found that the year of diagnosis was reported to be before the last wave without a reported diagnosis, we used the midpoint between the last wave

* Recently, a study showed successful remission of at least 6 months in some patients after the initiation of a very low-calorie diet (Steven et al.,  [2016](#page304)). However, while this shows that type 2 diabetes may be reversible, this cannot be expected for patients diagnosed and currently treated in any healthcare system.

without diagnosis and the first wave with a diagnosis as the year of diagnosis.3

**5.2.3 Assessment of outcomes**

The economic outcome of interest is employment status, and is measured through self-reported response stating that the person is currently working. People who reported not to be working because they were student are ex-cluded, while those who are not working for any other reason, such as doing housework, being disabled or being retired, were included.

The behavioural outcomes we estimate are current smoking status, if alco-hol was consumed equal to or more than three times per week4, body mass index  [(BMI),](#page14) waist circumference in centimetres and daily calorie consump-tion. Smoking status and alcohol consumption are self-reported, while  [BM](#page14)I and waist circumference are based on anthropometric measurements, minimiz-ing potential reporting errors. Waist circumference is reported in centimetres. Finally, daily calorie consumption is a constructed variable available in the  [CHNS,](#page14) based on the average daily consumption of carbohydrates, protein and fat of every individual in the survey, measured on three consecutive days. As robustness tests, we also considered overweight and obesity indicators instead of a continuous weight variable. These results suggest similar patterns. Since there is considerable discussion about the correct thresholds to use for Asian populations to define overweight and obesity (He et al.,  [2015;](#page291) World Health Organization,  [2004;](#page306) Zeng et al.,  [2014),](#page307) we do not include these results in our main analysis but report them in appendix. We applied thresholds suggested by the China Obesity Task Force of a  [BMI](#page14) ≥ 24 to define overweight and a  [BMI](#page14) ≥ 28 to define obesity (China Obesity Task Force,  [2004](#page287)).

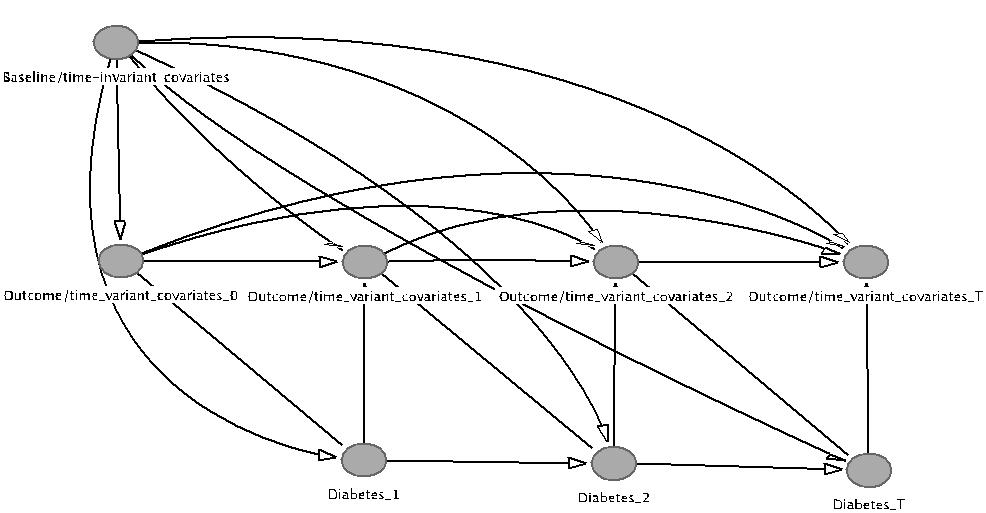
**5.2.4 Statistical analysis**

Our analysis focuses on two statistical approaches to account for potential confounding: marginal structural models  [(MSMs)](#page14) and fixed eﬀects  [(FE](#page14)).

3The number of observations replaced at each wave was: 21 (2000), 44 (2004), 51 (2006), 78 (2009), 59 (2011). Overall it aﬀected 43% of the self-reports of the year of diagnosis.

4We also estimated models investigating alcohol cessation instead of alcohol reduction, suggesting very similar eﬀects.

Figure 8: Direct acyclic graph for the marginal structural model



*Notes* [MSMs](#page14) *assume* the absence of unobserved time-invariant and unobserved time-variantconfounders but allow the past treatments to aﬀect the current outcomes (arrows going from Diabetes to time-variant covariates) and the past outcomes to aﬀect the current treatment (arrows going from time-variant covariates to Diabetes). Lagged time-variant covariates, baseline and time-invariant covariates predict current diabetes status.

**Marginal structural models**

[MSMs](#page14) apply inverse probability weights to adjust for confounding and selection bias as a result of time-varying confounders being aﬀected by prior exposure to the treatment (Robins et al.,  [2000](#page301)). Under the assumption of the  [MSM(Robin](#page14)s et al.,  [2000](#page301))—the reported treatment is the treatment that has actually been received (consistency), there are no unmeasured confounders (exchangeability) and every person in the sample has a non-zero chance of receiving the treatment (positivity) (see Section  [5.4](#page165) for a discussion of the validity of these assumptions in our case)—the causal direct acyclic graph  [(DAG)](#page14) shown in Figure  [8](#page149) displays the association between confounders and outcomes and a diabetes diagnosis.

In our context it seems possible that, for example,  [BMI](#page14) could aﬀect the probability of being diagnosed with diabetes which then itself may aﬀect sub-sequent  [BMI](#page14) levels, confounding the relationship between a diabetes diagnosis and  [BMI](#page14) due to non-random selection. Similarly, employment history and cur-rent employment could aﬀect the probability of a diabetes diagnosis through their impact on lifestyle and hence diabetes risk factors such as increases in weight or smoking. For example, an increase in disposable income or a reduc-tion in leisure time as a result of a new job and the subsequent eﬀect on risk behaviours could confound the relationship between a diabetes diagnosis and employment status.  [MSM](#page14) accounts for this by calculating weights based on the potential risk of a person being diagnosed at each point in time.

To calculate these weights we first construct unstabilized weights using base-line values of time-variant confounders, time-invariant confounders as well as time-variant confounders lagged by one period to predict the probability of developing diabetes at each wave. We use lagged time-variant confounders be-cause current diabetes status as reported in the survey was determined at some point within the current and the previous wave that were determined before the current diabetes status, to prevent reverse causality. The used predictors are age and age squared to account for changes in risk with increasing age, an index of urbanization pre-constructed within the  [CHNS](#page14) data, ranging from 1 to 120 as the level of urbanization increases (Zhang, Zhai, et al.,  [2014),](#page307) to account for the impact of urbanization on diabetes risk (Attard et al.,  [2012](#page282)). We also use secondary and university education, being married, having any medical in-surance, being of Han ethnicity, living in a rural area, dummies for the diﬀerent Chinese regions and the respective survey waves as predictors. Further we use inflation adjusted per-capita household income to adjust for eﬀects of house-hold wealth on diabetes. Finally, all outcome variables (employment status, alcohol consumption, smoking status,  [BMI,](#page14) waist circumference and average daily calorie consumption) are used as predictors.

Because unstabilized weights can be highly variable it is recommended to sta-bilize the weights (Cole and Hernan,  [2008](#page287)). Using the unstabilized weights as the denominator, stabilized weights are calculated by dividing the denominator by the predicted treatment propensity from a model using only time-invariant confounders and baseline information of the time-variant confounders as pre-dictors. Because our analysis is stratified by males and females, we create weights separately for both groups.

The  [MSMs](#page14) are estimated using  [OLS](#page15) for the continuous and a logistic model

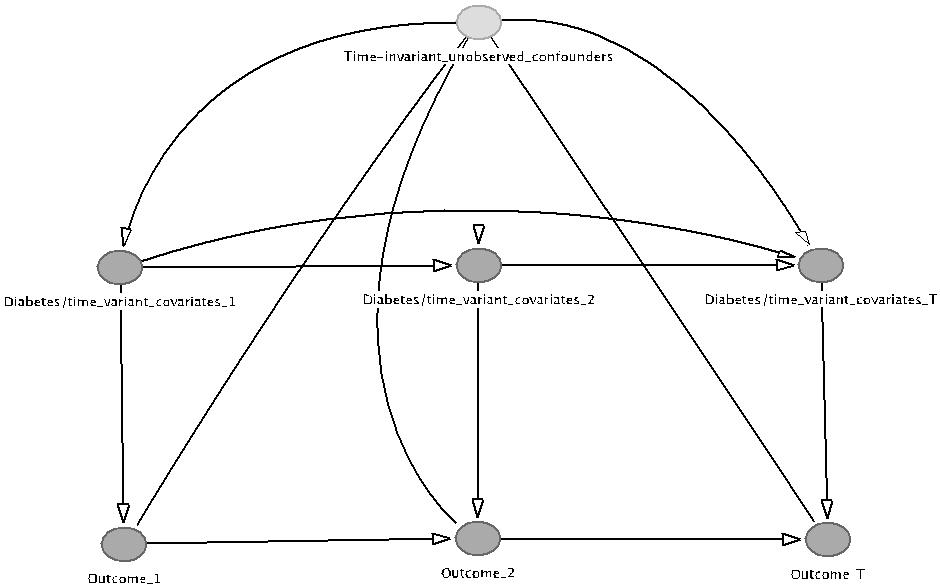
for the binary outcomes. For the logistic model we calculate average marginal eﬀects for greater comparability with the results of the FE models. All models are weighted by the stabilized weights constructed beforehand while adjusting for all baseline and time-invariant covariates used in the calculation of the sta-bilized weights, except for the respective outcome of interest. Robust standard errors to account for intra-class correlation of repeated outcome measurements in individuals are used throughout. In our primary analysis, we present the results of the  [MSM](#page14) with untruncated stabilized weights, as these provide theo-retically unbiased estimates, albeit they likely are less eﬃcient than truncated weights (Cole and Hernan,  [2008](#page287)). The distribution of the inverse probability weights supports this decision as there are no extreme values and the mean weight is 1 (see Table  [43](#page267)).

**Fixed eﬀects**

While the  [MSM](#page14) can account for pre-treatment selection on observable and time-variant confounders, it assumes that there are no unobserved time-invariant confounders such as family background, cognitive abilities, and other personal characteristics. This is a strong assumption that might be violated in practice. The individual level FE model can help remedy this problem as it is able to account for both observed time-variant and invariant variables as well as time-invariant unobserved variables as shown in the  [DAG](#page14) in Figure 9. It does so by demeaning all covariates at each time point with the overall individual mean across all observed time points. It then uses solely the within-person variation for identification, thereby accounting for any time-invariant observed or unobserved as well as observed time-variant eﬀects.

This comes at a price: due to the demeaning, time-invariant variables such as Han ethnicity, are dropped from the model and cannot be estimated. Fur-ther, because the FE model is not able to account for any eﬀects of a diabetes diagnosis on other time-variant confounders, only a more limited set of con-founders can be included compared to the  [MSM.](#page14) Otherwise the estimates of the eﬀect of a diabetes diagnosis would likely be biased due to the inclusion of ’bad controls’. Bad controls are control variables that have been aﬀected by the treatment itself—such as  [BMI](#page14) or smoking status after a diabetes diagnosis— and therefore likely capture part of the causal eﬀect of diabetes on the outcome of interest, biasing the diabetes coeﬃcient (Angrist and Pischke,  [2009](#page281)). Our FE specifications thus only include controls for age, age squared, the level of urbanization, education, being married, having any medical insurance, living in

Figure 9: Direct acyclic graph for the fixed eﬀects model



*Notes* FE models account for time-invariant unobserved confounding (light grey circle), butstill assume the absence of unobserved time-variant confounding. They further do not allow for past outcomes to aﬀect the current treatment, i.e. diabetes status.

a rural area, region and time dummies as well as per capita household income. For the estimation of the eﬀect of time since diagnosis, the linear age variable is dropped. In FE models, two or more variables that change at the same rate between waves cannot be separately identified. In our case this applies for age and time-dummies, as both variables increase by one each additional year (Wooldridge,  [2012](#page306)). To identify the eﬀect of diabetes duration we have to rely on the presence of people without diabetes in the sample, for which diabetes duration does not increase at the same rate as time. FE models also make an-other assumption, which have received much less attention, namely that there is no dynamic causal relationship between treatment and outcomes, i.e. that past treatments have no direct eﬀect on current outcomes, and that past out-comes no direct eﬀect on current treatment. If this assumption is violated, then results based on  [FE,](#page14) or any non-dynamic estimation method are biased (Imai and Kim,  [2016](#page292)). Accordingly, the choice between the use of a FE model or a  [MSM](#page14) depends on the tradeoﬀ between unobserved time-invariant confounding and dynamic causal relationships between diabetes and our outcome variables.5

* Because it is not possible to retrieve average marginal eﬀects from a logistic FE model, we prefer to use a linear FE model instead. It generally produces very similar estimates compared to non-linear models (Angrist and Pischke,  [2009](#page281)).

**5.2.5 Random eﬀects**

Random eﬀects assume, similar to the  [MSM,](#page14) no unmeasured confounding, and similar to the FE model no dynamic relationship between diabetes and our outcomes. Under these assumptions the RE model is eﬃcient and consistent, making it the preferable estimator if its assumptions are not violated. It is also preferable over the pooled  [OLS](#page15) estimator, as the RE estimator takes into account the serial correlation of the errors across time (Wooldridge,  [2012](#page306)).

To discriminate between the RE and FE estimator, a robust Hausman test is carried out using the user written Stata command xtoverid. A rejection of the null hypothesis suggests that the underlying RE assumptions are false and the FE model should be used instead (Wooldridge,  [2012](#page306)).6

**Multiple imputation**

To deal with missing data, we used chained multiple imputation to impute the missing values in Stata 13 using the user written ICE command (Royston and White,  [2009](#page301)). Overall, thirty imputed datasets were created. Imputation mod-els included all variables used in the  [MSMs.](#page14) We imputed missing data in the same wave for which some data were recorded; we did not impute completely missing waves. Further, we did not impute missing diabetes information and instead assumed that once a diabetes diagnosis was reported, the individual had diabetes in every ensuing wave, even when the observation was missing. If diabetes was never reported in any wave, we assumed that the individual never had diabetes. We then only imputed missing values for those observations that had a non-missing diabetes status. For the calculation of the marginal eﬀects in the  [MSM](#page14) logit models, Rubin’s rules were applied using the user written Stata command mimrgns (Klein,  [2014](#page293)).

**Numbers of observations**

Because we used lagged variables to construct the stabilized weights for the  [MSMs,](#page14) the number of observations used in the  [MSMs](#page14) is lower than those used in the FE and RE models, where we do not use lagged variables. The summary statistics shown in Table  [24](#page156) are based on the observations used in the FE models. The number of observations is stated below each table.

6We use the original non-imputed data to carry out the Hausman test.

**Sensitivity analyses**

We conduct three additional sensitivity analyses in order to test the robust-ness of our results. First, we truncate weights at the 1st and 99th percentile to investigate the sensitivity of the  [MSMs](#page14) to the most extreme weights. While untruncated weights provide unbiased estimates under the assumptions of the  [MSM,](#page14) they may not be the most eﬃcient and tend to have larger standard errors (Cole and Hernan,  [2008](#page287)). Second, we estimate the FE and  [MSMs](#page14) using the original non-imputed data to ascertain the extent to which multiple impu-tation aﬀected the results. Third, we report in the appendix the estimates of models using overweight and obesity instead of  [BMI](#page14) and waist circumference as the outcomes of interest, to investigate the eﬀect of a diabetes diagnosis on changes in the probabilities to be overweight or obese.

**5.3 Results**

From the descriptive statistics, we can observe that people with diabetes in any wave are less likely to be employed. Looking at health behaviours, the prevalence of smoking and drinking is lower for men with diabetes; they also consume fewer calories compared to men without diabetes. Note that it is mainly men who smoke and report alcohol consumption while very few women do so. Further, the diabetes group has both higher  [BMI](#page14) and waist circumfer-ence levels. They are also older, live in more urbanized areas, are more likely to have insurance and men are somewhat better educated while women are less educated compared to their counterparts without diabetes. Both men and women report an average time since diagnosis of around 4.5 years. Looking at per capita household income, men and women with diabetes come from household with higher income levels than those without a diabetes diagnosis. Further it appears that in China it is less educated women that report a diag-nosis, while men with diabetes are better educated compared to those without diabetes.

Predicting the denominator for the stabilized weights we find that for men a higher baseline  [BMI](#page14) increases the risk of a diabetes diagnosis. Further, in-creases in age, waist circumference as well as urbanization levels are associated with higher chances for men to be diagnosed with diabetes throughout the sur-vey. Interestingly becoming employed decreases the chances of being diagnosed with diabetes slightly, justifying the use of the  [MSM](#page14) in our employment models

as well (Table  [25](#page158)). Because these are not causal estimates, it may be that it is more likely for men with a lower risk of diabetes to select into employment. Interestingly, we do not find that higher household income levels are predictive of a diagnosis for men or women, despite what the descriptive statistics indi-cated. For women, higher age and waist circumference at baseline, increases in  [BMI](#page14) as well as living in a non-rural environment predict a diabetes diagnosis.

Table 24: Sample means for males and females, by diabetes status

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Males |  |  |  | Females |  |  |
|  |  |  |  |  |  |  |  |  |
|  | No diabetes | Diabetes | p-value (t-test) |  | No diabetes | Diabetes | p-value (t-test) |  |
|  |  |  |  |  | |  |  |  |
| Employed | 82% | 68% | *<*0.001 | 67% | | 29% | *<*0.001 |  |
| Smokes | 58% | 47% | *<*0.001 | 3% | | 4% | 0.409 |  |
| Any alcohol consumption | 63% | 53% | *<*0.001 | 9% | | 4% | *<*0.001 |  |
| Daily Kcal eaten (3-day average) | 2422 | 2166 | *<*0.001 | 2068 | | 1931 | 0.001 |  |
| BMI | 22.99 | 24.90 | *<*0.001 | 23.10 | | 25.80 | *<*0.001 |  |
| Waist circ. (cm) | 82.02 | 88.81 | *<*0.001 | 78.80 | | 87.55 | *<*0.001 |  |
| Age | 42.27 | 52.76 | *<*0.001 | 43.24 | | 55.32 | *<*0.001 |  |
| Han ethnicity | 87% | 89% | 0.292 | 87% | | 93% | 0.002 |  |
| Rural area | 69% | 52% | *<*0.001 | 68% | | 51% | *<*0.001 |  |
| Married | 83% | 93% | *<*0.001 | 88% | | 87% | 0.392 |  |
| Secondary education | 65% | 68% | 0.439 | 50% | | 43% | 0.007 |  |
| University education | 5% | 11% | *<*0.001 | 4% | | 1% | 0.017 |  |
| Any health insurance | 51% | 82% | *<*0.001 | 50% | | 71% | *<*0.001 |  |
| Urbanization Index | 60.87 | 74.48 | *<*0.001 | 61.77 | | 68.68 | *<*0.001 |  |
| Per capita household income (Yuan (2011)) | 8617 | 16328 | *<*0.001 | 8581 | | 11101 | *<*0.001 |  |
| Years since diabetes diagnosis | − | 4.5 | − |  | − | 4.65 | − | |
| Observations | 23159 | 284 |  | 23369 | | 333 |  |  |
|  |  |  |  |  |  |  |  |  |

The results of our regression analysis are presented in Table  [26.](#page159) Both  [theMSM](#page14) and FE model indicate that women with a diabetes diagnosis have lower probabilities of being employed than their counterparts without diabetes, with a reduction of 12 percentage points in the  [MSM](#page14) and 11 percentage points in the FE model. This translates into a relative reduction in employment prob-abilities between 16–17%. For men no such eﬀect is observed.

A more ambiguous picture is painted for the eﬀect of a diabetes diagnosis on behavioural risk factor outcomes. According to the  [MSM,](#page14) for males a diabetes diagnosis leads to smoking cessation, reductions in alcohol consumption as well as  [BMI,](#page14) waist circumference and calorie consumption. Results for women look diﬀerent. While the point estimates indicate a reduction in all outcomes, these tend to be smaller than those for men and only exhibit strong statistical significance smoking cessation and alcohol consumptions, who already have a very low prevalence. Compared to the  [MSM,](#page14) the FE model finds similar eﬀects for men, apart from a less important eﬀect on smoking cessation. For women, however, it finds much larger, and statistically significant, reductions in  [BM](#page14)I and waist circumference.

The results of the RE models suggest an even stronger eﬀect of diabetes on female employment probabilities and smaller reductions in male and female  [BMI](#page14) and waist circumference, even suggesting a positive association between a diabetes diagnosis and female waist circumference. For the other outcomes, results are very similar to those from the  [MSMs](#page14) and FE models. Nonetheless, the Hausman test still rejects the use of the RE model throughout (see Table  [49](#page273)).

Exploring the eﬀect of a diabetes diagnosis over time, we first estimate a specification using time since diagnosis as a continuous variable. The results of the  [MSMs](#page14) (Table  [27)](#page161) indicate a steady reduction of female employment probabilities of close to two percentage points per year and of male alcohol consumption,  [BMI,](#page14) waist circumference and calorie consumption. The FE model again supports the finding of the  [MSM,](#page14) showing very similar, though somewhat larger, eﬀects in terms of size and statistical significance. The ev-idence for changes in risk factors for females is less consistent across models and outcomes, with the  [MSM](#page14) suggesting almost no eﬀects while the FE model indicates a reduction in  [BMI.](#page14) The eﬀect sizes for changes in health behaviours in women are consistently lower than those found for men.

The RE models again find larger eﬀects on female employment probabilities and a smaller impact of a diabetes diagnosis on reductions in  [BMI](#page14) and waist

Table 25: Time variant and invariant predictors of a diabetes diagnosis (de-nominator of stabilized weights)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Males |  |  | Females |  |  |  |
|  |  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |  |
|  | *β* | SE |  | *β* | SE | |  |
|  |  |  |  |  |  |  |  |
| Age (bl) | −.000 | 0.001 |  | 0.004∗∗ | 0.002 |  |  |
| Age squared (bl) | 0.000 | 0.000 |  | −.000∗∗ | 0.000 |  |  |
| [BMI](#page14) (bl) | 0.001∗∗∗ | 0.000 | 0.001 | | 0.000 |  |  |
| Waist circumference (cm) (bl) | 0.000 | 0.000 |  | 0.000∗ | 0.000 |  |  |
| 3-Day Ave: Energy (kcal) (bl) | −.000 | 0.000 | 0.000 | | 0.000 |  |  |
| Smoking (bl) | 0.001 | 0.002 | 0.003 | | 0.006 |  |  |
| Alcohol consumption (bl) | 0.003∗ | 0.002 | 0.000 | | 0.005 |  |  |
| Urbanization index (bl) | −.000 | 0.000 |  | −.000 | 0.000 |  |  |
| Secondary educ. (bl) | −.001 | 0.003 | 0.003 | | 0.003 |  |  |
| University educ. (bl) | −.000 | 0.006 |  | − | − | |  |
| Married (bl) | −.002 | 0.004 |  | −.000 | 0.004 |  |  |
| Any medical insurance (bl) | 0.002 | 0.002 |  | −.000 | 0.002 |  |  |
| Employed (bl) | 0.002 | 0.003 | 0.001 | | 0.002 |  |  |
| Han ethnicity | 0.001 | 0.003 |  | −.002 | 0.003 |  |  |
| Rural | −.001 | 0.002 |  | −.005∗∗∗ | 0.002 |  |  |
| Per capita household income (2011 Yuan) (bl) | −.000 | 0.000 |  | −.000 | 0.000 |  |  |
| Survey year |  |  |  | −.001 |  |  |  |
| 2004 | 0.002 | 0.002 |  | 0.002 |  |  |
| 2006 | 0.003 | 0.002 |  | −.003 | 0.003 |  |  |
| 2009 | 0.009∗∗∗ | 0.003 |  | −.001 | 0.004 |  |  |
| 2011 | 0.001 | 0.003 | 0.001 | | 0.004 |  |  |
| Age | 0.003∗∗ | 0.001 |  | −.002 | 0.002 |  |  |
| Age squared | −.000∗∗ | 0.001 | 0.000 | | 0.000 |  |  |
| BMI | −.001 | 0.000 |  | 0.001∗∗ | 0.000 |  |  |
| Waist circumference (cm) | 0.000 | 0.000 |  | −.000 | 0.000 |  |  |
| 3-Day Ave: Energy (kcal) | −.000 | 0.000 |  | −.000 | 0.000 |  |  |
| Smoking | −.003 | 0.002 | 0.000 | | 0.006 |  |  |
| Alcohol consumption | −.004∗∗ | 0.002 |  | −.003 | 0.006 |  |  |
| Urbanization index | 0.000 | 0.000 | 0.000 | | 0.000 |  |  |
| Secondary education | 0.001 | 0.003 | 0.000 | | 0.003 |  |  |
| University education | 0.001 | 0.006 |  | − | − | |  |
| Married | −.000 | 0.004 |  | −.003 | 0.004 |  |  |
| Any medical insurance | 0.001 | 0.002 |  | −.001 | 0.002 |  |  |
| Employed | −.004∗∗ | 0.002 |  | −.003 | 0.002 |  |  |
| Per capita household income (2011 Yuan) (2011 Yuan) | 0.000 | 0.000 |  | −.000 | 0.000 |  |  |

*Notes* Results for province dummies omitted to preserve space. University education was dropped inthe female sample as having university education did perfectly predict diabetes status. N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 26: Analysis of the eﬀect of a diabetes diagnosis on employment status and behavioural outcomes using MSM, FE and RE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Marginal structural model* | |  |  |  |
| Male sample | −.009 | −.070∗∗ | −.094∗∗∗ | −.735∗∗∗ | −1.887∗∗∗ | −135.061∗∗ |  |
| Diabetes |  |
| Female sample | (.026) | (.032) | (.036) | (.180) | (.574) | (58.593) |  |
| −.117∗∗∗ | −.015∗ | −.029∗∗ | −.388 | −.335 | −45.630 |  |
| Diabetes |  |
|  | (.029) | (.008) | (.012) | (.240) | (.631) | (33.530) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Fixed eﬀects* | |  |  |  |
| Male sample |  | −.023 | −.104∗∗∗ | −.715∗∗∗ | −2.217∗∗∗ | −168.297∗∗∗ |  |
| Diabetes | 0.022 |  |
| Female sample | (.030) | (.032) | (.036) | (.183) | (.610) | (62.115) |  |
| −.112∗∗∗ | −.027∗∗ | −.012 | −.644∗∗ | −1.251∗∗ | −61.175 |  |
| Diabetes |  |
|  | (.035) | (.013) | (.010) | (.263) | (.616) | (47.420) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Random eﬀects* | |  |  |  |
| Male sample | −.022 | −.064∗∗ | −.104∗∗∗ | −.379∗∗ | −.756 | −172.467∗∗∗ |  |
| Diabetes |  |
| Female sample | (.028) | (.029) | (.029) | (.177) | (.542) | (48.768) |  |
| −.152∗∗∗ | −.021∗∗ | −.019∗∗∗ | −.263 |  | −39.267 |  |
| Diabetes | 0.459 |  |
|  | (.027) | (.011) | (.006) | (.247) | (.570) | (34.256) |  |

*Notes* Robust standard errors in parentheses. Other control variables for FE/RE: Age squared, region, urban,education, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures. RE additionally controls for age. MSM controls for baseline values of the same variables as the FE/RE models additionally to baseline values of age, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. Fixed/random eﬀects: N=23443 (male sample), N=23702 (female sample); MSM: N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

circumference for both sexes.

In a second step we estimate a specification using year dummies to capture the potential non-linearity in the relationship between time since diagnosis and our outcomes. The results for the diﬀerent estimation methods are visualized in Figures  [10,](#page162)  [11](#page163) and  [12](#page164) and presented in Tables  [44,](#page268)  [45](#page269) and  [46](#page270) for the  [MSM](#page14), FE and RE model, respectively. The  [MSM](#page14) model still indicates a reduction in female employment chances and male  [BMI,](#page14) waist circumference and calorie consumption as well as smoking and alcohol consumption, especially in the first 8 to 10 years after diagnosis. Behavioural risk factors for women are again not found to be reduced consistently, apart from  [BMI](#page14) where some trend towards a reduction over time is visible. Interestingly, female employment already decreases rapidly in the first to second year after diagnosis and it does not appear that females are able to increase their employment probabilities later on. Unfortunately it was not possible to estimate the eﬀects on female smoking and alcohol consumption due to the low prevalence of these risk factors in females and the lower sample size in the  [MSM.](#page14) Using the FE model, all point estimates suggest similar eﬀects. The RE model, again suggests larger eﬀects on female employment and lower eﬀects on  [BMI](#page14) and waist circumference than both other estimation methods.

The sensitivity analyses using truncated weights shows very similar eﬀects to those using the untruncated weights (Table  [47](#page271) and  [48),](#page272) suggesting no impor-tant bias and supporting the decision to use untruncated weights. The results using non-imputed data are broadly similar (Tables  [49,](#page273)  [50,](#page274)  [51,](#page275)  [52](#page276) and  [53](#page277) ), in particular for the FE model, still indicate a reduction in female employment chances and male alcohol consumption,  [BMI](#page14) and waist circumference. The coeﬃcients of the  [MSM](#page14) still point into the same direction as those using the imputed data, but the estimated eﬀects are smaller in size and confidence inter-vals are relatively large. The RE model still shows a stronger eﬀect on female employment probabilities and smaller reductions in especially the weight mea-sures  [BMI](#page14) and waist circumference. Using overweight and obesity instead of  [BMI](#page14) and waist circumference as indicators for weight changes, we do not find as consistent reductions in weight status for men as we did using the continuous estimates (Tables  [54](#page278) and  [55](#page279) and Figure  [13.](#page280) Nonetheless, the point estimates still show a reduction in obesity, in particular over time and for men, support-ing the reductions found using continuous measurements. The coeﬃcients for overweight are diﬃcult to interpret as it is unclear if the negative coeﬃcient is caused by people transferring into the obesity or into normal weight.

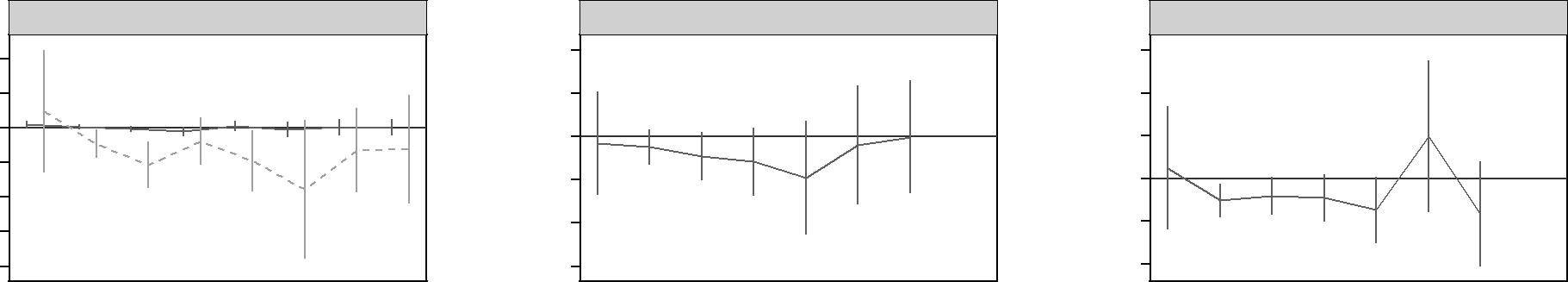
Table 27: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes using MSM, FE and RE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Marginal structural model* | |  |  |  |
| Male sample | −.003 | −.010∗ | −.014∗∗ | −.127∗∗∗ | −.340∗∗∗ | −21.770∗∗ |  |
| Time since diagnosis |  |
| Female sample | (.004) | (.005) | (.007) | (.031) | (.099) | (9.842) |  |
| −.017∗∗∗ | −.002 | −.004 | −.066∗ | −.072 | −8.735 |  |
| Time since diagnosis |  |
|  | (.005) | (.001) | (.003) | (.040) | (.109) | (5.589) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Fixed eﬀects* | |  |  |  |
| Male sample | −.001 | −.003 | −.017∗∗ | −.150∗∗∗ | −.520∗∗∗ | −22.286∗∗ |  |
| Time since diagnosis |  |
| Female sample | (.007) | (.006) | (.007) | (.037) | (.121) | (11.083) |  |
| −.019∗∗∗ | −.003 | −.000 | −.102∗∗∗ | −.215∗ | −6.747 |  |
| Time since diagnosis |  |
|  | (.007) | (.002) | (.001) | (.039) | (.117) | (7.028) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Random eﬀects* | |  |  |  |
| Male sample | −.006 | −.009∗ | −.015∗∗∗ | −.099∗∗∗ | −.269∗∗∗ | −24.703∗∗∗ |  |
| Diabetes |  |
| Female sample | (.006) | (.006) | (.005) | (.035) | (.096) | (8.655) |  |
| −.023∗∗∗ | −.002 | −.002∗∗ | −.056 |  | −6.444 |  |
| Diabetes | 0.013 |  |
|  | (.006) | (.002) | (.001) | (.039) | (.114) | (5.670) |  |

*Notes* Other control variables for FE/RE: Age squared, region, urban, education, Han ethnicity, marital status,urbanization index, time dummies, health insurance status, household expenditures. RE additionally controls for age. MSM controls for baseline values of the same variables as the FE/RE models additionally to baseline values of age, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. FE/RE: N=23443 (male sample), N=23702 (female sample); MSM: N=16047 (male sample), N=16658 (female sample).

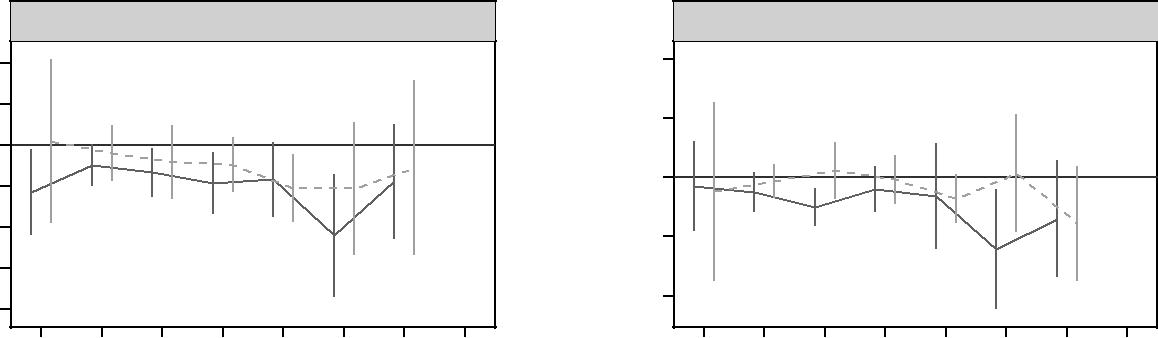
∗ *p <* 0*.*10,∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01..

Figure 10: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes (duration groups, marginal structural model)



|  |
| --- |
| Marginal effect |

|  |  |  |
| --- | --- | --- |
| Employed | Smoking |  |
| 2 | .4 |  |
|  |  |
| 1 | .2 |  |
| 0 | 0 |  |
|  |  |
| −1 | −.2 |  |
| −2 |  |
|  |  |
| −3 | −.4 |  |
|  |  |
| −4 | −.6 |  |



|  |  |  |
| --- | --- | --- |
| BMI | Waist (cm) |  |
| 2 | 10 |  |
| 1 | 5 |  |
|  |  |
| 0 |  |  |
| −1 | 0 |  |
|  |  |
| −2 | −5 |  |
|  |  |
| −3 |  |  |
| −4 | −10 |  |
|  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 | 0 | |  | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 |  |
|  |  |  |  |  |  |  |  |  |  | Years after diagnosis | | | | | | |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |
|  |  |  |  |  |  |  |  |  |  |  | men | |  |  |  | women | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Alcohol

.6

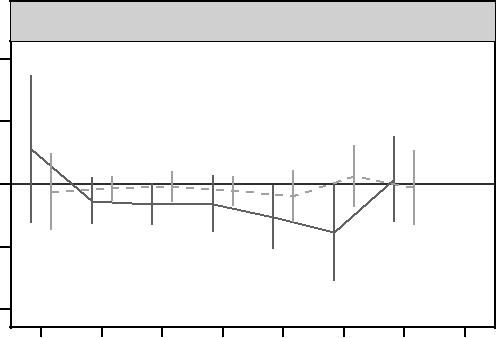
.4

.2

0

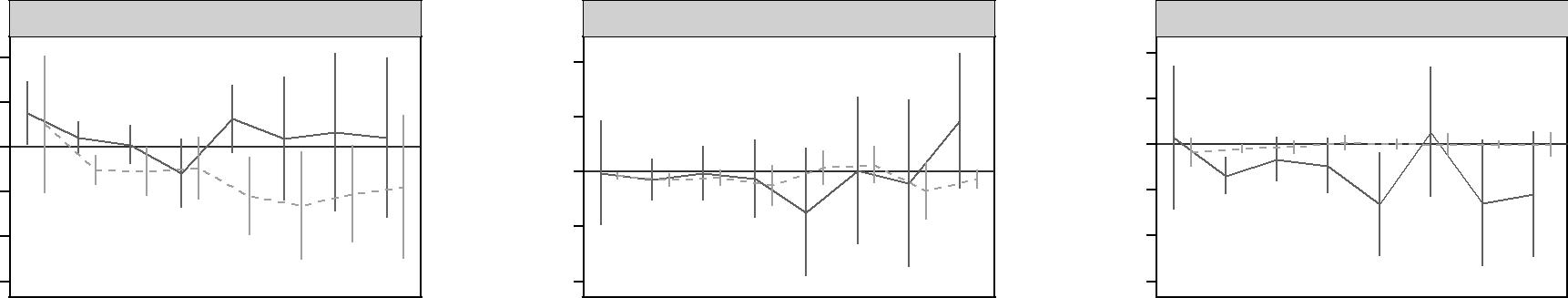
−.2

−.4



|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Kcal | |  |  |  |
| 1000 |  |  |  |  |  |  |  |
| 500 |  |  |  |  |  |  |  |
| 0 |  |  |  |  |  |  |  |
| −500 |  |  |  |  |  |  |  |
| −1000 |  |  |  |  |  |  |  |
| 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 |

Figure 11: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes (duration groups, fixed eﬀects)



|  |
| --- |
| Marginal effect |

Employed

.4

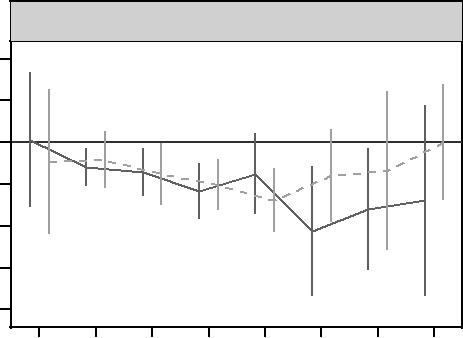
.2

0

−.2

−.4

−.6



BMI

2

1

0

−1

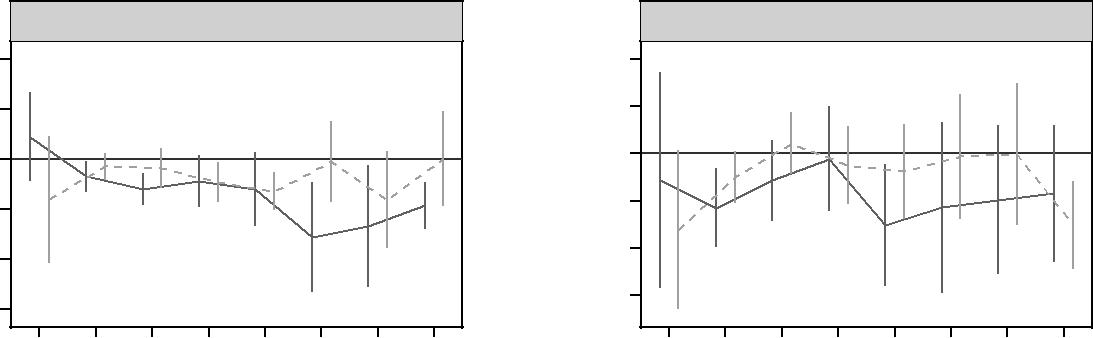
−2

−3

−4

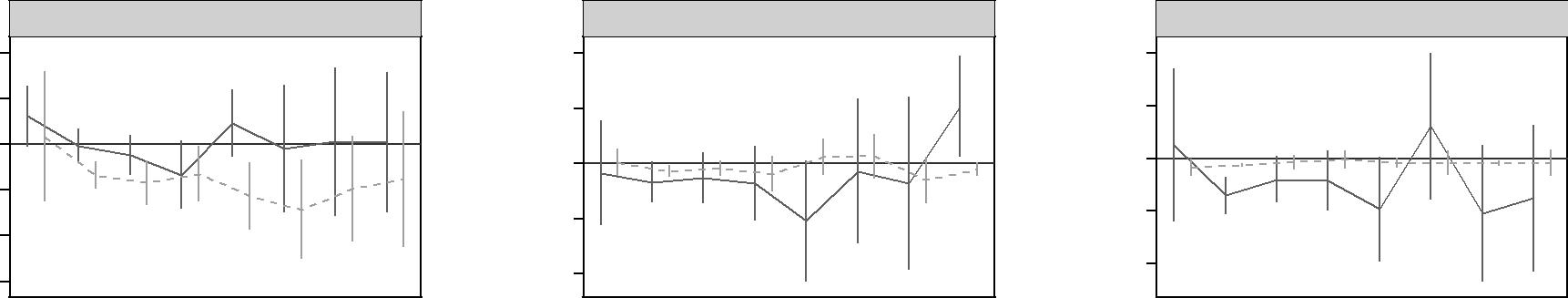
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 |

|  |  |  |
| --- | --- | --- |
| Smoking | Alcohol |  |
| .4 | .4 |  |
|  |  |
| .2 | .2 |  |
|  |  |
|  | 0 |  |
| 0 | −.2 |  |
|  |  |
| −.2 | −.4 |  |
|  |  |
| −.4 | −.6 |  |



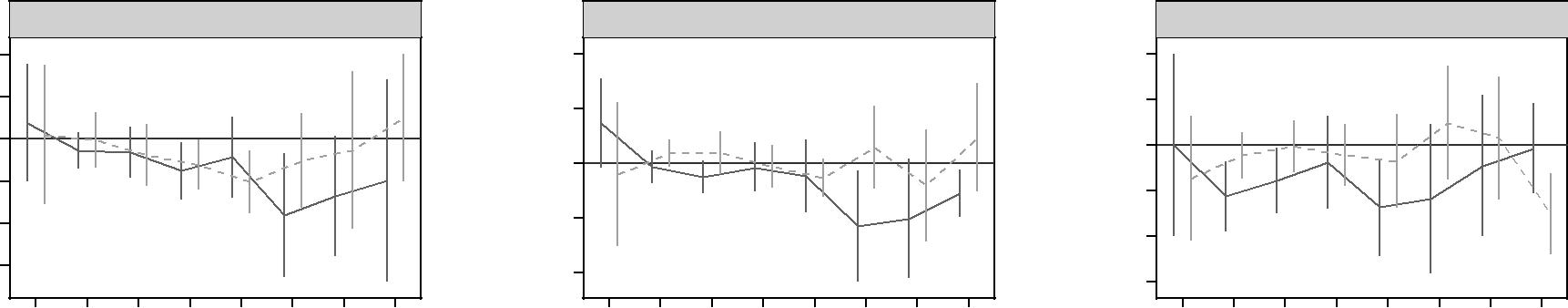
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Waist (cm) | |  |  |  |  |  |  | Kcal | |  |  |  |  |
| 10 |  |  |  |  |  |  |  | 400 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  | 200 |  |  |  |  |  |  |  |  |
| 0 |  |  |  |  |  |  |  | 0 |  |  |  |  |  |  |  |  |
| −5 |  |  |  |  |  |  |  | −200 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| −10 |  |  |  |  |  |  |  | −400 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| −15 |  |  |  |  |  |  |  | −600 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 | 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 |  |
| Years after diagnosis | | | | | |  |  |  |  |  |  |  |  |  |  |  |
| men | |  |  |  | women | |  |  |  |  |  |  |  |  |  |  |

Figure 12: The eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes (duration groups, random eﬀects)



|  |
| --- |
| Marginal effect |

|  |  |  |  |
| --- | --- | --- | --- |
| Employed | Smoking | Alcohol |  |
| .4 | .4 | .4 |  |
| .2 | .2 | .2 |  |
|  |  |
| 0 | 0 | 0 |  |
|  |  |
| −.2 |  | −.2 |  |
|  | −.2 |  |
| −.4 |  |  |
|  |  |  |
| −.6 | −.4 | −.4 |  |
|  |  |
|  |  |  |



|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | BMI | |  |  |  |  |  |  | Waist (cm) | |  |  |  |  |  |  | Kcal | |  |  |  |  |
| 2 |  |  |  |  |  |  |  | 10 |  |  |  |  |  |  |  | 400 |  |  |  |  |  |  |  |  |
| 1 |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  | 200 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 0 |  |  |  |  |  |  |  | 0 |  |  |  |  |  |  |  | 0 |  |  |  |  |  |  |  |  |
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| −1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | −200 |  |  |  |  |  |  |  |  |
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| −2 |  |  |  |  |  |  |  | −5 |  |  |  |  |  |  |  | −400 |  |  |  |  |  |  |  |  |
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| −3 |  |  |  |  |  |  |  | −10 |  |  |  |  |  |  |  | −600 |  |  |  |  |  |  |  |  |
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| 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 | 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 | 0 | 1−2 | 3−4 | 5−6 | 7−8 | 9−10 | 11−12 | 13−14 |  |
|  |  |  |  |  |  |  |  | Years after diagnosis | | | | | |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | men | |  |  |  | women | |  |  |  |  |  |  |  |  |  |  |

**5.4 Discussion**

The evidence for the impact of a diabetes diagnosis on employment chances and behavioural risk factors remains scarce, in particular in MICs, where diabetes has become a mayor contributor to the burden of disease. We added to this evidence by exploring these relationships using longitudinal data from China, also improving upon previous methodology by taking into account the potential relationship over time between these outcomes.

Our results suggest that receiving a diabetes diagnosis in China leads to a strong and lasting reduction in female, but not male employment probabilities. We also found reductions in male  [BMI](#page14) and waist circumference, alcohol and calorie consumption and potentially smoking. We did, however, not find similar changes in behavioural risk factors for women. Accordingly, it appears that women in China have to endure stronger adverse labour market eﬀects and at the same time are less successful then men at making risk behaviour changes to reduce their risk of diabetes complications.

The  [MSM](#page14) models and FE models indicated very similar results suggesting that they are robust and that time-invariant confounding factors may play a limited role over and above baseline and time varying confounding factors. The  [MSM](#page14) results suggest that in particular  [BMI](#page14) and waist circumference levels as well as employment status can cause selection into a diabetes diagnosis and are then later themselves aﬀected by the diagnosis, justifying the use of a  [MSM.](#page14) The RE models further indicated that insuﬃciently accounting for confounding can—at least in this setting—lead to an overestimation of the impact of diabetes on employment status and an underestimation of the eﬀects of a diagnosis on weight measures  [(BMI](#page14) and waist circumference). However, confounding may only be of limited relevance for alcohol consumption, where the RE models showed very similar results.

**5.4.1 Limitations**

The study has several limitations. While we used two estimation methods to reduce the influence of observed and unobserved confounding, respectively, none of the models is able to account for both forms of confounding. Therefore a causal interpretation is only possible under restrictive assumptions, namely no unobserved time-variant confounding for the FE model and positivity, ex-changeability and consistency for the  [MSM.](#page14) The assumption of positivity is likely to hold, given that every person should have at least a small chance of

receiving a diabetes diagnosis. This is also supported by the relatively small range of stabilized weights and absence of zero-weights. Exchangeability, or no unmeasured confounding could potentially be violated if not all time-invariant and time-variant confounders were accounted for, but there is no comprehen-sive test. We tested for part of this assumption by estimating a FE model and given that the results remained very similar, this suggests that unobserved time-invariant confounding may be of limited relevance in this case. Consis-tency would have been violated if a diabetes diagnosis had been reported but the person had actually not been diagnosed with diabetes. This was likely only violated in very rare cases of misreporting, given that specificity of diabetes self-report is very high in China (Yuan et al.,  [2015](#page307)). Because we were inter-ested in the eﬀect of a diabetes diagnosis, unobserved diabetes did not violate the consistency assumption.

A limitation of the FE model is the possibility of time-variant confounding due to prior outcomes (for example employment status) aﬀecting the current treatment (a diabetes diagnosis). Given that the FE estimates were close to those of the  [MSMs,](#page14) it is likely that there was no strong confounding due to pre-treatment changes. Rather, the similarity of results suggests that it is important to account for the selection into diabetes due to some form of baseline values, be it via demeaning as in the FE model—and thereby accounting for all time-invariant confounding—or by using baseline values as in the  [MSM](#page14).

Finally, an important limitation is that in this study we only observe the combined eﬀect of all that entails a diabetes diagnosis. However, a diabetes diagnosis can entail a variety of ’treatments’ that are diﬃcult to disentangle and may each have a distinct eﬀect on the explored outcomes.

**5.4.2 Potential mechanisms**

Firstly, there is the provision of information at diagnosis, potentially causing increases in stress and anxiety, but potentially also reducing anxiety by pro-viding an explanation for the experienced symptoms, both potentially aﬀecting productivity. Secondly, a diagnosis also is the starting point for medical treat-ment, which could help to alleviate symptoms and to lose weight, but also poses new challenges, in particular if treatment entails the exogenous provi-sion of insulin or adherence to strict meal plans, likely adding to the burden of diabetes in daily life. Thirdly, adherence to medical treatment may be het-erogeneous across people with diabetes, with non-adherence likely leading to a

further worsening of risk factors for complications, while good adherence may prevent or delay debilitating complications. Fourthly, a diagnosis may also cause lifestyle changes such as increasing exercise levels, eating healthier and reducing smoking or alcohol consumption, all potentially aﬀecting the risk to develop further complications and to experience changes in productivity. In the current study, it is not possible to ascertain the role of each of these fac-tors in aﬀecting employment chances and behavioural risk factors. Only for the reductions in smoking and alcohol consumption, it seems reasonable to at-tribute them to diagnosis induced awareness to reduce these risk factors, as other pathways appear less likely to be relevant.

The found adverse eﬀect of diabetes on employment is in line with other stud-ies on the labour market impact of diabetes that have found diabetes to reduce female employment probabilities (Harris,  [2009;](#page291) Latif,  [2009;](#page294) Minor,  [2011b;](#page296) Seur-ing, Serneels, et al.,  [2016](#page303))—often more than for men. Most comparable to our results are likely the results from Mexico in Chapter 4, which were also based on FE estimations and data for a similar time period (Seuring, Serneels, et al.,  [2016](#page303)). The study found significant reductions for both males and females of about 5 percentage points. Taking into account the lower overall employment rate of Mexican women compared to men, this translated into a 16% reduc-tion in female employment probabilities, a figure comparable to what Chinese women experienced. However, in Mexico also men experienced adverse eﬀects, unlike to what we found for China.

The found eﬀects on changes in behavioural risk factors can be compared to the study by Slade  [(2012](#page303)). Slade finds reductions in alcohol consumption and smoking, though it appears that these reductions were not maintained over a longer time period. Unfortunately, Slade only provided information for the entire sample and the male sample, so that we cannot compare them directly with our results for women. In terms of the eﬀect on weight, again both studies cannot be directly compared because Slade investigated the eﬀect of a diagnosis on being overweight or obese, while we used continuous weight measures in our primary analysis due to the discussed diﬃculties of defining cut-oﬀ values for Asian populations. Slade found an initial reduction in weight status, but also that people with diabetes tended to become more likely to be overweight or obese after some time. Our results using overweight and obesity could tentatively be interpreted to indicate a more constant reduction in obesity over time, suggesting that reductions in weight in Chinese men may be longer lived than in the USA. Importantly—and in concordance with our

findings—he found that simple covariate adjustment led to biased estimates of the impact on weight status, indicating a positive relationship. This underlines the importance of accounting for unobserved heterogeneity.

The permanent reduction in male  [BMI](#page14) and waist circumference we have found has also been observed in a cohort of Danish patients (De Fine Olivarius et al.,  [2015),](#page288) where weight increased the years preceding diagnosis, while after diagnosis weight decreased. The exact reasons for this decrease were unknown but attributed to motivation changes as a result of the diagnosis, concluding that time around the diagnosis may represent a window of opportunity to ob-tain long lasting weight change. Nonetheless, reductions in weight, as already eluded to in the limitations, may also be the result of treatment initiation with metformin or other diabetes drugs that have been shown to lead to weight reductions (Yang and Weng,  [2014](#page307)). Importantly, the reduction in male  [BM](#page14)I levels and waist circumference were accompanied by reduced energy intake, suggesting that the changes in weight were at least partly the result of lower energy intake. Further, given that in China diabetes incidence has been es-pecially attributed to a high accumulation of visceral fat and central obesity (Ma et al.,  [2014),](#page295) the reductions in waist circumference may have had a par-ticular positive eﬀect on diabetes control and the prevention of comorbidities. Together, the lower levels of energy intake and waist circumference after the diagnosis allow for the interpretation that the reductions in  [BMI](#page14) were due to fat loss and not less lean body mass (Klein et al.,  [2007](#page293)).

For women, however, we did not find similar strong evidence for reductions in  [BMI,](#page14) waist circumference or energy intake. The relatively smaller eﬀects for women could indicate a lower ability to change behaviours supportive of weight loss. This appears to be supported by the smaller reductions in energy intake. This could have—at least partly—contributed to a higher risk for dia-betes complications further down the line, also adversely aﬀecting employment probabilities. Apart from this, other explanations for the lower weight loss and larger employment penalty for women compared to men include their lower educational attainment, which has been indicated as a factor in preventing better glucose control (Luo et al.,  [2015)](#page295) and may also aﬀected the ability to successfully change behaviours. Lower income levels for females compared to men may also have negatively aﬀected the ability to receive adequate treatment following a diagnosis, limiting their ability to change health behaviours (Luo et al.,  [2015),](#page295) increasing the risk of complications. We found that women with diabetes lived in households with lower income levels compared to men with

diabetes, however, these income levels were still higher then for those without diabetes. Nonetheless, it may still be the case that women were more likely to not access care due to lower income levels than men. Further, there are likely biological factors that lead to worse health outcomes for women compared to men. There is some evidence that, due to diﬀerent ways of fat storage between men and women, men tend to cross the diabetes threshold at an earlier point in time and at a comparatively healthier metabolic state then women (Peters, Huxley, Sattar, et al.,  [2015;](#page299) Peters, Huxley, and Woodward,  [2014a,b](#page299)). Women are more likely to have spend more time in a pre-diabetes state (Bertram and Vos,  [2010)](#page284) and to cross the threshold only once the metabolic has significantly deteriorated, leading to a greater risk of cardiovascular disease and stroke (Pe-ters, Huxley, Sattar, et al.,  [2015](#page299)). Supporting this, a study for China found a greater prevalence of diabetes comorbidities in Chinese women than men (Liu, Fu, et al.,  [2010](#page295)). In this light it may not be surprising that we find more conclusive evidence of worsening employment probabilities for women than for men. If women are less likely to receive proper treatment and to change their health behaviours and at the same time have a greater risk for complications then men, the long term eﬀects of diabetes on their health are likely more se-vere than for men and consequently aﬀect their employment status to a greater extent.

Taken together these estimation results suggest that the eﬀect on the prob-ability of employment is reduced over time due to adaptations in health be-haviour, while the eﬀect for women is substantial because no such changes in behaviour take place. Further analysis is needed to test this formally, and is beyond the scope of this paper.

**5.5 Conclusion**

Our results indicate worse outcomes for women then men after a diabetes di-agnosis, with women experiencing a reduction in employment probabilities ac-companied by and potentially partly due to an inability to reduce important risk factors for diabetes complications. For males, the opposite pattern is found, as they do not experience adverse employment eﬀects and are able to achieve reductions in the investigated risk factors. These findings are robust to the ap-plication of two distinct, but complementary econometric techniques. Overall, given the large prevalence of undiagnosed diabetes, our results indicate that an early diagnosis may be a good way to foster early behaviour change that

could lead to more positive health and economic outcomes for people with di-abetes over time. It appears, however, that greater emphasis needs to be put on reducing the burden of diabetes for women if the observed inequities in the diabetes impact shall be reduced. Future research should try to unravel the mechanisms behind these diﬀerential outcomes for men and women, investi-gating more formally whether diﬀerences in behavioural risk factors could be a potential explanation.

**6 Discussion and conclusions**

**6.1 Chapter overview**

Diabetes has reached epidemic proportions in middle-income countries (MICs) and is a major contributing factor to poor health and early mortality, as also discussed in Chapter 1. The economic impact of diabetes on individuals and health-care systems has, however, received limited attention. In particular, we have limited understanding on the impact of individual labour outcomes of diabetes patients. Moreover, little is known about how people with diabetes currently achieve positive change in behaviour risk factors to prevent the dis-abling complications of diabetes, and whether this plays a role in the disease’s effect on labour outcomes. The goal of this thesis has been to assess the economic burden of diabetes in MICs, focusing on two predominant and large countries with an increasing diabetes disease burden. This should help to better understand the importance of primary and secondary prevention of diabetes and to identify those populations must susceptible to the adverse economic eﬀects of diabetes.

To meet these aims, four separate studies were conducted that intended to answer the research questions posed in Chapter 1. This concluding chapter has four parts. Firstly, it summarises the principal findings. Secondly, it contex-tualises the findings within the wider literature and provides implications for policies. Thirdly it reflects on the methods. Finally, there are suggestions for future research and concluding comments.

**6.2 Summary of principal findings**

Chapter  [2](#page28) set out to provide an overview of and critically assess existing studies on the economic costs of type 2 diabetes globally. This not only included cost-of-illness  [(COI)](#page14) studies but also studies on labour market outcomes. Systematic review methods were used and the evidence was synthesized narratively. 86  [COI](#page14) studies and 23 labour market studies were identified. Of those, 24 came from low- and middle-income countries (LMICs), with 23 being  [COI](#page14) studies.

For  [COI](#page14) studies, the review found a large range of estimated costs, with the largest per-capita costs being generated in the USA while costs were generally lower in LMICs. However, it also found that the direct economic burden caused by the treatment of type 2 diabetes is much higher in poorer countries when taking into account the lower income levels, in particular for the poorest parts of the population. Treatment costs were paid almost entirely out-of-pocket by the poor due to a lack of health insurance coverage, consuming considerable parts of their annual income. The review also found considerable diﬀerences in the used methodologies and the study quality. This made it diﬃcult to directly

compare the studies. While in many high-income countries (HICs) studies an incremental costing approach was used and data sources were representative for a distinct population, studies in developing countries often had to rely on non-representative, relatively small convenience samples, often lacking a control group. Many studies also lacked explicit mentioning of the used study perspective or the included costing components.

For labour market impact studies, most found adverse eﬀects of self-reported diabetes on employment probabilities, wages or working days. Studies were concentrated on a few  [HIC,](#page14) in particular the USA. More recent studies took into account potential biases due to the endogeneity of diabetes, mainly using an instrumental variable  [(IV)](#page14) strategy with the family history of diabetes as an instrument. However, the direction of bias was ambiguous across diﬀerent studies and countries.

The review also identified methodological and thematic areas so far only sparingly covered. No  [COI](#page14) studies took into account the possibility of biased estimates as a result of endogeneity of diabetes. Consequently, there is a lack of evidence in the literature about the potential bias in the cost estimates of diabetes  [COI](#page14) studies. Further, few studies used an incidence approach to investigate lifetime costs of people with diabetes, which could provide better information about the dynamics of cost increases after a diabetes diagnosis.

Despite these identified limitations of the  [COI](#page14) literature, the review was able to provided a picture of the healthcare costs of diabetes in almost every conti-nent. This was not the case for labour market studies, where almost no evidence was found for LMICs. Arguably, given their less advanced healthcare systems, later diagnosis but—in some populations—earlier onset of diabetes and greater susceptibility to develop it, the larger informal labour market and overall dif-ferent labour market structure in developing countries, the impact of diabetes could be very diﬀerent compared to HICs. Also, in terms of methodology, studies had not taken advantage of panel data techniques to achieve a causal interpretation of their estimates. Especially studies on the eﬀect on employ-ment probabilities had relied on the same—at least debatable—identification strategy using  [IVs.](#page14) Therefore, a study using a diﬀerent identification strategy was warranted.

Importantly, no study investigating the impact of undiagnosed diabetes on labour market outcomes was identified by the review. Hence, an important part of the diabetes population had been mostly neglected. This left open the question in how far results for self-reported diabetes were applicable to the

unaware population.

Based on the findings of the review, the three research studies that followed addressed parts of the identified gaps, in particular focusing on labour market outcomes.

The aim of Chapter  [3](#page74) was to provide first evidence for the impact of dia-betes on employment probabilities in a developing country, where diabetes had become a public health concern. Because little was known about the equity im-pacts of diabetes, a further goal was to investigate the heterogeneity of eﬀects across formal and informal employment and for the "rich" and "poor". Due to the unavailability of an alternative identification strategy, the study applied the already established IV approach using parental diabetes. However, using further background information on parental education, it improved upon ear-lier studies by controlling for a potential confounding pathway that could have invalidated the used instrument. It further used two methods to implement the IV approach. The main analysis was based on a bivariate probit model that had been shown to be better suited for our specific data, in comparison to a standard linear IV model. We nonetheless also provided the results of the latter approach. Both models found no indication of diabetes being exogenous in this context so that a simple univariate probit model was used for inference. The results showed an adverse eﬀect of diabetes on employment chances in Mexico, reducing them by about 10 percentage points for men and 5 percentage points for women. The subgroup analysis suggested that the adverse employment eﬀects occurred mainly to those above age 44, while younger people seemed less aﬀected. Also, being poorer increase the exposure to negative employment eﬀects of diabetes. The same was the case for those in the informal compared to those in the formal labour market. Across all models, the point estimates were bigger for males than for females.

While these results provided good evidence for an adverse eﬀect of diabetes on employment chances in a developing country, several questions identified in Chapter  [2](#page28) still remained. Further, the robustness of the findings of Chapter 3 had to be tested using more extensive and recent data and a diﬀerent identifi-cation strategy. Chapter  [4](#page101) addressed these issues taking advantage of a recent extension to the data used in Chapter 3. The data now spanned three waves and eight years, which allowed for the use of a longitudinal individual fixed eﬀects model to estimate the relationship of self-reported diabetes with employment. Additionally, the investigated labour market outcomes were extended to wages and working hours. Further, it was now possible to investigate the relation-

ship of diabetes duration with labour outcomes, in order to understand when diabetes tended to cause adverse labour market outcomes. Importantly, the ad-ditional wave also provided information on diabetes biomarkers to explore the eﬀects of diabetes for the entire diabetes population as well as those unaware of diabetes separately.

The analysis carried out in Chapter  [4](#page101) confirmed the adverse relationship of self-reported diabetes with employment, finding a five percentage point reduc-tion for males and females alike. Given the relatively low female employment rate, this translated into a 14% decrease in employment probabilities women compared to 6% for men. Compared to the cross-sectional results of Chapter 3, the estimated eﬀects of the fixed eﬀects  [(FE)](#page14) model are about half the size for men, but are similar and of stronger statistical significance for women. This is likely due to the additional data used in Chapter 4, but could also partly be the result of the diﬀerent estimation technique. For wages and working hours no adverse eﬀects of self-reported diabetes were found.

Further analysis showed that the most adverse eﬀects were concentrated among self-employed and independent agricultural workers, potentially due to lower job security and access to healthcare in these often informal jobs. Further, Chapter  [4](#page101) revealed that the adverse eﬀect of diabetes on employment appeared shortly after diagnosis, then levelled oﬀ for some time until it appeared again. This pattern was observed for both males and females, albeit only statistically significant for the former. Interestingly it was found that when the employ-ment eﬀects levelled oﬀ, wages started to fall, again for both genders. This suggested that during this period reductions in productivity mainly reduced wages, protecting against job loss.

Finally, the results of the biomarker analysis presented in Chapter  [4](#page101) showed that relying on self-reported diabetes information can lead to measurement bias in the coeﬃcient of diabetes. Using the biomarker data to identify people with diabetes, compared to self-reported diabetes smaller eﬀects especially on employment probabilities were found. This was caused by the non-existent associations between undiagnosed diabetes and employment chances. It was further found, that part of the diﬀerence in eﬀects between self-reported and undiagnosed diabetes could be explained by diﬀerences in subjective health status, with those self-reporting diabetes also reporting a worse health status. Interestingly, diﬀerences in glycated hemoglobin  [(HbA1c)](#page14) levels did not drive the stronger eﬀects for those self-reporting.

Chapters  [3](#page74) and  [4](#page101) produced evidence of the adverse eﬀect of self-reported

diabetes on labour market outcomes in Mexico. Chapter  [5](#page140) continued the in-vestigation of the impact of self-reported diabetes on employment probabilities, but this time in China. It further investigated how a diabetes diagnosis aﬀected diabetes relevant health behaviours in a developing country. Because the rela-tionships may be biased due to confounders not previously taken into account, the study used two diﬀerent econometric strategies in marginal structural mod-els  [(MSMs)](#page14) and  [FE.](#page14) Each controlled for a diﬀerent source of confounding, im-proving the robustness of the identified eﬀects. The used dataset consisted of six waves of the China Health and Nutrition Survey  [(CHNS),](#page14) covering a period from 1997 to 2011.

The results from Chapter  [5](#page140) provided further evidence of a deterioration of employment probabilities after a diabetes diagnosis, though this time only for women. They experienced a reduction in employment chances between 11 to 12 percentage points. For men, the  [MSM](#page14) and FE models showed insignificant re-lationships. These reductions for women were similar to those found in Mexico (16–17% in China and 14% in Mexico) when the diﬀerent female employment rates were taken into account. The results for behavioural risk factors also suggested diﬀerent eﬀects for men and women. According to the results, men were able to reduce alcohol consumption, body mass index  [(BMI)](#page14) levels, waist circumference and their daily calorie consumption, potentially reducing the risk for diabetes complications (Wilding,  [2014](#page306)). For women, no strong evidence for similar reductions was found. A similar picture remained when investigating the eﬀects over time using linear and non-linear specifications. On the one hand they suggested maintained reductions in female employment probabilities over time but no strong changes in risk factors. On the other hand, men were able to consistently reduce behavioural risk factors in the years following diagnosis while not experiencing any labour market penalties. Both at least suggests a potential relationship of changes in risk factors with changes in labour market outcomes.

1. **The context of the findings and their implications**

The findings of this thesis indicate an important global economic burden of diabetes and have added first evidence on the eﬀect of self-reported diabetes on labour market outcomes in MICs. The thesis also showed that diabetes—

at least in the case of labour market outcomes—did not similarly aﬀect the unaware diabetes population as it did those aware. Additionally it showed, that a diabetes diagnosis can elicit positive changes in health behaviours. Further, several potential equity issues are brought ot light, were the burden of diabetes appears to be distributed unequally, disproportionally aﬀecting the poor, those in the informal labour market and women.

These findings may lead to several implications to reduce the economic bur-den of diabetes in MICs.

**Inequities in the economic burden of diabetes**

An important observation of this thesis are the found economic inequities in the burden of diabetes. In Chapter  [2](#page28) the review found a high out-of-pocket  [(OOP](#page15)) burden in LMICs, especially for those with no insurance coverage. Chapter 3 showed that the adverse employment eﬀects were concentrated among those in the informal labour market and with fewer resources. This was further sup-ported by findings from Chapter  [4](#page101) that indicated a greater reduction in employ-ment probabilities to work in the agricultural or self-employed sector, while for those working in a non-independent wage job—that often entails greater con-tractual job security and better access to health insurance—diabetes did not appear to elicit negative eﬀects. Chapter  [5](#page140) found bigger adverse employment eﬀects and less positive behavioural changes in women compared to men after they had received a diabetes diagnosis. These gender inequities are also sup-ported by the results for Mexico, in particular by Chapter 4, where, taking into account the lower overall employment rates for women in Mexico, the relative reduction in employment chances was much greater for females than for males.

There may be several potential strategies how to reduce these inequalities and improve access to care. Several of these will be presented here with a focus on the identified populations in this thesis.

Summarise three messages here: for instance: early prevention, improve treatment, gender

**Identify people with diabetes to improve early prevention**

Adverse labour market outcomes were only observed for the self-reporting di-abetes population, suggesting that the adverse impact manifested only after some time of living with the disease and mainly after diagnosis. This is not surprising given the gradual increase in blood glucose as diabetes progresses and with this a relatively slow deterioration of health (Bertram and Vos,  [2010](#page284)). A first important step to reduce the economic burden of diabetes could there-

fore be the earlier diagnosis of diabetes. The large undiagnosed population found in Mexico in Chapter  [4](#page101) as well as for other LMICs in a recent study by Beagley et al.  [(2014),](#page284) suggests that in LMICs many people with diabetes remain undiagnosed for an extended period of time. The results of Chapter  [5](#page140) indicate that a diagnosis can introduce positive changes in behavioural risk-factors that may be directly related to a reduced economic burden of diabetes, suggesting that diagnosing those currently unaware could have positive eﬀects. Nonetheless, earlier detection would increase healthcare demands and costs in the short term, so that evidence is needed that would explore the trade-oﬀ between an increasing demand for healthcare and the economic gains made by the potential increases in productivity and productive life years in the working age population with diabetes, as well as lower inpatient expenditures due to reduced rates of severe, cost-intensive complications such as dialysis as a result of better health due to an earlier diagnosis (Engelgau and Gregg,  [2012](#page289)). Fur-ther, while earlier detection of diabetes via screening did not yield important improvements in disease outcomes in the Addition-Trial in European HICs, this might be markedly diﬀerent in MICs, where diabetes diagnosis often hap-pens later but diabetes aﬀects people at an earlier age, leaving more room for additional gains by an earlier diagnosis (Choukem and Mbanya,  [2013),](#page287) both in terms of health and the economic burden. Evidence on the cost-eﬀectiveness of a population-based diabetes screening program provided a recent study from Brazil, where over 22 million people over the age of 40 were screened for dia-betes, being the first evaluating an actual real-life population-based diabetes screening program in a developing country (Toscano et al.,  [2015](#page305)). It was un-clear if the program could be considered good value for the healthcare system, as the cost-eﬀectiveness of the findings depended strongly on the used assump-tions about how eﬀective treatment would be in preventing coronary heart disease and stroke. Given the results from this thesis, again cost-eﬀectiveness would likely be greater from a societal perspective if an earlier diagnosis would prevent or decrease losses in productivity and productive lifespan. Of course, early diagnosis may only be reasonable if the healthcare system is suﬃciently developed to allow all diagnosed cases access to appropriate treatment options (Engelgau and Gregg,  [2012;](#page289) Toscano et al.,  [2015](#page305)).

Apart from worse health in the population aware of its diabetes, another policy relevant reason for the diﬀerence in the observed eﬀects could be the psychological eﬀect of a diabetes diagnosis. Reductions in productivity may be the result of increasing anxiety and depression as a result of becoming aware of

the disease and its potential consequences. Further, diﬃculties in adapting to the treatment regime may cause additional stress. As discussed in Chapter 4, there is some evidence that becoming aware of the disease leads to reductions in labour income likely due to its psychological eﬀects (Liu and Zhu,  [2014](#page295)). If this is confirmed by other studies, then strategies to provide better guidance and support at diagnosis and thereafter to reduce the psychological burden of the disease could be worthwhile.

**Treating people with diabetes in resource constrained settings**

The adverse labour market eﬀects found for those with self-reported diabetes and the increase in eﬀect size over time after diagnosis, suggest that people aware of the disease are not able to prevent these adverse economic outcomes from happening. This may have several reasons. The diagnosis could hap-pen too late to prevent first complications from having developed, making it increasingly diﬃcult to prevent further complications. Another reason could be the sub-optimal treatment of the disease, in particular in the most ad-versely aﬀected—likely socioeconomically disadvantaged—groups identified in this thesis.

Therefore, an important step to improve outcomes would be the provision of better quality in diabetes treatment, targeting the identified groups and tailoring interventions according to their socioeconomic, physical and personal characteristics (Cefalu et al.,  [2016](#page286)). The existing evidence on treatment models applicable in very resource constrained settings has recently been reviewed by Esterson et al.  [(2014](#page290)). While the evidence is still limited, the study provided information on interventions that have had some success in improving diabetes treatment for the poor. Further, it identified common characteristics of these successful interventions: collaboration, education, standardization of guidelines and algorithms, technological innovations, and resource optimization. The au-thors recommended that initiatives to provide care to underserved populations should be built on collaborations between academic institutions, hospitals, the private sector and other organizations such as local governments. This should help to achieve goals that would otherwise be diﬃcult to reach for one stake-holder alone. Further, programs should aim at providing appropriate education to doctors to increase their ability to successfully treat people with diabetes. For very remote communities Esterson et al.  [(2014)](#page290) suggested the use of peer-support programs, so that few well educated community members or nurses could help their peers with the challenges of diabetes management. Further,

a need for standardized guidelines and treatment algorithms was identified as a means for healthcare professionals to improve and maintain their standards of care. Given that mobile phones have already reached even very remote ar-eas and are common in the developing world, interventions based on existent technologies could also improve care and diabetes outcomes. They could fa-cilitate communication between doctors and their patients as well as tracking and controlling diabetes management and outcome measures. Finally, resource optimization to use available and constrained resources more eﬀectively, e.g., by transferring certain responsibilities from doctors to nurses or from health-care professionals to peers could be an option in very resource constrained settings (Esterson et al.,  [2014](#page290)). Together, the presented strategies could help in reaching and treating poorer parts of the population.

A number of relevant interventions have been implemented in LMICs to improve care for people with diabetes, showing improvements in risk factors. Focusing on China, Mexico and other MICs some of these will be mentioned here. Most of these apply at least one of the recommendations mentioned in the previous para-graph. For Mexico, a recent randomized controlled trial tested the eﬀects of providing better diabetes training to physicians as well as supporting them with nurses trained in diabetes care and peer-support groups (Contreras et al.,  [2016](#page287)). In a separate treatment, the additional monitoring and support of patients via the use of mobile phone technology was tested in a second intervention group, given the common use of mobile phones in Mexico. First results indicated a signif-icant reduction in  [HbA1c](#page14) and better diabetes knowledge in both intervention groups compared to standard care, with better, but not statistical significant outcomes, for the group also using mobile phone technology. Other studies investigating the use of mobile phone technology have also shown promising re-sults (Singh et al.,  [2016](#page303)). Two randomized controlled trials investigated ways to improve diabetes outcomes in Costa Rica and China, respectively (Goldhaber-Fiebert et al.,  [2003;](#page290) Sun et al.,  [2008](#page304)). In Costa Rica, the application of a community-based nutrition and exercise program led to reductions on weight, fasting glucose and  [HbA1c](#page14) levels. In Shanghai,China, more extensive diabetes education and the provision of meal plans led to improvements in blood glucose,  [HbA1c](#page14) levels, blood pressure and waist-to-hip ratios compared to the group re-ceiving standard diabetes eduction. Unfortunately, so far information about the sustainability of these interventions in terms of cost-eﬀectiveness and long term eﬀects of the interventions is scarce, partly because investigation is still ongoing (Contreras et al.,  [2016)](#page287) or has remained nonevaluated (Singh et al.,  [2016](#page303)).

Further, in MICs, the provision of universal health care has been advocated for as a means to reduce health inequities by providing everyone with the abil-ity to access healthcare (Marmot et al.,  [2008](#page296)). So could this enable those in the informal economy to access aﬀordable treatments, narrowing inequities. Mex-ico has been one of the countries where the goal of universal health care has been almost accomplished through the introduction of "Seguro Popular", which provides those without prior health insurance coverage with social security and access to diabetes treatment options (Knaul et al.,  [2012;](#page293) Rivera-Hernandez et al.,  [2016](#page301)). However, evidence on the impact of diabetes treatment and out-comes has shown that the availability of this program has only led to very modest improvements, only finding a positive eﬀect on the use of pharmaco-logical therapy. No eﬀects were found on the monitoring of blood glucose or adherence to exercise plans by people with diabetes (Rivera-Hernandez et al.,  [2016](#page301)). A likely reason for this brought up by the authors was that many clinics were not prepared to provide specialized diabetes care and medications, sug-gesting that barriers to accessing appropriate diabetes care and education still existed. Hence, while public health care provision for those previously unin-sured can reduce inequities, such programs need to ensure that their eﬀorts are not sabotaged by the low quality of the oﬀered services.

**Diabetes prevention in resource constrained settings**

Apart from improving the quality of care for people with diabetes with few resources, the prevention of diabetes may also reduce the observed inequities and the individual economic burden of diabetes. Given the inequities found in this thesis, such eﬀorts may be particularly worthwhile if they focus on those disproportionally aﬀected by the adverse economic eﬀects of diabetes.

One option are the introduction of national policies to aﬀect food consump-tion. There is already some real life evidence of such interventions with the goal of reducing obesity in developing countries. In Mexico, a 10% tax on pur-chases of sugar-sweetened beverages and "junk food" has been introduced in 2014. First results suggested a reduction in purchases of these goods after the introduction of the tax, with a steeper decline for those with lower income lev-els (Batis et al.,  [2016;](#page283) Colchero et al.,  [2016](#page287)). If these changes in consumption actually lead to a healthier diet and are large enough to cause reductions in obesity and diabetes prevalence has not been evaluated yet and remains to be seen. Other eﬀorts to prevent diabetes in LMICs include increasing the aware-ness of diabetes and how to prevent it via population level campaigns, and

increasing the accessibility to sport courses and fitness equipment to increase physical activity Cefalu et al.  [(2016](#page286)).

Another option is the identification of at risk groups and targeting them with interventions to increase physical activity and dietary changes. These have shown promising results across the globe, including in developing countries such as India and China, where interventions have caused long term reductions in the risk of developing diabetes (Cefalu et al.,  [2016](#page286)). For example, for China a randomized controlled trial provided long term lifestyle interventions to re-duce the incidence of diabetes and cardiovascular disease as well as to reduce mortality in people at risk of developing type 2 diabetes. Over the active trial period of six years, the diet and exercise intervention reduced the relative risk for diabetes incidence by over 50% (Pan et al.,  [1997](#page298)). A more recent evaluation of the long-term impact of the interventions showed that over 20 years after the intervention had ended, the incidence of diabetes was still over 40% lower in the intervention group. Further, people that had received the intervention spend 3.6 years less with diabetes than those in the control group (Li, Zhang, et al.,  [2008](#page294)). However, all these interventions were tested in randomized controlled trials, and translation into real-world settings in community-interventions has been less successful, even in high-income countries (Kahn and Davidson,  [2014](#page292); Wareham and Herman,  [2016](#page306)). For example, weight loss has only been a small fraction of the reductions achieved in trials, often likely too little to prevent dia-betes. Kahn and Davidson  [(2014)](#page292) argue that weight loss is notoriously diﬃcult to maintain over a longer period of time, with trials often only capturing initial weight loss, but not the return to previous weight levels over time. Therefore, prevention eﬀorts based on lifestyle interventions or aiming at weight loss may not yet be translatable into real life, as too little is known about their cost-eﬀectiveness and long-term eﬀects to justify the use of limited resources (Kahn and Davidson,  [2014](#page292)). There are also questions about the cost-eﬀectiveness of these interventions if scaled to a population level and the problem of finding suﬃciently educated personal to implement lifestyle interventions at the local level.

The evidence for pharmacological interventions mainly using metformin also indicates a reduction in the risk of diabetes. However, Cefalu et al.  [(2016](#page286)) mention the potentially large heterogeneity in the benefit of pharmacological interventions across ethnicities. More research to this respect will be needed to find out if successful pharmacological interventions in one ethnicity can be translated to other ethnicities. Nonetheless, Cefalu et al.  [(2016)](#page286) argue that

preventive metformin treatment—which has been proven to reduce diabetes incidence in a number of randomized controlled trials—in individuals with a high risk of progressing to diabetes may be the best approach in countries with few economic resources. Low-cost generic versions of metformin exist, are considered essential diabetes medications in almost all LMICs (Bazargani et al.,  [2014),](#page283) are eﬀective in preventing or delaying the onset of diabetes, and are safe (Rojas and Gomes,  [2013](#page301)). They therefore may present a relatively cost-eﬀective intervention that could be applied using existent healthcare in-frastructure and pharmacies. It could be especially eﬀective in MICs, where the healthcare system infrastructure is much more developed than in low-income countries (LICs). Nonetheless, specific targeting of populations most likely to benefit from pharmacological preventative treatment will be need, as eﬀects of metformin appear to be heterogeneous across age a diabetes risk. Further, pharmacological treatments may also exhibit diﬀerent eﬀects across popula-tions and ethnicities (Cefalu et al.,  [2016](#page286)).

The identification of high-risk individuals that could be targeted with the mentioned interventions may pose an additional hurdle to successfully prevent-ing diabetes. Population level screening could be a way to identify people at risk. Screening could also be carried out at the workplace or the community and existing medical records could be used to identify people at an increased risk. Further, there may be possibilities to promote risk self-assessments us-ing online resources through advertising and social media (Cefalu et al.,  [2016](#page286)). However, scientific evidence of the cost-eﬀectiveness and feasibility of screening for high-risk individuals in LMICs is non-existent, and if it where to happen may overwhelm health care systems. It also carries the risk of further widen-ing health inequities if the lower income populations were less likely to attend screening eﬀorts (Wareham and Herman,  [2016](#page306)).

**The need to account for gender diﬀerences**

Finally, and one of the main results of this thesis, is the identification of women with diabetes as a specific target group. Gender diﬀerences in the disease bur-den of diabetes have come to the forefront only recently (Peters, Huxley, Sattar, et al.,  [2015),](#page299) but may hold one of the keys to reducing the economic burden of diabetes. The reduction in inequalities by the strategies discussed above may already lead to a reduction in the observed gender diﬀerences. If women have fewer economic resources then men, are more likely to work in the infor-mal labour market and less likely to be insured (Galli and Kucera,  [2008)](#page290) and

therefore are more adversely aﬀected by diabetes, then interventions targeting the poor and uninsured should specifically help women. However, it appears that biological diﬀerences between men and women may make it necessary to specifically target women. Diabetes likely aﬀects them to a greater extent (Bertram and Vos,  [2010;](#page284) Peters, Huxley, Sattar, et al.,  [2015;](#page299) Peters, Huxley, and Woodward,  [2014a,b)](#page299) and this could be driving the observed diﬀerences in the economic eﬀects. Eﬀorts to reduce the burden for females would include increasing awareness among doctors about the higher risks for women to de-velop diabetes complications, as well as screening for cardiovascular risk factors in women at or before a diabetes diagnosis. This would present an opportu-nity to prevent a further escalation of the cardiovascular risk profile (Peters, Huxley, Sattar, et al.,  [2015](#page299)). For women, weight reduction thereby seems to be the single most important step to reduce the risk of diabetes and ensuing complications (Peters, Huxley, Sattar, et al.,  [2015](#page299)). As this thesis has shown, women in China were not able to achieve weight reduction to the extent men did and therefore may need to be treated diﬀerently. Future work on LMICs can provide tremendous contributions to help develop effective strategies to obtain this type of imporvments in women’s health outcomes .

Overall it seems that for LMICs, national policies to change food consump-tion behaviours to prevent diabetes are currently the best option to halt the escalation of the economic impact of diabetes and to reduce inequities. The results of this thesis suggest that it should be a priority to design interventions that address the existent inequities by preventing diabetes in those populations that experience the worse economic consequences. Further, targeting those with little access to healthcare in screening programs for both undiagnosed diabetes and those at high-risk for diabetes, and then following up with oﬀers for preventive pharmacological treatment and potentially also lifestyle interven-tions could be of value, but more conclusive evidence on their cost-eﬀectiveness and sustainability will be needed first. Further, strategies to improve treatment of diabetes will need to take into account the specific circumstances of the re-spective target group and should be developed in cooperative eﬀorts to make them work.

**6.4 Reflections on the methods used in the thesis**

Apart from Chapter 2, the thesis used exclusively quantitative methods in an attempt to establish causal relationships between diabetes and the outcomes of interest. The goal of using econometrics in this thesis was to investigate the

relationship of diabetes with labour market outcomes and health behaviours in the absence of experimental data. Given the good quality of available data and the dearth of previous quantitative research on the economics of diabetes in  [MIC,](#page14) using econometric methods seemed to be the most appropriate way to answer the posed research questions and to provide evidence for diﬀerent geographical regions.

One of the challenges was the choice of the most appropriate method to es-tablish a causal relationship. The main concern was that unobserved variables, measurement error as well as reverse causality may introduce bias into the estimates. A variety of methods were used that each had advantages and dis-advantages in terms of the underlying assumptions and the ability to account for potential sources of bias. Their choice was mainly guided by the available data and the best way of achieving a causal interpretation under the given cir-cumstances. Nonetheless, regardless of the method used, results consistently showed an adverse relationship of self-reported diabetes with employment prob-abilities, suggesting a relatively robust and likely causal eﬀect.

**6.5 Strengths and limitations**

The strengths and limitations of each study and the methodological approach used have been evaluated within each chapter. Additionally, the thesis overall has strengths and limitations.

A strength of this thesis is the provision of a comprehensive overview and assessment of the state of economic research on the impact of diabetes. It pro-vides other researchers guidance by identifying areas for future research and suggestions on which methods to use. Further, the thesis itself fills some of the identified gaps by investigating the impact of diabetes on labour market outcomes in MICs. A strength of these analyses is the use of rigorous econo-metric approaches taking advantage of available and previously underexplored household data, allowing to investigate a variety of topics. The used methods also improved on previous approaches, providing more robust evidence and extended the range of methods used in the exploration to methods predomi-nantly known in epidemiology. A further strength is the provision of evidence on the potential of diabetes to widen the economic inequities in developing countries, identifying the groups that were disproportionally aﬀected by the disease. Further, it has also advanced the understanding of diabetes as a mul-tifaceted condition by exploring eﬀects over time and for those who are aware

and those who are unaware of their diabetes. Finally, it provides evidence from diﬀerent data sources and contexts and also investigates the value of becom-ing aware of the disease through a diagnosis and its ability to influence health behaviours.

The thesis has several limitations. Whilst the intention was to provide evi-dence on the economics of diabetes in MICs, the thesis mostly investigates the economic impact of diabetes. While this provided important information for researchers and policy makers, the thesis did not investigate how to curb this economic diabetes burden. Information about the best and most costs-eﬀective interventions that could be applied in MICs to lower the burden of diabetes is urgently needed as information about who is aﬀected most will not suﬃce to eﬀectively reduce the burden. Research on how to implement interventions feasible in non- [HIC](#page14) settings is therefore of paramount importance and has not been provided in this thesis.

This leads to the next limitation. The thesis does not investigate in how far healthcare systems in MICs need to change in order to better provide care. Because they often lack financial resources, do not eﬃciently use the available resources, are designed to treat acute infectious diseases rather then aﬀecting the outcomes of long-lasting non-acute non-communicable diseases  [(NCDs)](#page15), and often provide unequal access to their health services due to financial con-straints of those seeking care, research into how to better equip healthcare systems to confront the challenges of treating  [NCDs](#page15) (Guzmán et al.,  [2010](#page291); Mills,  [2014](#page296)).

A further limitation is the geographical concentration of the thesis in its em-pirical investigation. While Mexico and China are among the ten countries with most people with diabetes in the world, there are other large and small MICs currently facing similar challenges (NCD Risk Factor Collaboration,  [2016](#page297)). It cannot be assumed that the evidence provided in this thesis is representative of other MICs. It therefore will be important to investigate the economic bur-den and potential solutions in other countries, given their own specific context in terms of culture, the political system, economic development and existing inequities.

Finally, while the thesis intended to provide a picture of the potential in-equities in the economic impact of diabetes for socioeconomic subgroups, it did not investigate in detail why these inequities exist and could only speculate on the reasons. A better understanding of the underlying reasons will be in-tegral for designing adequate strategies to address these inequities. Further,

whilst the thesis has touched upon the potential reasons for the diﬀerences in employment eﬀects between those self-reporting diabetes and those unaware, it has not provided an in depth analysis of this phenomenon. A better identi-fication of the underlying reasons will be needed to design interventions that can prevent the adverse economic eﬀects of diabetes.

**6.6 Suggestions for future research**

This thesis has shown the global economic impact of diabetes and its adverse eﬀect on labour market outcomes in Mexico and China. It identified the poor, those in the informal economy and women as being most adversely aﬀected by the disease. It further found that, at least in China, it is men that appear to profit most from a diabetes diagnosis in terms of positively changing their health behaviours. Finally, it provided some indication that while self-reported diabetes is related to adverse labour market eﬀects, undiagnosed diabetes is not. Without a greater understanding of the underlying reasons for the found diﬀerences, it will be diﬃcult to design policies that can help prevent the burden of diabetes in  [MIC](#page14) and reduce inequalities.

Several reasons for the observed gender diﬀerences in the impact of diabetes have been discussed in this thesis, including biological reasons that increase the risk of complications in women Arnetz et al.  [(2014),](#page282) Catalan et al.  [(2015)](#page286), Engelmann et al.  [(2016),](#page289) Peters, Huxley, Sattar, et al.  [(2015),](#page299) Peters, Huxley, and Woodward  [(2014a),](#page299) Policardo et al.  [(2014),](#page299) Roche and Wang  [(2013),](#page301) and Seghieri et al.  [(2015)](#page302) and may also impair the ability of women to lose weight (Penno et al.,  [2013),](#page299) as well as diﬀerences in the access to appropriate health-care (Penno et al.,  [2013](#page299)). One strategy to further investigate these diﬀerences would be the use of biomarker data in combination with information on health-care utilization as well as socioeconomic outcomes. This could then be used to investigate potential heterogeneities in the relationship between diabetes and overall metabolic health with labour market outcomes. Further, information on healthcare usage could be used to investigate if diﬀerences in healthcare access mediate the economic impact of diabetes. A potentially rich source of information provide two Chinese household surveys, the China Health and Nu-trition Survey  [(CHNS)](#page14) and the The China Health and Retirement Longitudinal Study  [(CHARLS](#page14)). Both contain an extensive list of measured biomarkers and socioeconomic variables that could help to investigate diﬀerences in metabolic risk between men and women. This information may also be used to further

explore diﬀerences in metabolic risk between people aware and unaware of their diabetes. Also, studies measuring potential mediating variables—such as knowledge, motivation, treatment, diabetes control and complications—would help clarify the causal mechanisms through which diabetes aﬀects economic and other outcomes. Structural equation and mediation models could be use-ful with such data.

Researchers should also try to confirm the results regarding the found in-equities, using diﬀerent data and countries. If these relationships can be con-firmed, the underlying drivers of these inequities need to be explored to design adequate policies. This could be done by identifying countries where these in-equities may not have been found, to isolate the causal determinants. Further, strategies implemented currently or in the future in MICs that aim to re-duce these inequities, such as the implementation of universal health insurance schemes need to be evaluated in how far they are actually achieving this goal in terms of diabetes. The same is true for population level interventions such as taxes on foods or nutrients, as these theoretically should reduce consumption in particular for those with lower levels of income (Mytton et al.,  [2012](#page297)). This could then lead to a reduction in diabetes incidence in these groups. However, depending on the price elasticities of the taxed products as well as substitution eﬀects with equally untaxed products, such taxes may only reduce the dispos-able income. It could thereby reduce food purchases of healthy products or could cause a shift in consumption towards other equally unhealthy untaxed products (Mytton et al.,  [2012](#page297)).

Third, the diabetes population in all countries, but especially in LMICs is only partially observed. In other words many people with diabetes are not aware that they have the disease. This thesis has provided an investigation of the diﬀerences between those aware and unaware. It, however, still re-mains unclear to what extent diﬀerent factors such as health information and actual health status are causing the observed heterogeneity in the economic impact. Because increasingly household surveys are providing biomarker data in combination with socioeconomic information, they should be used together with quasi-experimental econometric techniques to investigate this topic. A regression-discontinuity design may be used in a similar vain as in Zhao, Kon-ishi, et al.  [(2013),](#page308) who use cut-oﬀ values for hypertension to identify those newly diagnosed and the subsequent eﬀect of this diagnosis on health behaviours. A similar approach could be used to explore the eﬀects of a diabetes diagnosis and the entailed health information on labour market outcomes, health behaviours

and other economic outcomes. Importantly, researches should assess the het-erogeneity of eﬀects across income groups, rural versus urban, education levels and between males and females. This would provide important information for designing interventions to reduce the physiological and economic burden of diabetes while preventing a widening of inequities.

Fourth and finally, there is a need to explore further economic downstream eﬀects of the economic impact of diabetes. If diabetes causes reductions in employment and potentially also income, it is likely that these will cause not only problems for the individual directly aﬀected, but for the entire household as well. In MICs, where social security is less extensive and comprehensive, adverse health shocks due to diabetes could have consequences for the chil-dren, spouses or other family members living in aﬀected households (Alam and Mahal,  [2014](#page281)). The loss in labour income due to diabetes needs to be compen-sated either by increasing the labour supply of other household members or by reducing expenditures for other consumption goods. Both could aﬀect children directly, for example by reducing the time for or quality of education when tuition fees cannot be paid anymore and also by having to substitute time for education with labour time. Similarly spouses may be forced to increase their labour supply, reducing the time they can care for their children. These ef-fects have remained unexplored for diabetes but given the scale of the diabetes epidemic may not be trivial.

**6.7 Concluding remarks**

Diabetes presents a major challenge for MICs, but evidence on its economics has been scarce. This thesis has found that diabetes has an adverse economic impact on individuals and puts a burden on healthcare systems. Because ev-idence on the impact of diabetes on labour market outcomes was lacking in developing countries, the thesis had a special focus on this topic. Thereby it not only provided evidence of the adverse impact of diabetes on employment, but also improved upon previously used econometric methods by using novel strategies to identify a causal relationship. The thesis also identified poten-tial inequities in the impact of diabetes, pointing to larger adverse eﬀects for the poor, those in the informal labour market and women. But the thesis did not only focus on the economic impact of diabetes, but also investigated the eﬀects of a diabetes diagnosis on health behaviours, unravelling evidence for diﬀerences in the ability to change health behaviours between men and women.

These findings suggest that there is a need to reduce the economic impact of diabetes in MICs. Considering the increasingly earlier onset of diabetes and the ongoing increase in incidence in many countries, the non-trivial adverse economic eﬀects could otherwise hinder economic development and present a substantial poverty risk. Strategies to combat the adverse diabetes eﬀects need to be tailored to the available resources within countries, target the most aﬀected groups to narrow inequities, also having in mind potential gender dif-ferences. Finally, there is a large undiagnosed diabetes population in MICs that is likely to experience severe diabetes complications if identified very late. Hence, ways to diagnose this population earlier in order to prevent further de-terioration of health may go a long way in preventing and delaying the most catastrophic economic and health outcomes.

In conclusion, it is hoped that the research presented in this thesis contribute to the knowledge on the economics of diabetes and help to identify cost-eﬀective strategies to lower the health and economic consequences of diabetes. It has demonstrated the economic burden currently caused by diabetes, in particular in Mexico and China, and has identified groups that are particularly vulnerable to the negative consequences of the disease and should be at the centre of eﬀorts to prevent the burden of diabetes.

**Appendix**

**Appendix to Chapter 1**

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  | |  |  |  |  |  |  |  |
| DHS | Armenia | Cross- |  | 2010 | women | | 6700 | yes | no | yes | diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-354.cfm): | |
|  |  | section |  |  | and | men | house- |  |  |  | questions, | //www. | |
|  |  |  |  |  | 15-49 |  | holds |  |  |  | health | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-354.cfm). | |
|  |  |  |  |  |  |  |  |  |  |  | expendi- | com/ | |
|  |  |  |  |  |  |  |  |  |  |  | tures | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | survey/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | survey-display-354. | |
|  |  |  |  |  |  |  |  |  |  |  |  | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-354.cfm)m | |
| DHS | Bangladesh | Cross- |  | 2011 | women | | 17141 | yes | no | yes |  | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-349.cfm): | |
|  |  | section |  |  | 12-49 |  | house- |  |  |  |  | //www. | |
|  |  |  |  |  | and | men | holds |  |  |  |  | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-349.cfm). | |
|  |  |  |  |  | 15-54 |  |  |  |  |  |  | com/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | survey/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | survey-display-349. | |
|  |  |  |  |  |  |  |  |  |  |  |  | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-349.cfm)m | |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| DHS | Benin | Cross- |  | 2011-2012 | women | 17422 | yes | yes | not yet | diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-420.cfm): | |
|  |  | section |  |  | 12-49 | house- |  |  |  | questions | //www. | |
|  |  |  |  |  | and men | holds |  |  |  |  | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-420.cfm). | |
|  |  |  |  |  | 15-64 |  |  |  |  |  | com/ | |
|  |  |  |  |  |  |  |  |  |  |  | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  |  | survey/ | |
|  |  |  |  |  |  |  |  |  |  |  | survey-display-420. | |
|  |  |  |  |  |  |  |  |  |  |  | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-420.cfm)m | |
| LSMS | Bosnia | Cross- |  | 2004 | both | 2969 | yes | no | yes | Diabetes | [http](http://go.worldbank.org/OLMHSTUX40): | |
|  | and | section |  |  | sexes | household |  |  |  | question, | //go. | |
|  | Herzegov- |  |  |  |  |  |  |  |  | health- | [worldbank](http://go.worldbank.org/OLMHSTUX40). | |
|  | ina |  |  |  |  |  |  |  |  | care | org/ | |
|  |  |  |  |  |  |  |  |  |  | expen- | [OLMHSTUX4](http://go.worldbank.org/OLMHSTUX40)0 | |
|  |  |  |  |  |  |  |  |  |  | ditures, |  |  |
|  |  |  |  |  |  |  |  |  |  | employ- |  |  |

ment, earnings

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| LSMS | Bulgaria | Cross- |  | 2001, | both | 4300 | yes | no | yes | diabetes | [http](http://econ.worldbank.org/): | |
|  |  | section |  | 2003, | sexes | house- |  |  |  | questions, | //econ. | |
|  |  |  |  | 2007 |  | holds |  |  |  | since | [worldbank](http://econ.worldbank.org/). | |
|  |  |  |  |  |  |  |  |  |  | when di- | [org](http://econ.worldbank.org/)/ | |
|  |  |  |  |  |  |  |  |  |  | agnosed, |  |  |
|  |  |  |  |  |  |  |  |  |  | health |  |  |

expen-ditures, earnings

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | | Sample | Nationally | Ongoing | Data | Interesting | | URL |
|  |  | section | / |  |  |  | size | Represen- |  | available | content | |  |
|  |  | Panel |  |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  | |  |  |  |  |  | |  |
| Cebu | Philippines | Panel | 5 | 1991-2005 | Filipino | | 2800 | no | yes | yes | diabetes, | | [http:/](http://www.cpc.unc.edu/projects/cebu/datasets)/ |
| Longi- | |  |  |  | women | | women |  |  |  | health, | | [www.cpc](http://www.cpc.unc.edu/projects/cebu/datasets). |
| tudinal | |  |  |  | who | gave | and 2260 |  |  |  | nutrition | | [unc.edu](http://www.cpc.unc.edu/projects/cebu/datasets)/ |
| Health | |  |  |  | birth |  | children |  |  |  | and | eco- | [projects](http://www.cpc.unc.edu/projects/cebu/datasets)/ |
| and | Nu- |  |  |  | between | |  |  |  |  | nomic | | cebu/ |
| trition | |  |  |  | May | 1, |  |  |  |  | data | for | [dataset](http://www.cpc.unc.edu/projects/cebu/datasets)s |
| Survey | |  |  |  | 1983, and | |  |  |  |  | mothers | |  |
|  |  |  |  |  | April | 30, |  |  |  |  | available | |  |
|  |  |  |  |  | 1984 |  |  |  |  |  | at | least |  |
|  |  |  |  |  |  |  |  |  |  |  | since |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 1991, | for |  |
|  |  |  |  |  |  |  |  |  |  |  | children | |  |
|  |  |  |  |  |  |  |  |  |  |  | blood | |  |
|  |  |  |  |  |  |  |  |  |  |  | samples | |  |
|  |  |  |  |  |  |  |  |  |  |  | taken | |  |
|  |  |  |  |  |  |  |  |  |  |  | in | 2005 |  |
|  |  |  |  |  |  |  |  |  |  |  | and | were |  |
|  |  |  |  |  |  |  |  |  |  |  | asked for | |  |

chronic illnesses

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | | Years | Population | | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |  |  |
| CHNS | China | Panel | Every | | 1989-2011 | both |  | Around | yes | yes (next | yes | Diabetes | [http:/](http://www.cpc.unc.edu/projects/china)/ | |
|  |  |  | 2 | years |  | sexes, | all | 16000 |  | wave |  | question, | [www.cpc](http://www.cpc.unc.edu/projects/china). | |
|  |  |  | since |  |  | ages |  | people |  | 2013) |  | biomark- | [unc.edu](http://www.cpc.unc.edu/projects/china)/ | |
|  |  |  | 1989 |  |  |  |  |  |  |  |  | ers | [projects](http://www.cpc.unc.edu/projects/china)/ | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | [chin](http://www.cpc.unc.edu/projects/china)a | |
| DHS | Dominican | Cross- |  |  | 2007 | Women | | 32000 | yes | no | yes | Diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-291.cfm): | |
|  | Republic | section |  |  |  | 15-49 |  | house- |  |  |  | question, | //www. | |
|  |  |  |  |  |  | and | men | holds |  |  |  | (earnings, | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-291.cfm). | |
|  |  |  |  |  |  | 15-59 |  |  |  |  |  | employ- | com/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | ment, | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | health | survey/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | expen- | survey-display-291. | |
|  |  |  |  |  |  |  |  |  |  |  |  | ditures, | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-291.cfm)m | |
|  |  |  |  |  |  |  |  |  |  |  |  | wealth) |  |  |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| DHS | Egypt | Cross- |  | 2008 | Females | 18968 | yes | no | yes | Diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-294.cfm): | |
|  |  | section |  |  | 15-49 and | house- |  |  |  | question, | //www. | |
|  |  |  |  |  | males | holds |  |  |  | socioe- | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-294.cfm). | |
|  |  |  |  |  | 15-59 |  |  |  |  | conomic | com/ | |
|  |  |  |  |  |  |  |  |  |  | infor- | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  | mation | survey/ | |
|  |  |  |  |  |  |  |  |  |  | (earnings, | survey-display-294. | |
|  |  |  |  |  |  |  |  |  |  | employ- | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-294.cfm)m | |
|  |  |  |  |  |  |  |  |  |  | ment, |  |  |
|  |  |  |  |  |  |  |  |  |  | health |  |  |
|  |  |  |  |  |  |  |  |  |  | expen- |  |  |
|  |  |  |  |  |  |  |  |  |  | ditures, |  |  |
|  |  |  |  |  |  |  |  |  |  | wealth) |  |  |
| DHS | India | Cross- |  | 2005 | women | 109041 | yes | no | yes | diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-264.cfm): | |
|  |  | section |  |  | 15-49 | house- |  |  |  | ques- | //www. | |
|  |  |  |  |  | and men | holds |  |  |  | tion and | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-264.cfm). | |
|  |  |  |  |  | 15-54 |  |  |  |  | history, | com/ | |
|  |  |  |  |  |  |  |  |  |  | earnings, | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  | employ- | survey/ | |
|  |  |  |  |  |  |  |  |  |  | ment, | survey-display-264. | |
|  |  |  |  |  |  |  |  |  |  | wealth | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-264.cfm)m | |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | | Sample | Nationally | Ongoing | Data | Interesting | | URL | |
|  |  | section | / |  |  |  | size | Represen- |  | available | content |  |  |  |
|  |  | Panel |  |  |  |  |  | tative |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |
| Indonesian | Indonesia | Panel | 4 | 1993, | both |  | 30000 | almost | no | yes | diabetes | | [http](http://www.rand.org/labor/FLS/IFLS.html): | |
| Family |  |  |  | 1997, | sexes, | all | people |  |  |  | question | | //www. | |
| Life |  |  |  | 2000, | ages |  |  |  |  |  | only | in | rand. | |
| Survey |  |  |  | 2007 |  |  |  |  |  |  | last wave | | org/ | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | labor/ | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | FLS/ | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | IFLS. | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | [htm](http://www.rand.org/labor/FLS/IFLS.html)l | |
| LSMS | Iraq | Cross- |  | 2007 | both |  | 18144 | yes | no | yes | diabetes | | [http](http://go.worldbank.org/HATUQJIMF0): | |
|  |  | section |  |  | sexes, | all | house- |  |  |  | questions, | | //go. | |
|  |  |  |  |  | ages |  | holds |  |  |  | comor- |  | [worldbank](http://go.worldbank.org/HATUQJIMF0). | |
|  |  |  |  |  |  |  |  |  |  |  | bidi- |  | org/ | |
|  |  |  |  |  |  |  |  |  |  |  | ties,health | | [HATUQJIMF](http://go.worldbank.org/HATUQJIMF0)0 | |
|  |  |  |  |  |  |  |  |  |  |  | expen- |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | ditures, |  |  |  |

earnings, employ-ment, wealth

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| DHS | Lesotho | Cross- |  | 2009 | Women | 9391 | yes | no | yes | diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-317.cfm): | |
|  |  | section |  |  | 15-49 | house- |  |  |  | questions, | //www. | |
|  |  |  |  |  | and men | holds |  |  |  | earnings, | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-317.cfm). | |
|  |  |  |  |  | 15-59 |  |  |  |  | income, | com/ | |
|  |  |  |  |  |  |  |  |  |  | wealth | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  |  | survey/ | |
|  |  |  |  |  |  |  |  |  |  |  | survey-display-317. | |
|  |  |  |  |  |  |  |  |  |  |  | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-317.cfm)m | |
| LSMS | Malawi | From |  | 2004, | both | 12271 | yes | yes | yes | diabetes | [http](http://go.worldbank.org/RMEFTSE8O0): | |
|  |  | 2013 | on | 2010 | sexes | house- |  |  |  | questions, | //go. | |
|  |  | partly |  |  |  | holds in |  |  |  | health | [worldbank](http://go.worldbank.org/RMEFTSE8O0). | |
|  |  | panel |  |  |  | 2010 |  |  |  | expen- | org/ | |
|  |  | structure | |  |  |  |  |  |  | ditures, | [RMEFTSE8O](http://go.worldbank.org/RMEFTSE8O0)0 | |
|  |  |  |  |  |  |  |  |  |  | employ- |  |  |
|  |  |  |  |  |  |  |  |  |  | ment, |  |  |
|  |  |  |  |  |  |  |  |  |  | income |  |  |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name |  | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  | |  |  |  |  |  |  |  |  |  |  |  |  |
| MxFLS | | Mexico | Panel | 2 | 2002, | both | 35000 | yes | no | yes | diabetes | [http](http://www.ennvih-mxfls.org/es/ennvih.php?seccion=1&subseccion=1&session=76719964140): | |
|  |  |  |  |  | 2005 | sexes, all |  |  |  |  | question, | //www. | |
|  |  |  |  |  |  | ages |  |  |  |  | labour | ennvih-mxfls. | |
|  |  |  |  |  |  |  |  |  |  |  | outcomes, | org/es/ | |
|  |  |  |  |  |  |  |  |  |  |  | parental | ennvih. | |
|  |  |  |  |  |  |  |  |  |  |  | diabetes | php? | |
|  |  |  |  |  |  |  |  |  |  |  |  | [seccion](http://www.ennvih-mxfls.org/es/ennvih.php?seccion=1&subseccion=1&session=76719964140)= | |
|  |  |  |  |  |  |  |  |  |  |  |  | 1& |  |
|  |  |  |  |  |  |  |  |  |  |  |  | [subseccion](http://www.ennvih-mxfls.org/es/ennvih.php?seccion=1&subseccion=1&session=76719964140)= | |
|  |  |  |  |  |  |  |  |  |  |  |  | 1& |  |
|  |  |  |  |  |  |  |  |  |  |  |  | [session](http://www.ennvih-mxfls.org/es/ennvih.php?seccion=1&subseccion=1&session=76719964140)= | |
|  |  |  |  |  |  |  |  |  |  |  |  | [7671996414](http://www.ennvih-mxfls.org/es/ennvih.php?seccion=1&subseccion=1&session=76719964140)0 | |
| Enquete | | Morocco | Cross- |  | 2007 | ? | 7200 | yes | no | no infor- | Diabetes | [http](http://www.hcp.ma/Enquete-nationale-sur-les-niveaux-de-vie-des-menages_a96.html): | |
| nationale | |  | section |  |  |  | house- |  |  | mation | question | //www. | |
| sur | les |  |  |  |  |  | holds |  |  | found |  | hcp.ma/ | |
| niveaux | |  |  |  |  |  |  |  |  |  |  | Enquete-nationale-su | |
| de vie des | |  |  |  |  |  |  |  |  |  |  | [a96.htm](http://www.hcp.ma/Enquete-nationale-sur-les-niveaux-de-vie-des-menages_a96.html)l | |
| menages | |  |  |  |  |  |  |  |  |  |  |  |  |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| LSMS | Nepal | Cross- | 3 | 1996, | both | 6000 | yes | no | yes | diabetes | [http](http://go.worldbank.org/LLAVNKC6E0): | |
|  |  | section/Panel | | 2003, | sexes | house- |  |  |  | questions, | //go. | |
|  |  |  |  | 2010 |  | holds, |  |  |  | since | [worldbank](http://go.worldbank.org/LLAVNKC6E0). | |
|  |  |  |  |  |  | Panel |  |  |  | when di- | org/ | |
|  |  |  |  |  |  | 1200 |  |  |  | agnosed, | [LLAVNKC6E](http://go.worldbank.org/LLAVNKC6E0)0 | |
|  |  |  |  |  |  |  |  |  |  | health |  |  |
|  |  |  |  |  |  |  |  |  |  | expen- |  |  |
|  |  |  |  |  |  |  |  |  |  | ditures, |  |  |
|  |  |  |  |  |  |  |  |  |  | earnings, |  |  |
|  |  |  |  |  |  |  |  |  |  | employ- |  |  |
|  |  |  |  |  |  |  |  |  |  | ment |  |  |
| DHS | Peru | Cross- |  | 2011 | only fe- | 26182 | yes | no | yes | diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-433.cfm): | |
|  |  | section |  |  | males, | house- |  |  |  | questions, | //www. | |
|  |  |  |  |  | 15-49 | holds |  |  |  | income, | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-433.cfm). | |
|  |  |  |  |  |  |  |  |  |  | health | com/ | |
|  |  |  |  |  |  |  |  |  |  | expen- | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  | ditures, | survey/ | |
|  |  |  |  |  |  |  |  |  |  | employ- | survey-display-433. | |
|  |  |  |  |  |  |  |  |  |  | ment, | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-433.cfm)m | |
|  |  |  |  |  |  |  |  |  |  | wealth |  |  |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| DHS | Senegal | Cross- |  | 2011 | Women | 7902 | yes | no | yes | diabetes | [http](http://www.measuredhs.com/what-we-do/survey/survey-display-365.cfm): | |
|  |  | section |  |  | 15-49 | house- |  |  |  | questions, | //www. | |
|  |  |  |  |  | and men | holds |  |  |  | income, | [measuredhs](http://www.measuredhs.com/what-we-do/survey/survey-display-365.cfm). | |
|  |  |  |  |  | 15-59 |  |  |  |  | health | com/ | |
|  |  |  |  |  |  |  |  |  |  | expen- | what-we-do/ | |
|  |  |  |  |  |  |  |  |  |  | ditures, | survey/ | |
|  |  |  |  |  |  |  |  |  |  | employ- | survey-display-365. | |
|  |  |  |  |  |  |  |  |  |  | ment, | [cf](http://www.measuredhs.com/what-we-do/survey/survey-display-365.cfm)m | |
|  |  |  |  |  |  |  |  |  |  | wealth |  |  |
| LSMS | Serbia | Panel | 2 | 2002, | both | 19725 | yes | no | yes | Diabetes | [http:/](http://microdata.worldbank.org/index.php/catalog/80)/ | |
|  | and Mon- |  |  | 2003 | sexes | persons |  |  |  | question, | [microdata](http://microdata.worldbank.org/index.php/catalog/80). | |
|  | tenegro |  |  |  |  | (2002), |  |  |  | health- | [worldbank](http://microdata.worldbank.org/index.php/catalog/80). | |
|  |  |  |  |  |  | 8027 |  |  |  | care | org/ | |
|  |  |  |  |  |  | persons |  |  |  | expen- | index. | |
|  |  |  |  |  |  | (2003) |  |  |  | ditures, | php/ | |
|  |  |  |  |  |  |  |  |  |  | employ- | [catalog](http://microdata.worldbank.org/index.php/catalog/80)/ | |
|  |  |  |  |  |  |  |  |  |  | ment | [8](http://microdata.worldbank.org/index.php/catalog/80)0 |  |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| South | South | Cross- | 2 | 2008, | both | 7300 | yes | yes | yes | Diabetes | [http](http://www.nids.uct.ac.za/home/): | |
| African | Africa | section |  | 2011 | sexes | house- |  |  |  | question, | //www. | |
| National |  |  |  |  |  | holds |  |  |  | taking | nids. | |
| Income |  |  |  |  |  |  |  |  |  | medi- | uct.ac. | |
| Dynamics |  |  |  |  |  |  |  |  |  | cation | [za/home](http://www.nids.uct.ac.za/home/)/ | |
| Study |  |  |  |  |  |  |  |  |  | and since |  |  |
| (NIDS) |  |  |  |  |  |  |  |  |  | when |  |  |
|  |  |  |  |  |  |  |  |  |  | diabetes, |  |  |
|  |  |  |  |  |  |  |  |  |  | income, |  |  |
|  |  |  |  |  |  |  |  |  |  | health |  |  |
|  |  |  |  |  |  |  |  |  |  | expen- |  |  |
|  |  |  |  |  |  |  |  |  |  | ditures, |  |  |
|  |  |  |  |  |  |  |  |  |  | labour |  |  |
|  |  |  |  |  |  |  |  |  |  | outcomes |  |  |
| LSMS | Tajikistan | Cross- |  | 2007 | both | 4860 | yes | no | yes | diabetes | [http](http://go.worldbank.org/6TUMCB3K30): | |
|  |  | section |  |  | sexes | house- |  |  |  | questions, | //go. | |
|  |  |  |  |  |  | holds |  |  |  | labour | [worldbank](http://go.worldbank.org/6TUMCB3K30). | |
|  |  |  |  |  |  |  |  |  |  | outcomes, | org/ | |
|  |  |  |  |  |  |  |  |  |  | health | [6TUMCB3K3](http://go.worldbank.org/6TUMCB3K30)0 | |
|  |  |  |  |  |  |  |  |  |  | expendi- |  |  |
|  |  |  |  |  |  |  |  |  |  | tures |  |  |

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data |  | Interesting | URL | |
|  |  | section | / |  |  | size | Represen- |  | available | | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| LSMS | Tanzania | Panel | 2 | 1994, | both | 900 | no | no | yes |  | diabetes | [http](http://go.worldbank.org/9F9RHLXM20): | |
|  |  |  |  | 2004 | sexes | house- |  |  |  |  | questions, | //go. | |
|  |  |  |  |  |  | holds |  |  |  |  | income, | [worldbank](http://go.worldbank.org/9F9RHLXM20). | |
|  |  |  |  |  |  |  |  |  |  |  | employ- | org/ | |
|  |  |  |  |  |  |  |  |  |  |  | ment, | [9F9RHLXM2](http://go.worldbank.org/9F9RHLXM20)0 | |
|  |  |  |  |  |  |  |  |  |  |  | health |  |  |
|  |  |  |  |  |  |  |  |  |  |  | expendi- |  |  |
|  |  |  |  |  |  |  |  |  |  |  | tures |  |  |
| WHO | Worldwide | Cross- |  | 2002 | both |  | yes | no | not | di- | Diabetes | [http](http://www.who.int/healthinfo/survey/instruments/en/index.html): | |
| World |  | section |  |  | sexes |  |  |  | rectly |  | question | //www. | |
| Health |  |  |  |  |  |  |  |  |  |  |  | [who.int](http://www.who.int/healthinfo/survey/instruments/en/index.html)/ | |
| Survey |  |  |  |  |  |  |  |  |  |  |  | [healthinfo](http://www.who.int/healthinfo/survey/instruments/en/index.html)/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | survey/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | [instruments](http://www.who.int/healthinfo/survey/instruments/en/index.html)/ | |
|  |  |  |  |  |  |  |  |  |  |  |  | en/ | |

index.  [htm](http://www.who.int/healthinfo/survey/instruments/en/index.html)l

Table 28: Household surveys from low- and middle-income countries including diabetes information as of 2014

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Country | Cross- | Waves | Years | Population | Sample | Nationally | Ongoing | Data | Interesting | | URL |
|  |  | section | / |  |  | size | Represen- |  | available | content |  |  |
|  |  | Panel |  |  |  |  | tative |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | |  |
| Russia | Russia | Panel | 15 | 1994-2011 | both | 4000-6000 | yes | yes | yes | diabetes | | [http:/](http://www.cpc.unc.edu/projects/rlms-hse)/ |
| Longi- |  |  |  |  | sexes | house- |  |  |  | question, | | [www.cpc](http://www.cpc.unc.edu/projects/rlms-hse). |
| tudinal |  |  |  |  |  | holds |  |  |  | time | of | [unc.edu](http://www.cpc.unc.edu/projects/rlms-hse)/ |
| Moni- |  |  |  |  |  |  |  |  |  | diagnosis, | | [projects](http://www.cpc.unc.edu/projects/rlms-hse)/ |
| toring |  |  |  |  |  |  |  |  |  | health |  | [rlms-hs](http://www.cpc.unc.edu/projects/rlms-hse)e |
| Survey |  |  |  |  |  |  |  |  |  | expen- |  |  |
| (RLMS) |  |  |  |  |  |  |  |  |  | ditures, |  |  |
|  |  |  |  |  |  |  |  |  |  | labour |  |  |
|  |  |  |  |  |  |  |  |  |  | outcomes | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

**LSMS** Living Standards Measurement Surveys **DHS** Demographic and Health Survey

**Appendix to Chapter 2**

**What is endogeneity?**

Endogeneity is a statistical problem that occurs in regression models if the as-sumptions about the flow or direction of causality are incorrect. If endogeneity is ignored, it could be that claims about causality between two variables or the magnitude of the eﬀect are false. In general, one can only be certain about a causal relationship of the eﬀect of x on y if the following three conditions are met (Antonakis et al.,  [2012)](#page282):

* y follows x temporally
* y changes as x changes (and this relationship is statistically significant)
* no other causes should eliminate the relation between x and y.

There are three major causes of endogeneity that violate the conditions above.

1. Omitted variables When a regression is run to determine the causal ef-fect of variable x on variable y, but there are unobserved variables that aﬀect variables x or x and y simultaneously, the estimated eﬀect of x on y will be biased. For the case of type 2 diabetes and employment chances, there is the danger that, e.g., personal traits like ambition, which are hard to observe, could influence the probability of developing type 2 diabetes through their eﬀect on a person’s lifestyle, but they could also simulta-neously aﬀect the chances of employment through their influence on a person’s determination to find work or to perform well at work. If we are not able to control for this, then our estimate of the eﬀect of diabetes on employment chances might, at least partially, represent the eﬀect of personal traits on employment chances. As a result, our estimate of the eﬀect of diabetes is biased and does not represent the true size of the relationship between the two variables.
2. Simultaneity Simultaneity is present if our outcome variable y and our variable of interest x influence each other simultaneously, so that y not only is aﬀected by x but x is also aﬀected by y. In the case of type 2 diabetes and labour market outcomes, not only diabetes could influence employment chances or work related income, but also resulting changes

in lifestyle due to employment or an increase in income could aﬀect the probabilities of developing diabetes. Due to an increase in income people could change their diet or change towards a less active lifestyle which in turn would make them more likely to develop type 2 diabetes.

1. Measurement error Measurement errors occur when the independent vari-able x is imprecisely measured. Here this would be the case if people in a survey did not remember if they have been diagnosed with type 2 diabetes and gave a wrong answer.

There are several solutions to the problem of endogeneity, but only using IV techniques has the potential to deal with all three causes of endogeneity at once. Endogeneity is a problem, because the variable of interest, here diabetes, is correlated with the error term of the estimated model, which includes all omitted variables as well as the eﬀect of y on x and if measurement error is present, the true values. To do this, one needs to find a suitable instrument that needs to fulfil the following conditions:

* it has to be causally related to the endogenous variable x and
* it should not be correlated to the dependent variable y other than through its correlation with x.

This instrument is then used in a first regression to obtain predicted values of the problematic endogenous regressor. Because the instrument is not correlated with the error term, these predicted values of the endogenous variable will be uncorrelated as well and can then be used in a second regression to predict the dependent variable y. The estimated coeﬃcients of this second stage can then be regarded as consistent estimates.

In the case of type 2 diabetes and labour market outcomes, an instrument has to predict the development of diabetes without being otherwise causally related to any of the labour market outcomes, be it employment chances, wages or some other measure of productivity. The instrument of choice so far has been the family history of diabetes. It has been shown that a considerable part of the risk of developing type 2 diabetes is hereditary (Hemminki et al.,  [2010;](#page291) Herder and Roden,  [2011;](#page291) The Interact Consortium,  [2013](#page304)). This fact is exploited when the instrument is used and it is assumed that this is the only pathway through which a family history of diabetes aﬀects a person’s diabetes risk, and also that, e.g., parental diabetes does not aﬀect the person’s labour market outcomes directly.

The most common estimation techniques for the estimation of IV regressions are the linear IV model and the bivariate probit model. The latter is often deemed more apt for models where both the outcome as well as the instrumen-tal variable are binary, so either 0 or 1, which is the case for employment as an outcome variable as well as diabetes family history as an instrument. Nonethe-less, there is some discussion in the econometrics literature regarding the best method to estimate these cases, as it also has been argued that because the lin-ear IV technique does not depend on the assumption of normality of the error terms, in contrast to the bivariate probit model, its results are more reliable in the case of non-normality, but can sometimes lead to imprecise estimators which can no longer be interpreted meaningfully (Chiburis et al.,  [2012](#page287)). Both methods can be found in the reviewed papers.

**Country codes**

Table 29: Country Codes

|  |  |  |  |
| --- | --- | --- | --- |
| Country | Country code | Country | Country code |
|  |  |  |  |
| 35 developing | LMIC | Jamaica | JAM |
| countries |  |  |  |
| Argentina | ARG | Japan | JPN |
| Australia | AUS | Latin America | LAC |
|  |  | and Caribbean |  |
| Bahamas | BHS | Mexico | MEX |
| Barbados | BRB | Netherlands | NLD |
| Belgium | BEL | Nicaragua | NIC |
| Bolivia | BOL | Nigeria | NGA |
| Brazil | BRA | Norway | NOR |
| Canada | CAN | Pakistan | PAK |
| Chile | CHL | Panama | PAN |
| China | CHN | Paraguay | PRY |
| Colombia | COL | Peru | PER |
| Costa Rica | CRI | Serbia | SRB |
| Cuba | CUB | Spain | ESP |
| Czech Republic | CZE | Sudan | SDN |
| Denmark | DNK | Sweden | SWE |
| Dominican | DOM | Switzerland | CHE |
| Republic |  |  |  |
| Ecuador | ECU | Taiwan | TWN |
| El Salvador | SLV | Thailand | THA |
| Europe | EUR | The Bahamas, | CARICOM |
|  |  | Barbados, |  |
|  |  | Jamaica, Trinidad |  |
|  |  | and Tobago |  |
| France | FRA | Trinidad and | TTO |
|  |  | Tobago |  |
| Germany | DEU | United Arab | ARE |
|  |  | Emirates |  |
| Guatemala | GTM | United Kingdom | GBR |
| Guyana | GUY | United States | USA |
| Haiti | HTI | Uruguay | URY |
| Honduras | HND | Venezuela | VEN |

Table 29: Country Codes

|  |  |  |  |
| --- | --- | --- | --- |
| Country | Country code | Country | Country code |
|  |  |  |  |
| Hong Kong | HKG | WHO African | AFR |
|  |  | Region |  |
| India | IND |  |  |
| Iran, Islamic Rep. | IRN |  |  |
| Ireland | IRL |  |  |
| Israel | ISR |  |  |
| Italy | ITA |  |  |
|  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | | Direct | | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | | ($) |  | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Smith- | 2002– | 35 | 121051 | General | Patient | RB/M | $ |  |  |  | 3 | at | 3.40 |  | at |  |  |
| Spangler | 2003 | LMIC |  | pop. |  |  |  |  |  |  | 50th | | 50th | |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  | per- |  | per- |  |  |  |  |
| [(2012](#page303)) |  |  |  |  |  |  |  |  |  |  | centile | | centile | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | to | 157 | to | 178 | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | at | 95th | at | 95th | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | per- |  | per- |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | centile | | centile | |  |  |  |
|  | NA | Various | NA | General | Healthc. | SAM | USD |  |  |  | UDD | |  |  |  |  |  |
| Boutayeb |  | Arab |  | pop. | system |  |  |  |  |  | 529j |  |  |  |  |  |  |
| and |  | coun- |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Boutayeb |  | tries |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2014](#page284)) |  |  |  |  |  |  |  |  |  | 15416b | 597a | | 904a | | 8145a | 12330a |  |
| Barceló | 2000 | ARG | 1250300 | General | Societal | SAM | ARS | 16547 | 1130 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  | 3496a | | 3379a | |  |  |  |
| Davis | 2000– | AUS | 1294 | General | Healthc. | SDS | AUD |  | 1514 |  |  |  |  |
| et al. | 2051 |  |  | pop. | system |  |  |  | (2000), |  | (2000) | | (2000) | |  |  |  |
| [(2006](#page288)) |  |  |  |  |  |  |  |  | 2282 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | (2051) |  |  |  |  |  |  |  |  |
| Barceló | 2000 | BHS | 12800 | General | Societal | SAM | BSD | 43 | 25.2 | 16 | 1605 | | 2507 | | 1009 | 1575 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 216b | 836a | | 1310a | | 10789a | 16914a |  |
| Ab- | 2001 | BHS | 10435 | General | Societal | SDS | BSD | 233 | 17 |  |
| dulkadri |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2009](#page281)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |
| Ab- | 2001 | BRB | 28438 | General | Societal | SDS | BBD | 75 | 69.2 | 5 | 2455 | | 2433 | 204 | 202 |  |
| dulkadri |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2009](#page281)) |  |  |  |  |  |  |  |  |  | 281b |  | 1099a | 1117a | 11880a | 12076a |  |
| Barceló | 2000 | BRB | 23300 | General | Societal | SAM | BBD | 307 | 26 |  |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Jönsson | 1999 | BEL | 735 | General | Healthc. | SAM | EUR |  | 1561 |  | 3295 | | 4704 |  |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  |  |  |  |  |  |  |  |
| Jönsson | 1999 |  | 7000 | General | Healthc. | SAM | EUR |  |  |  | 2834 | | Not |  |  |  |
| [(2002](#page292)) |  |  | (overall) | pop. | system |  |  |  |  |  |  |  | possible |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | be- |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | cause no |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | country |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | specific |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | estimate |  |  |  |
| Barceló | 2000 | BOL | 153900 | General | Societal | SAM | BOB | 901 | 338 | 563b |  | 3435a | 2199a | 5717a | 3659a |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 45294b |  | 1595a | 2118a | 1595a | 9993a |  |
| Barceló | 2000 | BRA | 4532600 | General | Societal | SAM | BRL | 54892 | 9598 |  |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lau | 2008– | CAN | 147498 | Four | Healthc. | SAM | CAD | 5934 |  | 4563a | 4023a |  |  |
| et al. | 2035 |  | with | Alberta | system |  |  | (2007); |  |  |  |  |  |
| [(2011](#page294)) |  |  | diabetes | Health |  |  |  | 20032 |  |  |  |  |  |
|  |  |  |  | and |  |  |  | (2035) |  |  |  |  |  |
|  |  |  |  | Wellness |  |  |  |  |  |  |  |  |  |
|  |  |  |  | databases |  |  |  |  |  |  |  |  |  |
| Pohar, | 1993– | CAN | 57774 |  | Healthc. | SAM | CAD |  |  | large | large |  |  |
| Majum- | 2001 |  |  | Saskatchewansystem | |  |  |  |  | urban: | urban: |  |  |
| dar, |  |  |  | Canadi- |  |  |  |  |  | 3563 | 2665 |  |  |
| et al. |  |  |  | ans |  |  |  |  |  | (1993), | (1993), |  |  |
| [(2007](#page299)) |  |  |  | (exclud- |  |  |  |  |  | 3454 | 3591 |  |  |
|  |  |  |  | ing |  |  |  |  |  | (2001), | (2001), |  |  |
|  |  |  |  | Indians) |  |  |  |  |  | small | small |  |  |
|  |  |  |  |  |  |  |  |  |  | urban: | urban: |  |  |
|  |  |  |  |  |  |  |  |  |  | 3321 | 3453 |  |  |
|  |  |  |  |  |  |  |  |  |  | (1993), | (1993), |  |  |
|  |  |  |  |  |  |  |  |  |  | 3427 | 3563 |  |  |
|  |  |  |  |  |  |  |  |  |  | (2001), | (2001), |  |  |
|  |  |  |  |  |  |  |  |  |  | rural: | rural: |  |  |
|  |  |  |  |  |  |  |  |  |  | 3368 | 3502 |  |  |
|  |  |  |  |  |  |  |  |  |  | (1993), | (1993), |  |  |
|  |  |  |  |  |  |  |  |  |  | 3289 | 3420 |  |  |
|  |  |  |  |  |  |  |  |  |  | (2001) | (2001) |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | | Direct | | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | | ($) |  | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  | |  | |  |  |
| Pohar | 2001 | CAN | 5284 | Regis- | Healthc. | RB/M | CAD |  |  |  | Excess | | Excess | |  |  |
| and |  |  | (Indi- | tered | system |  |  |  |  |  | costs: |  | costs: |  |  |  |
| Johnson |  |  | ans) + | Indians |  |  |  |  |  |  | Indians | | Indians | |  |  |
| [(2007](#page299)) |  |  | 41630 | accord- |  |  |  |  |  |  | 2227, |  | 2316, |  |  |  |
|  |  |  | (general | ing to |  |  |  |  |  |  | General | | General | |  |  |
|  |  |  | pop.) | the |  |  |  |  |  |  | pop. |  | pop. |  |  |  |
|  |  |  | with di- | Indian |  |  |  |  |  |  | 2378 |  | 2473: |  |  |  |
|  |  |  | abetes, | Act |  |  |  |  |  |  | (total |  | ( total | |  |  |
|  |  |  | 11692 |  |  |  |  |  |  |  | costs |  | costs |  |  |  |
|  |  |  | (Indi- |  |  |  |  |  |  |  | with | di- | with | di- |  |  |
|  |  |  | ans) + |  |  |  |  |  |  |  | abetes: | | abetes: | |  |  |
|  |  |  | 98680 |  |  |  |  |  |  |  | 3622 | for | 3766 |  |  |  |
|  |  |  | (general |  |  |  |  |  |  |  | Indians/ | | for | In- |  |  |
|  |  |  | pop.) |  |  |  |  |  |  |  | 3253 | in | dians | / |  |  |
|  |  |  | without |  |  |  |  |  |  |  | general | | 3382 | in |  |  |
|  |  |  | diabetes |  |  |  |  |  |  |  | pop., |  | general | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | controls: | | pop., |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 1,395 for | | controls: | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | Indians/ | | 1450 | for |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 875 | for | Indians | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | general | | / 910 for | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | pop.) |  | general | |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | pop.) |  |  |  |
| Barceló | 2000 | CHL | 496500 | General | Societal | SAM | CLP | 5890 | 719 | 5171b | 320601a | | 1447a |  | 2307131a | 10416a |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |
| Wang, | 2007 | CHN | 1478 | T2D | Healthc. | Survey | RMB |  |  |  | 4564 | | 1246 |  |  |
| Fu, |  |  |  | patients | system |  |  |  |  |  |  | (me- | (me- |  |  |
| Zhuo, |  |  |  | in these |  |  |  |  |  |  |  | dian), | dian), |  |  |
| et al. |  |  |  | Chinese |  |  |  |  |  |  | 7926 | | 2164 |  |  |
| [(2010](#page306)) |  |  |  | hospi- |  |  |  |  |  |  |  | (mean) | (mean) |  |  |
|  |  |  |  | tals |  |  |  |  |  |  |  |  |  |  |  |
| Wang, | 2007 | CHN | 2040 | In- | Societal | Survey | RMB | 72916 | 67946 | 4982 | 11555 | | 3401 | 1586 | 467 |
| Mc- | and |  |  | patients |  |  |  | (2007), | (2007), | (2007), |  |  |  |  |  |
| Greevey, | 2030 |  |  | and out- |  |  |  | 132472 | 123187 | 9058 |  |  |  |  |  |
| et al. | (projec- |  |  | patients |  |  |  | (2030) | (2030) | (2030) |  |  |  |  |  |
| [(2009](#page306)) | tion) |  |  | with |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | DM in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | 20 hos- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | pitals |  |  |  |  |  |  |  |  |  |  |  |
| Yang, | 2009– | CHN | 1232 | General | Healthc. | RB/M | RMB |  |  |  | 4135 | | 1136 |  |  |
| Zhao, | 2010 |  | (dia- | pop. | system |  |  |  |  |  | (3.38 | | (3.38 |  |  |
| et al. |  |  | betes), |  |  |  |  |  |  |  |  | times | times |  |  |
| [(2012](#page307)) |  |  | 1201 (no |  |  |  |  |  |  |  |  | greater | greater |  |  |
|  |  |  | dia- |  |  |  |  |  |  |  |  | than | than |  |  |
|  |  |  | betes) |  |  |  |  |  |  |  |  | controls) | controls) |  |  |
| Wang, | 2007 | CHN | 2054 | T2D | Healthc. | Survey | RMB |  |  |  | 4800 | | 1412 |  |  |
| Fu, Pan, |  |  |  | patients | system |  |  |  |  |  |  | (me- | (me- |  |  |
| et al. |  |  |  | in these |  |  |  |  |  |  |  | dian), | dian), |  |  |
| [(2009](#page305)) |  |  |  | Chinese |  |  |  |  |  |  | 10164 | | 2991 |  |  |
|  |  |  |  | hospi- |  |  |  |  |  |  |  | (mean) | (mean) |  |  |
|  |  |  |  | tals |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| extcite- | 32 years | COL | NA | Average | Societal | SAM | COP | 5.3 | 1.8 | 3.5 | 611750 | 570 | 1187000 | 1106 |  |
| Gonza- |  |  |  | Columbian |  |  |  |  |  |  |  |  |  |  |  |
| lez2009b |  |  |  | type 2 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | DM |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | patient |  |  |  |  |  | 6496b | 923826a | 1323a | 4836001a | 6928a |  |
| Barceló | 2000 | COL | 937700 | General | Societal | SAM | COP | 7737 | 1241 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 817b | 192194a | 1353a | 749278a | 5274a |  |
| Barceló | 2000 | CRI | 154900 | General | Societal | SAM | CRC | 1026 | 210 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 798b | 1219a | 1558a | 1054a | 1347a |  |
| Barceló | 2000 | CUB | 592400 | General | Societal | SAM | CUP | 1721 | 923 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Horak | 2007 | CZE |  | Insured | Healthc. | SAM | CHK |  | 190 |  |  |  |  |  |  |
| [(2009](#page292)) |  |  |  | in | system |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | health- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | care |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | system |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | (63.1% |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | of pop.) |  |  |  |  |  |  |  |  |  |  |  |
| Gyld- | 1993 | DNK | 948 | General | Societal | WTP | DKK |  |  |  |  |  | 1128 | 191 |  |
| mark |  |  |  | pop. |  |  |  |  |  |  |  |  | (mean), | (mean), |  |
| and |  |  |  |  |  |  |  |  |  |  |  |  | 300 (me- | 51 (me- |  |
| Morri- |  |  |  |  |  |  |  |  |  |  |  |  | dian) | dian) |  |
| son |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2001](#page291)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barceló | 2000 | DOM | 254100 | General | Societal | SAM | DOP | 1410 | 509 | 901b | 14580a | 2003a | 25801a | 3545a |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 1727b | 873a | 4129a | 1366a | 6460a |  |
| Barceló | 2000 | ECU | 267300 | General | Societal | SAM | USD | 2830 | 1104 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 1004b | 626a | 1737a | 1650a | 4577a |  |
| Barceló | 2000 | SLV | 219400 | General | Societal | SAM | SVC | 1385 | 381 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2005– | FIN | 1890 | People | Healthc. | SDS | EUR |  |  |  | 1038 | 1087 |  |  |  |
| Honkasalo | 2010 |  | with | with | system |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  | T2D | T2D in |  |  |  |  |  |  |  |  |  |  |  |
| [(2014](#page291)) |  |  |  | two |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | cities in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Finland |  |  |  |  |  |  |  |  |  |  |  |
| Ri- | 1998, | FRA | 704423 |  | Healthc. | RB/M | EUR |  | 2784 |  | 1529 | 2107 |  |  |  |
| cordeau | 2000 |  | (1998), | Metropoli- | system |  |  |  | (1998), |  | (1998), | (1998), |  |  |  |
| et al. |  |  | 1145603 | tan |  |  |  |  | 3268 |  | 1655 | 2241 |  |  |  |
| [(2003](#page300)) |  |  | (2000) | France |  |  |  |  | (2000) |  | (2000) | (2000) |  |  |  |
|  |  |  | with |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | diabetes |  |  |  |  |  |  |  |  |  |  |  |  |
| Jönsson | 1999 | FRA | 751 | General | Healthc. | SAM | EUR |  | 5478 |  | 3064 | 4214 |  |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  |  |  |  |  |  |  |
| Jönsson | 1999 | DEU | 809 | General | Healthc. | SAM | EUR |  | 1653 |  | 3576 | 4752 |  |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Köster, | 2001 | DEU | 306736 | General | Societal | RB/M | EUR |  | Excess: |  | Excess | Excess: | Excess | Excess: |  |
| Ferber, |  |  | (26971 | pop. |  |  |  |  | 19364 |  | 2507 | 3329 | 1328 | 1763 |  |
| et al. |  |  | with di- |  |  |  |  |  | (total: |  | (total | (total: | (total: | (total: |  |
| [(2006](#page293)) |  |  | abetes) |  |  |  |  |  | 40650) |  | 5262) | 6987) | 5019) | 6664) |  |
| Köster, | 2000– | DEU | 320000 | AOK | Healthc. | RB/M | EUR |  | 17299 |  | 2400 | 3493 |  |  |  |
| Hup- | 2007 |  | (2000) | Hessen | system |  |  |  | (2000), |  | (2000), | (2007), |  |  |  |
| pertz, |  |  | to |  |  |  |  |  | 25614 |  | 2605 | 3218 |  |  |  |
| et al. |  |  | 275000 |  |  |  |  |  | (2007) |  | (2007) | (2000) |  |  |  |
| [(2011](#page293)) |  |  | (2007) |  |  |  |  |  |  |  |  |  |  |  |  |
| Martin | 1995– | DEU | 3268 | Newly | Healthc. | SAM | EUR |  |  |  | 3210 | 4075 |  |  |  |
| et al. | 2003 |  |  | diag- | system |  |  |  |  |  |  |  |  |  |  |
| [(2007](#page296)) |  |  |  | nosed |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | T2D |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |
| Köster, | 2000– | DEU | not | AOK | Healthc. | RB/M | EUR |  | 21230 |  | 2779 | 3471 |  |  |  |
| Schu- | 2009 |  | given, | Hessen | system |  |  |  | (2000), |  | (2000), | (2000), |  |  |  |
| bert, |  |  | only |  |  |  |  |  | 26226 |  | 2611 | 3261 |  |  |  |
| et al. |  |  | DM |  |  |  |  |  | (2009) |  | (2009) | (2009) |  |  |  |
| [(2012](#page293)) |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | stated |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | (30472) |  |  |  |  |  |  | 1657b | 6131a | 2382a | 11572a | 4495a |  |
| Barceló | 2000 | GTM | 368700 | General | Societal | SAM | GTQ | 2535 | 878 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 62b | 131041a | 2800a | 102135a | 2182a |  |
| Barceló | 2000 | GUY | 28400 | General | Societal | SAM | GYD | 141 | 80 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barceló | 2000 | HTI | 79500 | General | Societal | SAM | HTG | 249 | 152 | 97b |  | 12782a | 1912a | 8175a | 1223a |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 405b |  | 8750a | 1898a | 9680a | 2100a |  |
| Barceló | 2000 | HND | 193000 | General | Societal | SAM | HNL | 772 | 366 |  |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  | 1817e | 357e |  |
| Chan, | 2004 | HKG | 147 | T2D | Societal | Survey | USD |  |  |  | 11638 | | 2288 |  |
| Tsang, |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | attend- |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2007](#page286)) |  |  |  | ing the |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | DM out- |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | patient |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | clinic at |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | a public |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | hospital |  |  |  |  |  |  |  |  |  |  |  |  |
| Ra- | 1998, | IND | 556 with | T2D | Patient | Survey | INR |  |  |  |  | Median | Median |  |  |  |
| machan- | 2005 |  | T2D | patients |  |  |  |  |  |  |  | values: | values: |  |  |  |
| dran, |  |  | (urban | in India |  |  |  |  |  |  | 10000 | | 773 (ur- |  |  |  |
| Ra- |  |  | = 309, |  |  |  |  |  |  |  |  | (urban), | ban), |  |  |  |
| machan- |  |  | rural = |  |  |  |  |  |  |  | 6260 | | 484 |  |  |  |
| dran, |  |  | 247) |  |  |  |  |  |  |  |  | (rural) | (rural) |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2007](#page300)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tharkar | 2009 | IND | 718 | Diabetes | Societal | Survey | INR |  | 268 |  | 25391 | 1557 | 4970 | 305 (me- |  |
| et al. |  |  |  | patients |  |  |  |  |  |  | (me- | (me- | (me- | dian) |  |
| [(2010](#page304)) |  |  |  | in |  |  |  |  |  |  | dian) | dian) | dian) |  |  |
|  |  |  |  | Chennai |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | city |  |  |  | 9611h | 5187h | 4420h |  |  |  |  |  |
| Javan- | 2009 | IRN | 4500 | Diabetes | Societal | Survey | IRR | 8358592 | 2142 | 8578816 | 2199 |  |
| bakht |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | from |  |  |  |  |  |  |  |  |  |  |  |
| [(2011](#page292)) |  |  |  | Tehran |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | and Fars |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | province |  |  |  |  |  |  |  |  |  |  |  |
| Es- | 2004, | IRN | 710 | Pop. in | Societal | RB/M | IRR | 401 | 327 | 74 | 876622 | 443 | 200146 | 101 |  |
| teghamati | 2005 |  | (T2D), | Teheran |  |  |  | (Teheran); | (Teheran); | (Teheran), | (Teheran) | (Teheran) | (Teheran) | (Teheran) |  |
| et al. |  |  | 904 |  |  |  |  | 2117h | 1727h | 390h |  |  |  |  |  |
| [(2009](#page290)) |  |  | (con- |  |  |  |  | (Iran) | (Iran) | (Iran) |  |  |  |  |  |
|  |  |  | trols) |  |  |  |  |  |  |  |  |  |  |  |  |
| Nolan | 1999 | IRL | 701 | T2D | Healthc. | SAM | EUR |  |  |  | 2469 | 2867 |  |  |  |
| et al. |  |  |  | patients | system |  |  |  |  |  |  |  |  |  |  |
| [(2006](#page298)) |  |  |  | of four |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Irish |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | hospi- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tals |  |  |  |  |  |  |  |  |  |  |  |
| Chodick | 2001 | ISR | 24632 | Insured | Healthc. | RB/M | ILS |  | 433 |  | 6002 | 1950 |  |  |  |
| et al. |  |  |  | patients | system |  |  |  |  |  | (2001), | (2001), |  |  |  |
| [(2005](#page287)) |  |  |  | in HMO |  |  |  |  |  |  | 3926 | 1275 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | (1999) | (1999) |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lucioni | 1998 | ITA | 1263 | T2D | Societal | SAM | EUR | 8289d | 7930 | 359 | 2991 | 4588 | 135ac | 208ac |
| et al. |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page295)) |  |  |  | from |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | ran- |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | domly |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | drawn |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | prac- |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tices |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | across |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Italy |  |  |  |  |  |  |  |  |  |  |
| Bruno | 2003– | ITA | 33792 | Turin | Healthc. | RB/M | EUR |  |  |  | 2465 | 3328 |  |  |
| et al. | 2004 |  | (dia- | pop. | system |  |  |  |  |  | (3361 | (4537 |  |  |
| [(2012](#page285)) |  |  | betes) |  |  |  |  |  |  |  | (dia- | (dia- |  |  |
|  |  |  | and |  |  |  |  |  |  |  | betes), | betes), |  |  |
|  |  |  | 863123 |  |  |  |  |  |  |  | 896 (no | 1210 |  |  |
|  |  |  | (no dia- |  |  |  |  |  |  |  | dia- | (no dia- |  |  |
|  |  |  | betes) |  |  |  |  |  |  |  | betes) | betes) |  |  |
| Mor- | 2001– | ITA | 299 | T2D | Healthc. | SAM | EUR |  |  |  | 1910 | 2823 |  |  |
| sanutto | 2002 |  |  | patients | system |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | who |  |  |  |  |  |  |  |  |  |  |
| [(2006](#page297)) |  |  |  | visited a |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | diabeto- |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | logic |  |  |  |  |  |  |  |  |  |  |

center in Italy (DC)

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| March- | 2006 | ITA | 311979 | People | Healthc. | RB/M | EUR |  |  |  | 2589 | 3296 |  |  |  |
| esini |  |  |  | with | system |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | DM at |  |  |  |  |  |  |  |  |  |  |  |
| [(2011](#page296)) |  |  |  | 22 local |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | health |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | districts |  |  |  |  |  |  |  |  |  |  |  |
| Ab- | 2001 | JAM | 186036 | General | Societal | SDS | JMD | 556 | 454 | 102 | 44647 | 2439 | 10046 | 549 |  |
| dulkadri |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2009](#page281)) |  |  |  |  |  |  |  |  |  | 693a | 32251a | 1901a | 64787a | 3818a |  |
| Barceló | 2000 | JAM | 181400 | General | Societal | SAM | JMD | 1037 | 345 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Naka- | 1990– | JPN | 4535 |  | Healthc. | SAM | JPY |  |  |  | 189060 | 1674 (di- |  |  |  |
| mura | 2001 |  |  | Community-system | |  |  |  |  |  | (dia- | abetes), |  |  |  |
| et al. |  |  |  | dwelling |  |  |  |  |  |  | betes), | 884 for |  |  |  |
| [(2008](#page297)) |  |  |  | in Shiga |  |  |  |  |  |  | 99900 | (non- |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | (non- | diabetes) |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | diabetes) |  |  |  |  |
| Barceló | 2000 | LAC | Diabetes | Pop. | Societal | SAM | USD | 82304 | 13529 | 68774b | 703a | 887a | 3576a | 4512a |  |
| et al. |  |  | preva- | from all |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  | lence of | coun- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 15.2 | tries in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | million | Latin |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | America |  |  |  |  |  |  |  |  |  |  |  |

and Caribbean

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barceló | 2000 | MEX | 3738000 | General | Societal | SAM | MXN | 30677 | 4006 | 26671b | 4994a | 1072a | 33249a | 7135a |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  | 290d |  |  | 1472a | 242a | 386a | 64a |  |
|  | 2004, | MEX | 951417 | All users | Societal | SAM | MXN | 229 | 61k |  |
| Arredondo, 2006 | |  | esti- | of |  |  |  |  |  |  |  |  |  |  |  |
| Zúñiga, |  |  | mated | health |  |  |  |  |  |  |  |  |  |  |  |
| and |  |  | cases | care in |  |  |  |  |  |  |  |  |  |  |  |
| Parada |  |  |  | public |  |  |  |  |  |  |  |  |  |  |  |
| [(2005](#page282)) |  |  |  | institu- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tions |  |  |  |  |  |  | 4016a | 485a | 5090a | 610a |  |
|  | 2010 | MEX | Whole | Popula- | Societal | SAM | MXN | 1066 | 470 | 596 |  |
| Arredondo |  |  | pop. | tion |  |  |  |  |  |  |  |  |  |  |  |
| and |  |  |  | demand- |  |  |  |  |  |  |  |  |  |  |  |
| De Icaza |  |  |  | ing |  |  |  |  |  |  |  |  |  |  |  |
| [(2011a](#page282)) |  |  |  | services |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | at |  |  |  |  |  |  |  |  |  |  |  |

Mexican health-care institu-tions for T2D

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2005 | MEX | Whole | General | Patient | SAM | MXN |  | 284 |  |  |  |  |  |  |
| Arredondo |  |  | pop. | pop. |  |  |  |  | OOP |  |  |  |  |  |  |
| and |  |  |  |  |  |  |  |  | expen- |  |  |  |  |  |  |
| Barcelo |  |  |  |  |  |  |  |  | ditures |  |  |  |  |  |  |
| [(2007](#page282)) |  |  |  |  |  |  |  |  | (52% | of |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | overall |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | expendi- | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | tures) |  | 1467a | 263a | 1852a | 331a |  |
|  | 2003, | MEX | Whole | General | Societal | SAM | MXN | 532 | 235 | 297 |  |
| Arredondo | 2005 |  | pop. | pop. |  |  |  | (2005) | (2005) | (2005) | (2005) | (2005) | (2005) | (2005) |  |
| and |  |  |  | using |  |  |  |  |  |  |  |  |  |  |  |
| Zúñiga |  |  |  | public |  |  |  |  |  |  |  |  |  |  |  |
| [(2004](#page282)) |  |  |  | health- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | care |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | institu- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tions |  |  |  |  |  |  | 35622a | 4672a |  |  |  |
| Ro- | 2002, | MEX | 497 | IMSS | Healthc. | SDS | MXN |  | 661 |  |  |  |  |
| dríguez | 2004 |  |  | insured | system |  |  |  | (2004) |  | (2004) | (2004) |  |  |  |
| Bolaños |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2010](#page301)) |  |  |  |  |  |  |  | 1014d |  |  |  |  | 282a | 195a |  |
| Redekop | 1998 | NLD | 1371 | T2D | Societal | SAM | NLG | 953 | 61 | 4023 | 2780 |  |
| et al. |  |  | with | patients |  |  |  |  |  |  |  |  |  |  |  |
| [(2002](#page300)) |  |  | T2D | in the |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Nether- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | lands |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Linden | 2000– | NLD | 2.5 | Dutch | Healthc. | SDS | EUR |  | 571 |  | 974 | 1259 |  |  |  |
| et al. | 2004 |  | million | people | system |  |  |  | (2000), |  | (2000), | (2000), |  |  |  |
| [(2009](#page295)) |  |  | (641200 | with |  |  |  |  | 1063 |  | 1283 | 1658 |  |  |  |
|  |  |  | with di- | diabetes |  |  |  |  | (2004) |  | (2004) | (2004) |  |  |  |
|  |  |  | abetes) |  |  |  |  |  |  |  |  |  |  |  |  |
| Jönsson | 1999 | NLD | 909 | General | Healthc. | SAM | EUR |  | 671 |  | 1827 | 2761 |  |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  | 150b | 7922a | 2145a | 4082a | 1105a |  |
| Barceló | 2000 | NIC | 136100 | General | Societal | SAM | NIO | 442 | 292 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | July | NGA | 35 | Diabetes | Patient | SDS | NGN |  |  |  | 29366 | 662 |  |  |  |
| Suleiman | 2003– |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |
| et al. | June |  |  | in out- |  |  |  |  |  |  |  |  |  |  |  |
| [(2006](#page304)) | 2004 |  |  | patient |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | clinic in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Nigeria |  |  |  |  |  |  | 20492a | 2061a | 5067a | 650a |  |
| Solli | 2005 | NOR | 4.6 | General | Societal | SDS | NRK | 319 | 242 | 76 |  |
| et al. |  |  | million | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2010](#page303)) |  |  | from |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | register |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | data of |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | entire |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | pop. |  |  |  |  |  |  |  | 11580f | 620f | 840e | 45e |  |
|  | 2006 | PAK | 345 | Diabetes | Societal | Survey | PKR |  |  |  |  |
| Khowaja |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | in |  |  |  |  |  |  |  |  |  |  |  |
| [(2007](#page293)) |  |  |  | Karachi |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barceló | 2000 | PAN | 120500 | General | Societal | SAM | PAB | 926 | 222 | 704b |  | 866a | 1846a | 2741a | 5840a |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 495b |  | 2661903a | 2587a | 5397747a | 5245a |  |
| Barceló | 2000 | PRY | 94300 | General | Societal | SAM | PYG | 738 | 244 |  |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 4094b |  | 2890a | 2526a | 7717a | 6746a |  |
| Barceló | 2000 | PER | 606800 | General | Societal | SAM | PEN | 5627 | 1533 |  |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2009 | POL | Whole | All | Healthc. | SAM | RSD | 3396 | 1910 | 1486 |  |  |  |  |  |  |
| Lesniowska |  |  | pop. | Polish | system |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | diabetes |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2014](#page294)) |  |  |  | patients |  |  |  | 7579h |  |  |  |  |  |  |  |  |
| Biorac | 2007 | SRB | 99 | T2D | Societal | Survey | RSD |  |  | 47865 | | 1610 | 5548 | 187 |  |
| et al. |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2009](#page284)) |  |  |  | in |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | health |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | centre in |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Svila- |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | jnac |  |  |  |  |  |  |  | 12457a | 761a |  |  |  |
| Bjegovic | 2002 | SRB | 360433 | Serbian | Healthc. | SAM | RSD |  | 280 |  |  |  |  |  |
| et al. |  |  | people | T2D | system |  |  |  |  |  |  |  |  |  |  |  |
| [(2007](#page284)) |  |  | with | patients |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | T2D in |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | Serbia |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |
| Mata | 1998 | ESP | 1004 | Diabetes | Healthc. | SDS | EUR |  |  |  | 771 | | 1488 |  |  |
| et al. |  |  |  | patients | system |  |  |  |  |  |  |  |  |  |  |
| [(2002](#page296)) |  |  |  | from 29 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | primary |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | health- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | care |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | centres |  |  |  |  |  |  |  |  |  |  |  |
| Ballesta | 1999 | ESP | 517 | People | Societal | SDS | EUR |  |  |  | 2560 | | 4690 | 1844 | 3379 |
| et al. |  |  |  | with |  |  |  |  |  |  |  |  |  |  |  |
| [(2006](#page282)) |  |  |  | DM in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | region of |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Cadiz |  |  |  |  |  |  |  |  |  |  |  |
| Oliva | 2002 | ESP | 1675304 | Diabetes | Healthc. | SAM | EUR |  | 4010 |  | 1290 | | 2155 |  |  |
| et al. |  |  | to | patients | system |  |  |  | (6% |  | (6% | | (6% |  |  |
| [(2004](#page298)) |  |  | 2010365 | in |  |  |  |  | prev.)– |  |  | prev.)– | prev.)– |  |  |
|  |  |  | depend- | National |  |  |  |  | 4461 |  | 1476 | | 2466 |  |  |
|  |  |  | ing on | Health |  |  |  |  | (5% |  | (5% | | (5% |  |  |
|  |  |  | assumed | System |  |  |  |  | prev.) |  |  | prev.) | prev.) |  |  |
|  |  |  | preva- |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | lence |  |  |  |  |  |  |  |  |  |  |  |  |
| Jönsson | 1999 | ESP | 1004 | General | Healthc. | SAM | EUR |  | 3679 |  | 1305 | | 2453 |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bastida, | 1998 | ESP | Whole | Canary | Societal | SDS | Pts (pre | 75 | 47 | 28 | 78240 | 907 | 47928b | 556b |  |
| Aguilar, |  |  | pop. | Island |  |  | Euro) |  |  |  |  |  |  |  |  |
| et al. |  |  | (exact | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2002](#page283)) |  |  | number | with |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | not | diabetes |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | given) |  |  |  |  |  |  |  |  |  |  |  |  |
| Elrayah- | 2005 | SDN | 822 | Patients | Patient | Survey | USD |  |  |  | 438 | 456 |  |  |  |
| Eliadarous |  |  |  | with |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | T2D in |  |  |  |  |  |  |  |  |  |  |  |
| [(2010](#page289)) |  |  |  | Khar- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | toum |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | state in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Sudan |  |  |  |  |  |  |  |  | 15000a | 1840a |  |
| Bolin | 1987 | SWE | Whole | General | Societal | SDS | SEK | 499 | 223 | 276 | 12102 | 1484 |  |
| et al. | and |  | pop. | pop. |  |  |  | (1987), | (1987), | (1987), | (1987), | (1987), | (1987), | (1987), |  |
| [(2009](#page284)) | 2005 |  |  |  |  |  |  | 1045 | 383 | 662 | 12287 | 1507 | 21253a | 2606a |  |
|  |  |  |  |  |  |  |  | (2005) | (2005) | (2005) | (2005) | (2005) | (2005) | (2005) |  |
| Norlund | 1993 | SWE | 70786 | South- | Societal | RB/M | SEK |  |  |  | 19411 | 2855 | 14777 | 2174 |  |
| et al. |  |  | (1677 | ern |  |  |  |  |  |  |  |  |  |  |  |
| [(2001](#page298)) |  |  | with di- | Sweden |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | abetes) |  |  |  |  |  |  |  |  |  |  |  |  |
| Wiréhn | 2005 | SWE | 415990 | Whole | Healthc. | RB/M | EUR |  |  |  | 18293 | 2243 |  |  |  |
| et al. |  |  | (19226 | Östergöt- | system |  |  |  |  |  |  |  |  |  |  |
| [(2008](#page306)) |  |  | with di- | land |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | abetes) | popula- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tion |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |
| Jönsson | 1999 | SWE | 773 | General | Healthc. | SAM | SEK |  | 929 |  | 24927 | | 3319 |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  |  |  |  |  |  |  |
| Ring- | 2004 | SWE | 8230 | Diabetes | Healthc. | SAM | SEK |  |  |  | 33210 | | 3888 |  |  |
| borg |  |  |  | patients | system |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | in |  |  |  |  |  |  |  |  |  |  |  |
| [(2008](#page300)) |  |  |  | Uppsala |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | county |  |  |  |  |  |  |  |  |  |  |  |
| Schmitt- | 1998 | CHE | 1479 | T2D | Healthc. | SDS | CHF |  | 561 |  | 3004 | | 2030 |  |  |
| Koopmann |  |  |  | patients | system |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | from |  |  |  |  |  |  |  |  |  |  |  |
| [(2004](#page302)) |  |  |  | ran- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | domly |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | drawn |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | prac- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tices |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | across |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Switzer- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | land |  |  |  |  |  |  |  |  |  |  |  |
| Lin | 1998– | TWN |  | People | Healthc. | SDS | TWD |  |  |  | 62617 | | 3499 |  |  |
| et al. | 1999 |  | 20757185 | with | system |  |  |  |  |  | (1998), | | (1998), |  |  |
| [(2004](#page295)) |  |  | (in | DM in |  |  |  |  |  |  | 60775 | | 3396 |  |  |
|  |  |  | 1998), | National |  |  |  |  |  |  | (1999) | | (1999) |  |  |
|  |  |  | 21089859 | Health |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | (in | Insur- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 1999) | ance |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Chang | 2006– | TWN | 498 | Diabetes | Societal | WTP | TWD |  |  | 4003 |  |  | 68118 | 4004 |  |
| [(2010](#page286)) | 2007 |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | in out- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | patient |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | clinics in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | northern |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Taiwan |  |  |  |  |  |  |  |  |  |  |  |
| Chi |  | TWN | 16094 | Elderly | Healthc. | SAM |  |  | 51 |  | 111982 | 6338 |  |  |  |
| et al. |  |  |  | with | system |  |  |  |  |  |  |  |  |  |  |
| [(2011](#page287)) |  |  |  | DM in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Taiwan |  |  |  |  |  |  |  |  |  |  |  |
| Chatter- | 2008 | THA | 475 | Diabetes | Societal | Survey | TWD |  |  |  | 17638 | 1082 | 10569 | 649 |  |
| jee et al. |  |  |  | patients |  |  |  |  |  |  |  |  |  |  |  |
| [(2011](#page286)) |  |  |  | treated |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | district |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | hospital |  |  |  |  |  | 468b | 3358a | 1011a | 21780a | 6560a |  |
| Barceló | 2000 | TTO | 71300 | Pop. | Societal | SAM | TTD | 540 | 72 |  |
| et al. |  |  |  | from all |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  | coun- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tries in |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | Latin |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | America |  |  |  |  |  |  |  |  |  |  |  |

and Caribbean

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  | Per capita costs | |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |
| Ab- | 2001 | TTO | 135093 | General | Societal | SDS | TTD | 852 | 227 | 625 | 5722 | | 1677 | 15797 | 4628 |
| dulkadri |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2009](#page281)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Al- | 2004 | ARE | 150 | Diabetes | Healthc. | Survey | AED |  |  |  |  | no | no |  |  |
| Maskari |  |  |  | patients | system |  |  |  |  |  |  | compli- | compli- |  |  |
| et al. |  |  |  | in |  |  |  |  |  |  |  | cation: | cations: |  |  |
| [(2010](#page296)) |  |  |  | Al-Ain |  |  |  |  |  |  | 5906, | | 2047, |  |  |
|  |  |  |  | District |  |  |  |  |  |  |  | with | with |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | compli- | compli- |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | cations: | cations: |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 20774, | | 7199, |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | overall: | overall: |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 16115 | | 5585 |  |  |
| Jönsson | 1999 | GBR | 756 | General | Healthc. | SAM | GBP |  | 244 |  | 1558 | | 3065 |  |  |
| [(2002](#page292)) |  |  | patients | pop. | system |  |  |  |  |  |  |  |  |  |  |
| Dall, | 2007 | USA | Diabetes | General | Societal | SDS | USD | 167862 | 111257 | 56604 | 6414 | | 6751 | 3263 | 3434 |
| Zhang, |  |  | preva- | pop. |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  | lence of |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2010](#page288)) |  |  | 16.5 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | million |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1998 | USA | 127991 | Medi- | Healthc. | SDS | USD |  | 540 |  | 4098 | | 4221 |  |  |
| Buescher |  |  |  | caid | system |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2010](#page285)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dall, | 2002 | USA | Diag- | General | Societal | SDS | USD | 161896 | 112947 | 48948 | 7601a | 9346a | 3294a | 4050a |  |
| Nikolov, |  |  | nosed | pop. |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  | DM |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page288)) |  |  | preva- |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | lence of |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 12.1 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | million |  |  |  |  |  |  |  |  |  | 380ac | 518ac |  |
| Druss | 1996 | USA | 23200 | General | Societal | Survey | USD | 78518 | 13768 | 4771 | 1097 | 1495 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2001](#page289)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Durden | 2000, | USA | 21592 | Employ- | Healthc. | RB/M | USD |  |  |  | 7365 | 8349 |  |  |  |
| et al. | 2005 |  | (2000), | ees of | system |  |  |  |  |  | (2000), | (2000), |  |  |  |
| [(2009](#page289)) |  |  | 127254 | large, |  |  |  |  |  |  | 7327 | 8306 |  |  |  |
|  |  |  | (2005) | privately- |  |  |  |  |  |  | (2005) | (2005) |  |  |  |
|  |  |  |  | insured |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | compa- |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | nies |  |  |  |  |  |  | 5035i | 5708i |  |  |  |
| Trogdon | 2000– | USA | 3790 | General | Healthc. | RB/M | USD |  |  |  |  |  |  |
| and | 2004 |  | (dia- | pop. | system |  |  |  |  |  |  |  |  |  |  |
| Hylands |  |  | betes), |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2008](#page305)) |  |  | 42413 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | (no dia- |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | betes) |  |  |  |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | Total | Direct | Indirect Direct | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Brandle | 2000 | USA | 1364 | People | Healthc. | SAM | USD |  | 3715 | 4747 |  |  |
| et al. |  |  |  | with | system |  |  |  | (me- | (me- |  |  |
| [(2003](#page285)) |  |  |  | T2D |  |  |  |  | dian) | dian) |  |  |
|  |  |  |  | enrolled |  |  |  |  |  |  |  |  |
|  |  |  |  | in man- |  |  |  |  |  |  |  |  |
|  |  |  |  | aged |  |  |  |  |  |  |  |  |
|  |  |  |  | care |  |  |  |  |  |  |  |  |
|  |  |  |  | pro- |  |  |  |  |  |  |  |  |
|  |  |  |  | grams |  |  |  |  |  |  |  |  |
|  | 2005 | USA | 32052 | Ameri- | Healthc. | RB/M | USD |  | 5542 | 6282 |  |  |
| O’Connell |  |  |  | can | system |  |  |  |  |  |  |  |
| et al. |  |  |  | Indians |  |  |  |  |  |  |  |  |
| [(2012](#page298)) |  |  |  | in and |  |  |  |  |  |  |  |  |
|  |  |  |  | around |  |  |  |  |  |  |  |  |
|  |  |  |  | Phoenix, |  |  |  |  |  |  |  |  |
|  |  |  |  | Arizona |  |  |  |  |  |  |  |  |
| Peele | 1996 | USA | 20937 | Em- | Healthc. | SAM | USD | 126 | 4430 | 6039 |  |  |
| et al. |  |  | with | ployed | system |  |  |  | (17.9% | (17.9% |  |  |
| [(2002](#page299)) |  |  | diabetes | DM |  |  |  |  | [OOP](#page15)) | [OOP](#page15)) |  |  |
|  |  |  |  | patients |  |  |  |  |  |  |  |  |
| Rod- | 2006 | USA | 3551 | General | Patient | RB/M | USD |  | 233 | 264 |  |  |
| bard |  |  | (dia- | pop. |  |  |  |  |  |  |  |  |
| et al. |  |  | betes), |  |  |  |  |  |  |  |  |  |
| [(2010](#page301)) |  |  | 8686 (no |  |  |  |  |  |  |  |  |  |
|  |  |  | dia- |  |  |  |  |  |  |  |  |  |
|  |  |  | betes) |  |  |  |  |  |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | | Direct | | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  | (LCU) | | ($) |  | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | | |  |  |
| Honey- | 1998– | USA | 96873 | General | Healthc. | SDS and | USD | 61958 |  | 4240 |  | 4966(regression), | | |  |  |
| cutt | 2003 |  | (5289 | pop. | system | RB/M |  | (regres- |  | (regres- | | 3490 |  |  |  |  |
| et al. |  |  | had dia- |  |  |  |  | sion), |  | sion), | | (at- |  |  |  |  |
| [(2009](#page291)) |  |  | betes) |  |  |  |  | 43452 |  | 2980 |  | tributable | |  |  |  |
|  |  |  |  |  |  |  |  | (at- |  | (at- |  | fraction) | |  |  |  |
|  |  |  |  |  |  |  |  | tributable |  | tributable | |  |  |  |  |  |
|  |  |  |  |  |  |  |  | fraction) |  | fraction) | |  |  |  |  |  |
| Ma- | 1998 | USA | 429918 | USA | Healthc. | SAM | USD | 2214 |  | 3888a | | 5150a | |  |  |  |
| ciejew- |  |  |  | veterans | system |  |  |  |  |  |  |  |  |  |  |  |
| ski and |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| May- |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| nard |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2004](#page296)) |  |  |  |  |  |  |  |  |  |  |  | 6680for | |  |  |  |
| Birn- | 1997– | USA | 3759 | Em- | Healthc. | RB/M | USD |  |  | 5.500 for | |  |  |  |
| baum | 1998 |  | (dia- | ployed | system |  |  |  |  | women | | women | |  |  |  |
| et al. |  |  | betes), | and |  |  |  |  |  | <age | 65 | <age | 65 |  |  |  |
| [(2003](#page284)) |  |  | 3759 | retired |  |  |  |  |  | per year, | | per year, | |  |  |  |
|  |  |  | (without | women |  |  |  |  |  | 25000 | | 30362 | |  |  |  |
|  |  |  | dia- |  |  |  |  |  |  | for |  | for |  |  |  |  |
|  |  |  | betes) |  |  |  |  |  |  | women | | women | |  |  |  |
|  |  |  |  |  |  |  |  |  |  | >= | age | >= | age |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 65 | per | 65 | per |  |  |  |
|  |  |  |  |  |  |  |  |  |  | year, |  | year, |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 233000 | | 282973 | |  |  |  |
|  |  |  |  |  |  |  |  |  |  | lifetime | | lifetime | |  |  |  |
|  |  |  |  |  |  |  |  |  |  | costs |  | costs |  |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach | | LCU | Aggregate costs (mill. $) | | |  |  |  | Per capita costs | | |  |
|  |  |  | size | tion |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | |  | |  |  |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect |  | Direct | | Direct | | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  |  |  | (LCU) | | ($) |  | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |
| Zhou, | 10 year | USA | 1223 | People | Healthc. | SAM | USD |  |  |  | 7100 | |  | 9072 |  |  |  |
| Isaman, | follow |  | with | with | system |  |  |  |  |  |  | (undis- | | (undis- | |  |  |
| et al. | up |  | T2D | DM in |  |  |  |  |  |  |  | counted | | counted | |  |  |
| [(2005](#page308)) |  |  |  | Michi- |  |  |  |  |  |  |  | per | year | per | year |  |  |
|  |  |  |  | gan |  |  |  |  |  |  |  | over | 10 | over | 10 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | year |  | year |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | period) | | period) | |  |  |
| Dall, | 2007 | USA | Diag- | General | Societal | SDS | USD | 185682 | 123788 | 62108 | 6649 | |  | 7095 |  | 3328 | 3552 |
| Mann, |  |  | nosed | pop. |  |  |  |  |  |  |  |  |  |  |  |  |  |
| et al. |  |  | DM |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [(2008](#page288)) |  |  | preva- |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | lence of |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 17.5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | million |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tunceli, | 2007 | USA | 256245 | Non- | Healthc. | SDS and | USD |  |  |  |  | Matching: | | Matching: | |  |  |
| Wade, |  |  | (T2D), | institutionalizedsystem | | RB/M |  |  |  |  | 4217, | | | 4500, | |  |  |
| et al. |  |  | 256223 | adults |  |  |  |  |  |  |  | Dis- |  | Dis- |  |  |  |
| [(2010](#page305)) |  |  | (con- |  |  |  |  |  |  |  |  | ease | at- | ease | at- |  |  |
|  |  |  | trols) |  |  |  |  |  |  |  |  | tributable: | | tributable: | |  |  |
|  |  |  |  |  |  |  |  |  |  |  | 3002 | |  | 3204 |  |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | Total | Direct | Indirect | Direct |  | Direct | Indirect | Indirect |
|  |  |  |  |  |  |  |  |  |  | (LCU) |  | ($) | (LCU) | ($) |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2007 | USA | 7514 | USA | Healthc. | SAM | USD |  |  | 11167g |  | 11917g |  |  |
| Condliﬀe |  |  | with | pop. | system |  |  |  |  |  |  |  |  |  |
| and |  |  | diabetes | with |  |  |  |  |  |  |  |  |  |  |
| Link |  |  |  | positive |  |  |  |  |  |  |  |  |  |  |
| [(2014](#page287)) |  |  |  | health- |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | care |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | expendi- |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | tures in |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | survey |  |  |  |  |  |  |  |  |  |  |
| Ramsey | 1998 | USA | 8748 | Employ- | Employer | RB/M | USD |  |  | 3842 |  | 5021 | 568 | 743 |
| et al. |  |  | diabetes | ees of |  |  |  |  |  |  |  |  |  |  |
| [(2002](#page300)) |  |  | patients, | large, |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 8748 | privately- |  |  |  |  |  |  |  |  |  |  |
|  |  |  | matched | insured |  |  |  |  |  |  |  |  |  |  |
|  |  |  | controls | compa- |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | nies |  |  |  |  |  |  |  |  |  |  |
| Lee | 2000 | USA | 984 with | White, | Healthc. | SAM | USD |  |  | 6616 |  | 8453 |  |  |
| et al. |  |  | DM | African | system |  |  |  |  | (6887 | if | (8799 | if |  |
| [(2006](#page294)) |  |  | (540 | Ameri- |  |  |  |  |  | white, |  | white, |  |  |
|  |  |  | white, | cans and |  |  |  |  |  | 6162 | if | 7873 | if |  |
|  |  |  | 210 | Hispan- |  |  |  |  |  | African |  | African |  |  |
|  |  |  | African | ics in |  |  |  |  |  | Amer- |  | Amer- |  |  |
|  |  |  | Ameri- | the USA |  |  |  |  |  | ican, |  | ican, |  |  |
|  |  |  | can, 234 |  |  |  |  |  |  | 5647 |  | 7215 |  |  |
|  |  |  | His- |  |  |  |  |  |  | if His- | | if His- | |  |
|  |  |  | panic) |  |  |  |  |  |  | panic) |  | panic) |  |  |

Table 30: COI study characteristics and cost estimates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ref. | Horizon | Country | Sample | Popula- | Perspective Approach LCU |
|  |  |  | size | tion |  |

Aggregate costs (mill. $) Per capita costs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | Total | Direct | Indirect | Direct | Direct | Indirect | Indirect |  |
|  |  |  |  |  |  |  |  |  |  |  | (LCU) | ($) | (LCU) | ($) |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barceló | 2000 | URY | 119000 | General | Societal | SAM | UYU | 1202 | 147 | 1055b | 9619a | 1233a | 69171a | 8867a |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  | 4503b | 342a | 518a | 2100a | 7373a |  |
| Barceló | 2000 | VEN | 610800 | General | Societal | SAM | VEF | 4820 | 317 |  |
| et al. |  |  |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2003](#page283)) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Kirigia | 2005 | WHO | 7020000 | General | societal | SAM | USD | 28610 | 9090 | 19520 | 876 | 983 | 10556 | 11845 |  |
| et al. |  | African |  | pop. |  |  |  |  |  |  |  |  |  |  |  |
| [(2009](#page293)) |  | region |  |  |  |  |  |  |  |  |  |  |  |  |  |

DM Diabetes Mellitus Healthc. System Healthcare system LCU Local currency unit Pop. Population Prev. Prevalence Ref. Reference RB/M regression based/matching SAM Sum-all medical SDS Sum-diagnosis specific.

b a Own calculation dividing presented aggregate cost estimate by number of people with diabetes in study. Total and direct cost estimates were presented in paper and indirect costs calculated, but not explicitly stated. We calculated indirect costs by deducting the presented direct costs estimate from the presented total costs estimate to arrive at an indirect costs estimate.

c Calculated the number of people with diabetes by dividing the aggregated direct costs and the per capita direct costs estimate as presented in the study. d Calculated total costs of diabetes for papers summing up direct and indirect costs.

e Calculated per capita indirect costs deducting direct from total cost estimate presented in study.

f Costs originally presented per visit, to arrive at yearly costs had to multiply costs per visit by number of visits per year.

g Per capita direct costs were presented for diﬀerent groups of diabetics, calculated average costs for person with diabetes by summing up and weighting costs people with diabetes + hypertension, people with diabetes + obesity, people with diabetes + obesity + hypertension.

h The study assumes sample would be nationally representative.

i Study only reported the adjusted incremental cost ratio of 2.39 compared to the average healthcare expenditures of people without diabetes of USA$3630. To calculate the incremental costs of a person with diabetes we multiplied the average healthcare expenditures of people without diabetes by the given cost ratio .

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | |  |  |  |
| Smith-Spangler et al. | LMIC |  |  |  |  |  | No breakdown of costs provided | |  |  |  |
| [(2012](#page303)) | (2002- |  |  |  |  |  |  |  |  |  |  |
|  | 2003) |  |  |  |  |  |  |  |  |  |  |
| Kirigia et al.  [(2009](#page293)) | AFR |  | x | x | x | x | x | x | x | x | No exact information |
|  | (2000- |  |  |  |  |  |  |  |  |  | on share in |
|  | 2005) |  |  |  |  |  |  |  |  |  | expenditures is |
|  |  |  |  |  |  |  |  |  |  |  | available |
| Davis et al.  [(2006](#page288)) | AUS |  | x | x | x | x | x | x |  |  | No exact information |
|  | (1993- |  |  |  |  |  |  |  |  |  | on share in |
|  | 1996) |  |  |  |  |  |  |  |  |  | expenditures is |
|  |  |  |  |  |  |  |  |  |  |  | available |
| Lau et al.  [(2011](#page294)) | CAN |  | x | x | x |  |  |  |  |  | Hospital, physician |
|  | (1995- |  |  |  |  |  |  |  |  |  |  |
|  | 2007) |  |  |  |  |  |  |  |  |  |  |
| Pohar, Majumdar, | CAN |  | x | x | x | x | x | x |  |  | Hospital, medication |
| et al.  [(2007](#page299)) | (1993- |  |  |  |  |  |  |  |  |  |  |
|  | 2001) |  |  |  |  |  |  |  |  |  |  |
| Ohinmaa et al.  [(2004](#page298)) | CAN |  | x | x | x | x | x | x |  |  | Hospital, medication |
|  | (1996) |  |  |  |  |  |  |  |  |  |  |
| Dawson et al.  [(2002](#page288)) | CAN |  | x | x | x | x | x |  |  |  | No exact information |
|  | (1998) |  |  |  |  |  |  |  |  |  | on share in |
|  |  |  |  |  |  |  |  |  |  |  | expenditures is |
|  |  |  |  |  |  |  |  |  |  |  | available |
| Johnson et al.  [(2006](#page292)) | CAN |  | x | x | x | x |  |  |  |  | Hospital |
|  | (1992- |  |  |  |  |  |  |  |  |  |  |
|  | 2001) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Simpson et al.  [(2003](#page303)) | CAN |  | x | x | x | x |  |  |  |  | Hospital, prescription |
|  | (1991- |  |  |  |  |  |  |  |  |  | drugs |
|  | 1996) |  |  |  |  |  |  |  |  |  |  |
| Pohar and Johnson | CAN |  | x | x | x |  |  |  |  |  | Hospital |
| [(2007](#page299)) | (1991- |  |  |  |  |  |  |  |  |  |  |
|  | 2001) |  |  |  |  |  |  |  |  |  |  |
| Wang, Fu, Zhuo, | CHN |  | x | x | x |  |  |  | x |  | Complications, |
| et al.  [(2010](#page306)) | (2007) |  |  |  |  |  |  |  |  |  | insulin therapy |
| Wang, McGreevey, | CHN |  | x | x |  |  |  |  | x |  | Hospital, outpatient |
| et al.  [(2009](#page306)) | (2007) |  |  |  |  |  |  |  |  |  | visits |
| Yang, Zhao, et al. | CHN |  | x | x | x | x | x | x |  |  | Hospital, medication |
| [(2012](#page307)) | (2009- |  |  |  |  |  |  |  |  |  |  |
|  | 2010) |  |  |  |  |  |  |  |  |  |  |
| Wang, Fu, Pan, et al. | CHN |  | x | x | x | x | x | x | x |  | No exact information |
| [(2009](#page305)) | (2007) |  |  |  |  |  |  |  |  |  | on share in |
|  |  |  |  |  |  |  |  |  |  |  | expenditures available |
| Camilo González | COL |  |  |  |  |  | No breakdown of costs provided | |  |  |  |
| et al.  [(2009](#page285)) | (2007) |  |  |  |  |  |  |  |  |  |  |
| Horak  [(2009](#page292)) | CZE |  | x | x | x | x | x | x |  |  | Hospital, medication |
|  | (2007) |  |  |  |  |  |  |  |  |  |  |
| Honkasalo et al. | FIN (2005- | | x | x | x | x | x | x |  |  |  |
| [(2014](#page291)) | 2010) |  |  |  |  |  |  |  |  |  |  |
| Ricordeau et al. | FRA |  | x | x | x |  |  |  | x |  | Hospital, medication |
| [(2003](#page300)) | (1998,2000) | |  |  |  |  |  |  |  |  |  |
| Köster, Ferber, et al. | DEU |  | x | x | x | x | x | x | x |  | Hospital, medication |
| [(2006](#page293)) | (2001) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Köster, Huppertz, | DEU |  | x | x | x | x | x | x | x | x | Hospital, other |
| et al.  [(2011](#page293)) | (2000- |  |  |  |  |  |  |  |  |  | services (medical |
|  | 2007) |  |  |  |  |  |  |  |  |  | devices, remedies, |
|  |  |  |  |  |  |  |  |  |  |  | professional home |
|  |  |  |  |  |  |  |  |  |  |  | nursing, |
|  |  |  |  |  |  |  |  |  |  |  | transportation) |
| Martin et al.  [(2007](#page296)) | DEU |  | x | x | x | x | x | x |  |  | No exact information |
|  | (1995- |  |  |  |  |  |  |  |  |  | on share in |
|  | 2003) |  |  |  |  |  |  |  |  |  | expenditures available |
| Köster, Schubert, | DEU |  | x | x | x | x | x | x | x | x | Hospital, medication |
| et al.  [(2012](#page293)) | (2000- |  |  |  |  |  |  |  |  |  |  |
|  | 2009) |  |  |  |  |  |  |  |  |  |  |
| Jönsson  [(2002](#page292)) | EUR |  | x | x | x | x | x | x | x |  | Hospital, medication |
|  | (1999) |  |  |  |  |  |  |  |  |  |  |
| Chan, Tsang, et al. | HKG |  | x | x | x | x | x | x | x | x | Hospital, outpatient |
| [(2007](#page286)) | (2004) |  |  |  |  |  |  |  |  |  | clinic visits |
| Ramachandran, | IND |  | x | x | x | x | x | x |  |  | Hospital/surgery, |
| Ramachandran, et al. | (2005) |  |  |  |  |  |  |  |  |  | medication |
| [(2007](#page300)) |  |  |  |  |  |  |  |  |  |  |  |
| Tharkar et al.  [(2010](#page304)) | IND |  | x | x | x |  |  |  | x |  | Hospital, medication |
|  | (2009) |  |  |  |  |  |  |  |  |  |  |
| Javanbakht et al. | IRN |  | x | x | x | x | x | x | x | x | Complications, |
| [(2011](#page292)) | (2009) |  |  |  |  |  |  |  |  |  | medication |
| Esteghamati et al. | IRN |  | x | x | x | x | x | x | x |  | Hospital, medication |
| [(2009](#page290)) | (2004;2005) | |  |  |  |  |  |  |  |  | and devices |
| Nolan et al.  [(2006](#page298)) | IRL (1999- | | x | x | x | x | x |  |  |  | Hospital, |
|  | 2000) |  |  |  |  |  |  |  |  |  | ambulatory/drug |
|  |  |  |  |  |  |  |  |  |  |  | costs |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country | | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  | |  |  |  |  |  |  |  |  |  |
| Chodick et al.  [(2005](#page287)) | ISR (1999- | | x | x | x | x |  |  |  |  | Medication and |
|  | 2001) |  |  |  |  |  |  |  |  |  | lab/diagnostics |
| Lucioni et al.  [(2003](#page295)) | ITA (1999) | | x | x | x | x | x |  |  |  | Hospital, drugs |
| Bruno et al.  [(2012](#page285)) | ITA | (Au- | x | x |  | x | x |  |  |  | Hospital, drugs |
|  | gust | 2003- |  |  |  |  |  |  |  |  |  |
|  | July 2004) | |  |  |  |  |  |  |  |  |  |
| Morsanutto et al. | ITA | (Jan | x |  | x | x | x |  |  |  | Hospital, drugs |
| [(2006](#page297)) | 2001-Aug | |  |  |  |  |  |  |  |  |  |
|  | 2002) |  |  |  |  |  |  |  |  |  |  |
| Marchesini et al. | ITA (1997- | | x |  | x | x | x | x |  |  | Hospital, drugs |
| [(2011](#page296)) | 2006) |  |  |  |  |  |  |  |  |  |  |
| Nakamura et al. | JPN |  |  |  |  |  | No breakdown of costs provided | |  |  |  |
| [(2008](#page297)) | (1990- | |  |  |  |  |  |  |  |  |  |
|  | 2001) |  |  |  |  |  |  |  |  |  |  |
| Barceló et al.  [(2003](#page283)) | LAC |  | x | x | x | x |  |  |  |  | Medication, |
|  | (2000) | |  |  |  |  |  |  |  |  | complications |
| Arredondo, Zúñiga, | MEX |  | x | x | x | x | x |  |  |  | No exact information |
| and Parada  [(2005](#page282)) | (1989- | |  |  |  |  |  |  |  |  | on share in |
|  | 2003) |  |  |  |  |  |  |  |  |  | expenditures available |
| Arredondo and | MEX |  | x | x | x | x | x |  |  |  | Medication, |
| De Icaza  [(2011a](#page282)) | (1990- | |  |  |  |  |  |  |  |  | complications |
|  | 2008) |  |  |  |  |  |  |  |  |  |  |
| Arredondo and | MEX |  | x | x | x | x | x |  |  |  | Drugs, complications |
| Zúñiga  [(2004](#page282)) | (1989- | |  |  |  |  |  |  |  |  |  |
|  | 2002) |  |  |  |  |  |  |  |  |  |  |
| Arredondo and | MEX |  | x | x | x | x | x |  |  |  | Drugs, complications |
| Barcelo  [(2007](#page282)) | (2002- | |  |  |  |  |  |  |  |  |  |
|  | 2004) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Rodríguez Bolaños | MEX |  | x | x | x | x | x | x |  | x | Hospital, |
| et al.  [(2010](#page301)) | (2002- |  |  |  |  |  |  |  |  |  | administrative costs |
|  | 2004) |  |  |  |  |  |  |  |  |  |  |
| Redekop et al.  [(2002](#page300)) | NLD |  | x | x | x | x | x | x | x |  | Hospital, medication |
|  | (1998) |  |  |  |  |  |  |  |  |  |  |
| Linden et al.  [(2009](#page295)) | NLD |  | x |  |  | x |  |  |  |  | Hospital, medication |
|  | (2000- |  |  |  |  |  |  |  |  |  |  |
|  | 2004) |  |  |  |  |  |  |  |  |  |  |
| Suleiman et al.  [(2006](#page304)) | NGA |  |  | x |  | x | x | x | x | x | Drugs, diagnostic |
|  | (2003- |  |  |  |  |  |  |  |  |  | tests |
|  | 2004) |  |  |  |  |  |  |  |  |  |  |
| Solli et al.  [(2010](#page303)) | NOR |  | x | x | x | x |  | x |  | x | Drugs, medical |
|  | (2005) |  |  |  |  |  |  |  |  |  | devices |
| Khowaja et al.  [(2007](#page293)) | PAK |  |  | x |  | x | x |  | x |  | Medicine cost, |
|  | (2006) |  |  |  |  |  |  |  |  |  | laboratory costs |
| Lesniowska et al. | POL |  | x | x | x | x | x | x |  |  | Medication, primary |
| [(2014](#page294)) | (2005- |  |  |  |  |  |  |  |  |  | care |
|  | 2009) |  |  |  |  |  |  |  |  |  |  |
| Biorac et al.  [(2009](#page284)) | SRB |  | x | x | x | x | x | x |  |  | Medication, medical |
|  | (2007) |  |  |  |  |  |  |  |  |  | services (incl. |
|  |  |  |  |  |  |  |  |  |  |  | ambulatory and |
|  |  |  |  |  |  |  |  |  |  |  | hospital costs) |
| Bjegovic et al.  [(2007](#page284)) | SRB |  |  | x | x | x | x | x |  |  | No exact information |
|  | (2002) |  |  |  |  |  |  |  |  |  | on share in |
|  |  |  |  |  |  |  |  |  |  |  | expenditures available |
| Mata et al.  [(2002](#page296)) | ESP |  | x | x | x | x | x | x |  |  | Drugs, hospital |
|  | (1998- |  |  |  |  |  |  |  |  |  |  |
|  | 1999) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country | | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Ballesta et al.  [(2006](#page282)) | ESP |  | x | x | x | x |  | x |  | x | Medication, hospital |
|  | (1999) |  |  |  |  |  |  |  |  |  |  |
| Oliva et al.  [(2004](#page298)) | ESP |  | x | x | x |  |  |  |  |  | Hospital, medication |
|  | (2002) |  |  |  |  |  |  |  |  |  |  |
| Bastida, Aguilar, | ESP |  | x | x | x | x | x |  |  |  | Hospital, medication |
| et al.  [(2002](#page283)) | (1998) |  |  |  |  |  |  |  |  |  |  |
| Elrayah-Eliadarous | SDN |  |  | x |  | x | x |  |  |  | Outpatient clinic, |
| et al.  [(2010](#page289)) | (2005) |  |  |  |  |  |  |  |  |  | drugs |
| Bolin et al.  [(2009](#page284)) | SWE |  | x | x |  | x |  |  |  |  | Hospital, drugs |
|  | (1987 | and |  |  |  |  |  |  |  |  |  |
|  | 2005) |  |  |  |  |  |  |  |  |  |  |
| Norlund et al.  [(2001](#page298)) | SWE |  | x | x | x |  |  |  | x |  | Hospital, home help |
|  | (1992- |  |  |  |  |  |  |  |  |  | hours |
|  | 1993) |  |  |  |  |  |  |  |  |  |  |
| Wiréhn et al.  [(2008](#page306)) | SWE |  | x | x | x |  |  |  |  |  | Hospital, medication |
|  | (2005) |  |  |  |  |  |  |  |  |  |  |
| Ringborg et al.  [(2008](#page300)) | SWE |  | x | x |  | x | x | x |  |  | Hospital, outpatient |
|  | (2000- |  |  |  |  |  |  |  |  |  | visits |
|  | 2004) |  |  |  |  |  |  |  |  |  |  |
| Schmitt-Koopmann | CHE |  | x | x | x |  |  |  |  |  | Hospital, medication |
| et al.  [(2004](#page302)) | (1998- |  |  |  |  |  |  |  |  |  |  |
|  | 1999) |  |  |  |  |  |  |  |  |  |  |
| Lin et al.  [(2004](#page295)) | TWN |  | x | x | x | x | x |  |  |  | No exact information |
|  | (1998- |  |  |  |  |  |  |  |  |  | on share in |
|  | 1999) |  |  |  |  |  |  |  |  |  | expenditures available |
| Chi et al.  [(2011](#page287)) | TWN |  | x | x |  |  |  |  |  |  | Outpatient visits |
|  | (2000) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Chatterjee et al. | THA |  | x | x |  | x | x |  | x | x | Informal care, |
| [(2011](#page286)) | (2007- |  |  |  |  |  |  |  |  |  | hospitalizations |
|  | 2008) |  |  |  |  |  |  |  |  |  |  |
| Abdulkadri et al. | CARICOM | | x | x | x | x | x |  |  |  | Medication and |
| [(2009](#page281)) | (2001) |  |  |  |  |  |  |  |  |  | lab/diagnostics |
| Al-Maskari et al. | ARE |  | x | x | x | x | x |  |  |  | Hospital (information |
| [(2010](#page296)) | (2004- |  |  |  |  |  |  |  |  |  | on other cost |
|  | 2005) |  |  |  |  |  |  |  |  |  | components not |
|  |  |  |  |  |  |  |  |  |  |  | presented) |
| Dall, Zhang, et al. | USA |  | x | x | x | x | x | x | x | x | No exact information |
| [(2010](#page288)) | (2007) |  |  |  |  |  |  |  |  |  | on share in |
|  |  |  |  |  |  |  |  |  |  |  | expenditures available |
| Ramsey et al.  [(2002](#page300)) | USA |  | x | x | x | x | x | x |  | x | Inpatient, outpatient |
|  | (1998) |  |  |  |  |  |  |  |  |  |  |
| Buescher et al.  [(2010](#page285)) | USA |  | x | x | x | x | x | x | x | x | Physician visits, |
|  | (1998) |  |  |  |  |  |  |  |  |  | hospital |
| Dall, Nikolov, et al. | USA |  | x | x | x | x | x | x |  |  | Institutional care |
| [(2003](#page288)) | (1998- |  |  |  |  |  |  |  |  |  | (nursing home stays, |
|  | 2000) |  |  |  |  |  |  |  |  |  | hospital), outpatient |
|  |  |  |  |  |  |  |  |  |  |  | care |
| Druss et al.  [(2001](#page289)) | USA |  |  |  | No breakdown of costs provided. Only self reported healthcare cost estimate. | | | | | |  |
|  | (1996) |  |  |  |  |  |  |  |  |  |  |
| Durden et al.  [(2009](#page289)) | USA |  | x | x | x | x | x | x |  |  | Hospital, outpatient |
|  | (2000, |  |  |  |  |  |  |  |  |  | services |
|  | 2005) |  |  |  |  |  |  |  |  |  |  |
| Trogdon and Hylands | USA |  |  |  | No breakdown of costs provided. Only self reported healthcare cost estimate. | | | | | |  |
| [(2008](#page305)) | (2000- |  |  |  |  |  |  |  |  |  |  |
|  | 2004) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory | Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Brandle et al.  [(2003](#page285)) | USA |  | x | x |  | x | x |  |  |  | No exact information |
|  | (2000- |  |  |  |  |  |  |  |  |  | on share in |
|  | 2001) |  |  |  |  |  |  |  |  |  | expenditures is |
|  |  |  |  |  |  |  |  |  |  |  | available |
| O’Connell et al. | USA |  | x | x | x |  |  |  |  |  | Hospital, medication |
| [(2012](#page298)) | (2004- |  |  |  |  |  |  |  |  |  |  |
|  | 2005) |  |  |  |  |  |  |  |  |  |  |
| Peele et al.  [(2002](#page299)) | USA |  | x | x | x |  | x |  |  |  | No exact information |
|  | (1996) |  |  |  |  |  |  |  |  |  | on share in |
|  |  |  |  |  |  |  |  |  |  |  | expenditures available |
| Rodbard et al.  [(2010](#page301)) | USA |  |  |  |  |  | No breakdown of costs provided. | |  |  |  |
|  | (2006) |  |  |  |  |  |  |  |  |  |  |
| Honeycutt et al. | USA |  | x | x | x | x | x | x |  |  | No exact information |
| [(2009](#page291)) | (1998- |  |  |  |  |  |  |  |  |  | on share in |
|  | 2003) |  |  |  |  |  |  |  |  |  | expenditures available |
| Maciejewski and | USA |  | x | x |  |  |  |  |  |  | Hospital |
| Maynard  [(2004](#page296)) | (1998) |  |  |  |  |  |  |  |  |  |  |
| Birnbaum et al. | USA |  |  |  | No breakdown of costs provided. Only self reported healthcare cost estimate. | | | | | |  |
| [(2003](#page284)) | (1997- |  |  |  |  |  |  |  |  |  |  |
|  | 1998) |  |  |  |  |  |  |  |  |  |  |
| Zhou, Isaman, et al. | USA |  | x | x | x | x | x | x |  |  | No exact information |
| [(2005](#page308)) | (2000) |  |  |  |  |  |  |  |  |  | on share in |
|  |  |  |  |  |  |  |  |  |  |  | expenditures available |
| Dall, Mann, et al. | USA |  | x | x | x |  |  |  |  |  | Hospital, medication |
| [(2008](#page288)) | (2006) |  |  |  |  |  |  |  |  |  |  |
| Tunceli, Wade, et al. | USA |  | x | x | x |  |  |  |  |  | Hospital, medication |
| [(2010](#page305)) | (2006- |  |  |  |  |  |  |  |  |  |  |
|  | 2007) |  |  |  |  |  |  |  |  |  |  |

Table 31: COI study costing components

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ref. | Country |  | Hospital | Outpatient | Physician | Drugs | Laboratory Equipment | Non- | Other | Two main cost |
|  | (year | of | Visits | Visits | Visits |  |  | medical | Costs | contributors |
|  | cost data) | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| Condliﬀe and Link | USA |  |  |  |  |  | No breakdown of costs provided. |  |  |  |
| [(2014](#page287)) | (2004- |  |  |  |  |  |  |  |  |  |
|  | 2007) |  |  |  |  |  |  |  |  |  |
| Lee et al.  [(2006](#page294)) | USA |  |  | x | x |  |  | x | x | Medication, |
|  | (2000) |  |  |  |  |  |  |  |  | ambulatory |

**Appendix to Chapter 3**

**Linear IV estimates (1st and 2nd stage)**

Table 32: Impact of diabetes on employment probabilities (linear IV, 1st and 2nd stage)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | linear IV male | |  |  |  | linear IV female | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | (1) |  | (2) |  |  | (3) |  | (4) |  |  |  |
|  | Diabetes |  | Employed |  |  | Diabetes |  | Employed |  |  |  |
|  |  |  |  |  |  | |  |  |  |  |  |
| Age 25–34 | −.001 | (.005) | 0.151∗∗∗ | (.015) | 0.003 | | (.005) | 0.111∗∗∗ | (.015) |  |  |
| Age 35–44 | 0.016∗ | (.009) | 0.154∗∗∗ | (.019) |  | 0.032∗∗∗ | (.008) | 0.198∗∗∗ | (.017) |  |  |
| Age 45–54 | 0.081∗∗∗ | (.014) | 0.098∗∗∗ | (.028) |  | 0.108∗∗∗ | (.014) | 0.122∗∗∗ | (.028) |  |  |
| Age 55–64 | 0.101∗∗∗ | (.016) | −.052 | (.039) |  | 0.198∗∗∗ | (.021) | 0.001 | (.040) |  |  |
| Small city | 0.001 | (.010) | −.010 | (.019) |  | −.005 | (.011) | 0.034∗∗ | (.017) |  |  |
| City | 0.014 | (.014) | −.041∗∗ | (.020) |  | −.009 | (.013) | 0.032∗ | (.019) |  |  |
| Big city | 0.008 | (.008) | 0.027∗ | (.014) |  | −.004 | (.009) | 0.093∗∗∗ | (.013) |  |  |
| Central | 0.011 | (.011) | 0.024 | (.017) | 0.015 | | (.011) | −.035∗∗ | (.017) |  |  |
| Westcentral | −.002 | (.010) | 0.021 | (.017) |  | −.002 | (.010) | −.006 | (.018) |  |  |
| Northeastcentral | 0.007 | (.012) | 0.005 | (.017) | 0.009 | | (.012) | −.051∗∗∗ | (.017) |  |  |
| Northwestcentral | −.006 | (.009) | −.033∗∗ | (.017) | 0.007 | | (.011) | −.095∗∗∗ | (.017) |  |  |
| Primary | −.009 | (.020) | 0.060∗∗ | (.027) | 0.017 | | (.018) | −.011 | (.019) |  |  |
| Secondary | −.003 | (.020) | 0.056∗ | (.030) |  | −.005 | (.018) | 0.052∗∗ | (.021) |  |  |
| Highschool | −.027 | (.020) | 0.045 | (.031) |  | −.008 | (.020) | 0.117∗∗∗ | (.026) |  |  |
| College or university | −.018 | (.023) | 0.057∗ | (.032) |  | −.028 | (.020) | 0.291∗∗∗ | (.025) |  |  |
| Indigenous | 0.009 | (.010) | 0.005 | (.017) | 0.012 | | (.013) | −.006 | (.018) |  |  |
| Married | 0.015∗∗ | (.007) | 0.086∗∗∗ | (.012) |  | −.002 | (.007) | −.216∗∗∗ | (.011) |  |  |
| Children (under 15) | −.005∗∗ | (.002) | 0.010∗∗ | (.004) | 0.003 | | (.002) | −.016∗∗∗ | (.004) |  |  |
| Wealth | 0.003 | (.004) | −.001 | (.007) | 0.003 | | (.004) | 0.030∗∗∗ | (.006) |  |  |
| Parental education | 0.019∗∗ | (.009) | −.010 | (.013) | 0.014 | | (.009) | −.001 | (.011) |  |  |
| Diabetes father | 0.068∗∗∗ | (.020) |  |  |  | 0.035∗∗ | (.014) |  |  |  |  |
| Diabetes mother | 0.043∗∗∗ | (.016) |  |  |  | 0.055∗∗∗ | (.013) |  |  |  |  |
| Diabetes | −.015 |  | 0.098 | (.215) |  | −.020 |  | 0.239 | (.214) |  |  |
| Constant | (.022) | 0.607∗∗∗ | (.036) |  | (.021) | 0.289∗∗∗ | (.027) |  |  |
| R2 | 0.075 |  | 0.067 |  | 0.090 | |  | 0.120 |  |  |  |
| F stat (H0: weak instruements) |  |  | 20.483 |  |  |  |  | 27.706 |  |  |  |
| Sargan test (H0: valid instruments) |  |  | 0.862 |  |  |  |  | 0.295 |  |  |  |
| p value |  |  | 0.353 |  |  |  |  | 0.587 |  |  |  |
| Endogeneity (H0: Diabetes exogenous) |  |  | 0.864 |  |  |  |  | 1.796 |  |  |  |
| p value |  |  | 0.353 |  |  |  |  | 0.180 |  |  |  |
| N | 6228 |  | 6286 |  | 8186 | |  | 8243 |  |  |  |

*Notes* Robust standard errors in parentheses. Instruments: diabetes of mother, diabetes of father. Other control variables: age, region, urban,education, indigenous marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**Results for older age groups**

Table 33: Impact of diabetes on employment probabilities by age groups older than 44 (probit)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 45-54 | | 55-64 | | |  |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Males | Females |  | Males | Females | |
|  |  |  |  |  |  | |
| Diabetes | −.083∗ | −.076∗∗ |  | −.128∗∗ | −.033 | |
|  | (.048) | (.034) | (.056) | | (.039) |  |
|  |  |  |  |  |  | |
| Log likelihood | −451.544 | −764.722 |  | −458.632 | −392.174 | |
| N | 1101 | 1399 | 770 | | 847 |  |

*Notes* Average marginal eﬀects; robust standard errors in parentheses.Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05,

∗∗∗ *p <* 0*.*01.

**Results for wealth quartiles**

Table 34: Impact of diabetes on employment probabilities by wealth quartile (probit)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 1st |  |  | 2nd |  |  | 3rd |  |  | 4th | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  | (5) | (6) |  | (7) | (8) |  |
|  | Males | Females |  | Males | Females |  | Males | Females |  | Males | Females | |
|  |  |  |  |  |  |  |  |  |  |  |  | |
| Diabetes | −.142∗ | −.101∗∗∗ |  | −.144∗∗ | 0.028 |  | −.082 | −.026 |  | −.040 | −.053 | |
|  | (.077) | (.029) | (.060) | | (.048) | (.053) | | (.044) | (.046) | | (.048) |  |
|  |  |  |  |  |  |  |  |  |  |  |  | |
| Log likelihood | −776.619 | −937.144 |  | −672.633 | −1092.280 |  | −689.910 | −1266.304 |  | −703.495 | −1144.588 | |
| N | 1577 | 2039 | 1563 | | 2052 | 1516 | | 2143 | 1590 | | 1974 |  |

*Notes* Average marginal eﬀects; robust standard errors in parentheses. Other control variables: region, urban, education, indigenous,marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**Instrumental variable analysis for age groups**

The results of the bivariate probit models do not indicate endogeneity for the older age group and for males in the younger age group (see Tables  [35](#page256) and  [36),](#page257) suggesting that particularly for males the results of the more eﬃcient pro-bit model (Table  [11)](#page92) show the true eﬀect of diabetes on employment chances. Only for females in the younger age group the test for endogeneity rejects the assumption of exogeneity and the diabetes coeﬃcient—surprisingly—shows a strong positive eﬀect of diabetes on female employment chances. Instrument strength, however, is reduced significantly, which together with the very low treatment probabilities questions the validity of the IV results for the sample of the younger age group, as weak instruments possibly introduce a bias similar to or stronger than the potential bias in the probit estimates (Staiger and Stock,  [1997](#page304)). We therefore additionally apply a method proposed by Lewbel  [(2012)](#page294), which uses heteroscedasticity in the estimated models to construct additional instruments. Instruments are generated by multiplying the heteroscedastic residuals from the first-stage regressions with a subset of the included exogenous variables. Lewbel  [(2012)](#page294) recommends the use of this method when traditional instruments are not available or if it is suspected that the traditional instrument is too weak for identification, which is the issue at hand. The approach has been widely used over the last years both in health economics (Brown,  [2014](#page285); Drichoutis et al.,  [2011;](#page289) Kelly et al.,  [2014;](#page292) Schroeter et al.,  [2012)](#page302) and in other economic disciplines (Denny and Oppedisano,  [2013;](#page288) Emran and Shilpi,  [2012](#page289); Huang et al.,  [2009](#page292)). Using this method to construct additional instruments by using our age group dummies, we are able to increase instrument strength significantly in the younger age group and the overidentification test indicates validity of the instruments. The results of the linear IV model with the addi-tional instruments show exogeneity of diabetes for males and females and do not indicate a significant positive eﬀect of diabetes on employment chances.

Apart from the results of the Lewbel approach, we also think that there are theoretical reasons why diabetes is likely exogenous in the younger age group. While we cannot distinguish between the types of diabetes with the data at hand, it is likely that a relatively large proportion of the people reporting diabetes in this age group have type 1 diabetes, which people tend to get at a younger age (Maahs et al.,  [2010](#page296)). The disease has a strong genetic component and it is very unlikely that there are unobserved factors that aﬀect the chances to develop type 1 diabetes and being employed at the same time, nor that

employment status would aﬀect the development of type 1 diabetes. Therefore, for a large part of the people reporting diabetes in the younger age group, endogeneity should not present a problem because they have type 1 diabetes. Furthermore, it is also less likely that reverse causality is a problem for those having type 2 diabetes in this age group, because any eﬀects of being employed on developing type 2 diabetes take time to develop. It would be reasonable to expect that if being employed aﬀected a person’s weight or any other diabetes risk factor, this would happen by changing the person’s lifestyle due to changes in income or available leisure time, or by reducing or increasing a person’s activity levels at work. Until these changes are expressed in changes in weight or any other risk factor for diabetes and finally cause a development of type 2 diabetes, a considerable time period of various years has likely passed and people have reached an advanced age. We therefore believe, that the risk of diabetes being aﬀected by employment is much lower in the younger age group based on the nature of the disease, compared to the older age group. Hence we think that the assumption of exogeneity of diabetes in the younger age group is valid—which is also supported by the Lewbel estimates—and that the endogeneity indicated for younger females in the bivariate probit model is likely the result of the low prevalence rates, and consequently the very low treatment probabilities, together with weak instruments, making a meaningful IV analysis diﬃcult (Chiburis et al.,  [2012](#page287)). We are therefore confident that we can rely on our probit estimates for inference.

Table 35: IV estimates for the age group 15–44

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | BP |  |  | Lewbel IV | | |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Males | Females |  | Males | Females | |
|  |  |  |  | |  |  |
| Diabetes | 0.171∗∗∗ | 0.496∗∗∗ | 0.007 | | 0.051 |  |
|  | (.046) | (.080) | (.053) | | (.071) |  |
|  |  |  |  | |  |  |
| R2 |  |  | 0.093 | | 0.143 |  |
| Score goodness-of-fit (H0=normality of errors) | 9.56 | 14.25 |  |  |  |  |
| p value | 0.387 | 0.114 |  |  |  |  |
| F stat (H0: weak instruments) | 4.288*a* | 10.835*a* | 366.480 | | 65.872 |  |
| Sargan test (H0: valid instruments) | 0.008*a* | 0.044*a* | 1.817 | | 3.487 |  |
| p value | 0.930*a* | 0.834*a* | 0.611 | | 0.322 |  |
| Endogeneity (H0: Diabetes exogenous) | 1.422 | 12.948 | 1.065 | | 1.429 |  |
| p value | 0.233 | 0.000 | 0.302 | | 0.232 |  |
| N | 4415 | 5997 | 4415 | | 5997 |  |

*Notes* Average marginal eﬀects for bivariate probit (BP); robust standard errors in parentheses. Instru-ments: diabetes of mother, diabetes of father; for Lewbel additionally created age groups instruments. The models contain the age categories 25–34 and 35–44 with 15–24 as the reference category. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental ed-ucation. *a* The test statistics are taken from the linear IV model not presented here. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01.

Table 36: IV estimates for the age group 45–64

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | BP | |  |  | Lewbel IV | | |
|  |  |  |  |  |  |  |  |
|  | (1) |  | (2) |  | (3) | (4) |  |
|  | Males |  | Females |  | Males | Females | |
|  |  |  |  |  |  |  | |
| Diabetes | −.022 |  | −.112 |  | −.178 | −.042 | |
|  | (.138) |  | (.111) | (.160) | | (.104) |  |
|  |  |  |  |  | |  |  |
| R2 |  |  |  | 0.058 | | 0.118 |  |
| Score goodness-of-fit (H0=normality of errors) | 7.00 |  | 11.10 |  |  |  |  |
| p value | 0.637 |  | 0.269 |  |  |  |  |
| F stat. (H0: weak instruments) | 15.408*a* |  | 18.305*a* | 12.534 | | 18.897 |  |
| Sargan test (H0: valid instruments) | 2.717*a* |  | 0.482*a* | 4.397 | | 1.688 |  |
| p value | 0.067*a* |  | 0.487*a* | 0.111 | | 0.430 |  |
| Endogeneity (H0: Diabetes exogenous) | 0.688 |  | 0.574 | 0.082 | | 0.024 |  |
| p value | 0.407 |  | 0.449 | 0.774 | | 0.876 |  |
| N | 1871 | 2246 | | 1871 | | 2246 |  |

*Notes* Average marginal eﬀects for bivariate probit (BP); robust standard errors in parentheses.Instruments: diabetes of mother, diabetes of father; for Lewbel additionally created age groups instruments. The models contain the age categories 55–64 with 45–54 as the reference category. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. *a* The test statistics are taken from the linear IV model not presented here.

∗ *p <* 0*.*10,∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01.

**Instrumental variable analysis for wealth groups**

To consider the possible endogeneity of diabetes in the upper and lower wealth half, we again present the results of the bivariate probit and the Lewbel model. The stratification into wealth groups significantly reduces instrument power as well as sample size. For none of the wealth groups the bivariate probit model indicates endogeneity (see Table  [37](#page259) and Table  [3](#page260)8*)*. This does not change even when using the Lewbel approach to increase instrument strength. Accordingly, we do not find any indication of endogeneity of diabetes in the wealth groups and rely on our probit estimates for inference.

Table 37: IV results for lower wealth half

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | BP | |  |  | Lewbel IV | | |
|  |  |  |  |  |  |  |  |
|  | (1) |  | (2) |  | (3) | (4) |  |
|  | Males |  | Females |  | Males | Females | |
|  |  |  |  |  |  |  | |
| Diabetes | −.354 |  | −.064 |  | −.142∗∗∗ | −.054∗ | |
|  | (.241) |  | (.139) | (.050) | | (.032) |  |
|  |  |  |  |  | |  |  |
| R2 |  |  |  | 0.071 | | 0.099 |  |
| Score goodness-of-fit (H0=normality of errors) | NA*a* |  | 7.41 |  |  |  |  |
| p value | NA*a* |  | 0.594 |  |  |  |  |
| F stat (H0: weak instruments) | 6.322*b* |  | 15.420*b* | 2589.091 | | 1311.647 |  |
| Sargan test (H0: valid instruments) | 0.342*b* |  | 1.106*b* | 4.169 | | 2.804 |  |
| p value | 0.558*b* |  | 0.293*b* | 0.525 | | 0.730 |  |
| Endogeneity (H0: Diabetes exogenous) | 1.190 |  | 0.016 | 0.005 | | 0.156 |  |
| p value | 0.275 |  | 0.901 | 0.941 | | 0.693 |  |
| N | 3169 | 4111 | | 3169 | | 4111 |  |

*Notes* Average marginal eﬀects for bivariate probit (BP); robust standard errors in parentheses.Instruments: diabetes of mother, diabetes of father; for Lewbel additionally created age groups instruments. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. *a* The test statistics are taken from the linear IV model not presented here. The command SCOREGOF failed to produce the test statistic for this subsample. ∗ *p <* 0*.*10,

∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01.

Table 38: IV results for upper wealth half

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | BP | |  |  | Lewbel IV | | |
|  |  |  |  |  |  |  |  |
|  | (1) |  | (2) |  | (3) | (4) |  |
|  | Males |  | Females |  | Males | Females | |
|  |  |  |  |  |  |  | |
| Diabetes | −.142 |  | 0.103 |  | −.057 | −.000 | |
|  | (.199) |  | (.203) | (.037) | | (.039) |  |
|  |  |  |  |  | |  |  |
| R2 |  |  |  | 0.089 | | 0.142 |  |
| Score goodness-of-fit (H0=normality of errors) | 11.40 |  | 12.92 |  |  |  |  |
| p value | 0.249 |  | 0.166 |  |  |  |  |
| F stat (H0: weak instruments) | 14.003*a* |  | 13.215*a* | 28673.088 | | 1225.456 |  |
| Sargan test (H0: valid instruments) | 0.848*a* |  | 0.019*a* | 10.180 | | 5.787 |  |
| p value | 0.357*a* |  | 0.889*a* | 0.070 | | 0.327 |  |
| Endogeneity (H0: Diabetes exogenous) | 0.238 |  | 0.730 | 0.955 | | 1.807 |  |
| p value | 0.626 |  | 0.393 | 0.329 | | 0.179 |  |
| N | 3117 | 4132 | | 3117 | | 4132 |  |

*Notes* Average marginal eﬀects for bivariate probit (BP); robust standard errors in parentheses.Instruments: diabetes of mother, diabetes of father; for Lewbel additionally created age groups instruments. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. *a* The test statistics are taken from the linear IV model not presented here. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**Multinomial logit and IV results for formal and informal**

**employment**

Table 39: Impact of diabetes on employment probabilities by employment sta-tus (multinomial logit)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Males | |  | Females | | |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Informal | Formal |  | Informal | Formal | |
|  |  |  |  |  |  |  |
| Diabetes | −.073∗∗ | 0.031 |  | −.044∗∗ | 0.008 |  |
|  | (.031) | (.026) | (.019) | | (.018) |  |
|  |  |  |  |  |  | |
| Log likelihood | −4997.064 | −4997.064 |  | −6267.941 | −6267.941 | |
| N | 6286 | 6286 | 8243 | | 8243 |  |

*Notes* Average marginal eﬀects. Base category is being unemployed. Othercontrol variables: region, urban, education, indigenous, marital status, children, wealth, parental education. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

To consider the possible endogeneity of diabetes when estimating its eﬀect on formal and informal employment, we again present the results of the bivariate probit and the Lewbel model. The stratification into formal and informal employment groups significantly reduces instrument power as well as sample size. For none of the employment groups the bivariate probit model indicates endogeneity (see Table  [40](#page264) and Table  [41](#page265)). This does not change even when using the Lewbel approach to increase instrument strength. Accordingly, we do not find any indication of endogeneity of diabetes for the stratification into formal and informal employment and rely on our probit estimates for inference.

Table 40: IV results for informal employment

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | BP | |  |  | Lewbel IV | | |
|  |  |  |  |  |  |  |  |
|  | (1) |  | (2) |  | (3) | (4) |  |
|  | Male |  | Female |  | Male | Female | |
|  |  |  |  |  |  |  | |
| Diabetes | −.046 |  | 0.069 |  | −.048 | −.037 | |
|  | (.123) |  | (.130) | (.030) | | (.025) |  |
|  |  |  |  |  | |  |  |
| R2 |  |  |  | 0.103 | | 0.088 |  |
| Score goodness-of-fit (H0=normality of errors) | 13.84 |  | 17.37 |  |  |  |  |
| p value | 0.128 |  | 0.043 |  |  |  |  |
| F stat (H0: weak instruments) | 13.565*a* |  | 25.123*a* | 5349.118 | | 2536.362 |  |
| Sargan test (H0: valid instruments) | 0.551*a* |  | 1.684*a* | 4.067 | | 4.063 |  |
| p value | 0.458*a* |  | 0.194*a* | 0.540 | | 0.540 |  |
| Endogeneity (H0: Diabetes exogenous) | 0.025 |  | 1.152 | 1.128 | | 0.722 |  |
| p value | 0.873 |  | 0.283 | 0.288 | | 0.395 |  |
| N | 4604 | 6983 | | 4604 | | 6983 |  |

*Notes* Average marginal eﬀects for bivariate probit (BP); robust standard errors in parentheses.Instruments: diabetes of mother, diabetes of father; for Lewbel additionally created age groups instruments. The models contain the age categories 55–64 with 45–54 as the reference category. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. *a* The test statistics are taken from the linear IV model not presented here. Base category is being unemployed. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

Table 41: IV results for formal employment

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | BP | |  |  | Lewbel IV | | |
|  |  |  |  |  |  |  |  |
|  | (1) |  | (2) |  | (3) | (4) |  |
|  | Male |  | Female |  | Male | Female | |
|  |  |  |  |  |  |  |  |
| Diabetes | 0.098 |  | −.103 |  | −.022 | 0.003 |  |
|  | (.195) |  | (.069) | (.049) | | (.021) |  |
|  |  |  |  |  | |  |  |
| R2 |  |  |  | 0.256 | | 0.262 |  |
| Score goodness-of-fit (H0=normality of errors) | 12.95 |  | 8.03 |  |  |  |  |
| p value | 0.165 |  | 0.531 |  |  |  |  |
| F stat (H0: weak instruments) | 8.518*a* |  | 19.996*a* | 2764.273 | | 1647.887 |  |
| Sargan test (H0: valid instruments) | 1.111*a* |  | 1.075*a* | 9.286 | | 6.741 |  |
| p value | 0.292*a* |  | 0.300*a* | 0.098 | | 0.241 |  |
| Endogeneity (H0: Diabetes exogenous) | 0.516 |  | 1.833 | 1.602 | | 0.318 |  |
| p value | 0.473 |  | 0.176 | 0.206 | | 0.573 |  |
| N | 2204 | 5652 | | 2204 | | 5652 |  |

*Notes* Average marginal eﬀects for bivariate probit (BP); robust standard errors in parentheses.Instruments: diabetes of mother, diabetes of father; for Lewbel additionally created age groups instruments. The models contain the age categories 55–64 with 45–54 as the reference category. Other control variables: region, urban, education, indigenous, marital status, children, wealth, parental education. *a* The test statistics are taken from the linear IV model not presented here. Base category is being unemployed. ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01.

**Appendix to Chapter 5**

**Attrition**

Table 42: Attrition between waves

1997–2000 11.9% 2000–2004 13.0% 2004–2006 8.3% 2006–2009 16.2% 2009–2011 16.7% Total 10.6%

**Stabilized weights**

Table 43: Summary of stabilized weights

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mean | Min | Max |
|  |  |  |  |
| Untruncated (men) | 1.000515 | 0.281853 | 2.642838 |
| Untruncated (women) | 0.999907 | 0.451526 | 2.053581 |
| Truncated 1 and 99 percentile (men) | 0.999756 | 0.945491 | 1.057514 |
| Truncated 1 and 99 percentile (women) | 1.000001 | 0.960039 | 1.049472 |
|  | | |  |
| Using overweight and obesity instead of BMI and waist circumference | | |  |
| Untruncated (men) | 1.000516 | 0.232143 | 2.592925 |
| Untruncated (women) | 0.999857 | 0.251297 | 2.491703 |
| Truncated 1 and 99 percentile (men) | 0.999794 | 0.944632 | 1.058910 |
| Truncated 1 and 99 percentile (women) | 0.999782 | 0.932321 | 1.077095 |
|  |  |  |  |

**Duration groups results**

Table 44: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes using marginal structural models (duration groups)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  | −.031 |  | −1.138∗∗ | −.728 |  |  |
| 0 | 0.088 | 0.049 | 278.504 |  |
|  | (.059) | (.122) | (.147) | (.530) | (1.927) | (301.190) |  |
| 1-2 | 0.024 | −.049 | −.102∗∗ | −.485∗ | −1.261 | −133.527 |  |
|  | (.034) | (.042) | (.040) | (.260) | (.876) | (96.402) |  |
| 3-4 | −.033 | −.091 | −.082∗ | −.665∗∗ | −2.505∗∗∗ | −160.612∗ |  |
|  | (.042) | (.056) | (.045) | (.309) | (.814) | (84.241) |  |
| 5-6 | −.110 | −.116 | −.090 | −.917∗∗ | −1.009 | −156.064 |  |
|  | (.068) | (.080) | (.056) | (.384) | (.980) | (117.322) |  |
| 7-8 | 0.044 | −.191 | −.146∗ | −.833∗ | −1.590 | −260.923∗∗ |  |
|  | (.076) | (.134) | (.079) | (.467) | (2.276) | (130.336) |  |
| 9-10 | −.052 | −.040 | 0.197 | −2.198∗∗∗ | −6.075∗∗ | −386.292∗ |  |
|  | (.117) | (.140) | (.181) | (.765) | (2.591) | (199.311) |  |
| 11-12 | 0.013 | −.001 | −.165 | −.881 | −3.505 | 40.936 |  |
|  | (.120) | (.132) | (.125) | (.708) | (2.522) | (174.858) |  |
| 13-14 | 0.004 |  |  |  |  |  |  |
|  | (.124) |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Female sample |  |  |  |  | −1.210 | −59.570 |  |
| 0 | 0.078 |  |  | 0.099 |  |
|  | (.139) |  |  | (1.021) | (3.866) | (157.723) |  |
| 1-2 | −.085∗∗ |  |  | −.191 | −.303 | −32.947 |  |
|  | (.040) |  |  | (.352) | (.724) | (50.797) |  |
| 3-4 | −.202∗∗∗ |  |  | −.411 | 0.591 | −21.502 |  |
|  | (.067) |  |  | (.461) | (1.232) | (62.460) |  |
| 5-6 | −.070 |  |  | −.475 | −.187 | −53.234 |  |
|  | (.066) |  |  | (.337) | (1.055) | (61.737) |  |
| 7-8 | −.180∗∗ |  |  | −1.049∗∗ | −1.787∗ | −94.532 |  |
|  | (.088) |  |  | (.426) | (1.057) | (105.698) |  |
| 9-10 | −.329∗ |  |  | −1.054 | 0.324 | 66.951 |  |
|  | (.168) |  |  | (.822) | (2.538) | (125.902) |  |
| 11-12 | −.119 |  |  | −.554 | −3.906 | −29.022 |  |
|  | (.120) |  |  | (1.089) | (2.464) | (152.223) |  |
| 13-14 | −.117 |  |  |  |  |  |  |
|  | (.154) |  |  |  |  |  |  |

*Notes* Other control variables: baseline values of age, age squared, region, urban, education, Han ethnic-ity, marital status, urbanization index, time dummies, health insurance status, household expenditures, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 45: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes using fixed eﬀects (duration groups)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  | −.005 |  |  |  | −112.476 |  |
| 0 | 0.151∗∗ | 0.027 | 0.064 | 2.200 |  |
|  | (.072) | (.097) | (.161) | (.822) | (2.257) | (232.264) |  |
| 1-2 | 0.040 | −.029 | −.137∗∗∗ | −.598∗∗∗ | −1.714∗∗ | −228.738∗∗∗ |  |
|  | (.038) | (.038) | (.042) | (.230) | (.784) | (85.913) |  |
| 3-4 | 0.010 | −.007 | −.066 | −.706∗∗ | −2.992∗∗∗ | −113.409 |  |
|  | (.044) | (.051) | (.050) | (.296) | (.797) | (86.909) |  |
| 5-6 | −.118 | −.026 | −.093 | −1.164∗∗∗ | −2.191∗ | −22.369 |  |
|  | (.079) | (.072) | (.062) | (.341) | (1.309) | (112.692) |  |
| 7-8 | 0.126 | −.147 | −.262∗∗ | −.750 | −3.009 | −302.744∗∗ |  |
|  | (.078) | (.120) | (.116) | (.493) | (1.886) | (131.910) |  |
| 9-10 | 0.036 | 0.004 | 0.054 | −2.123∗∗∗ | −7.756∗∗∗ | −228.356 |  |
|  | (.141) | (.138) | (.145) | (.788) | (2.799) | (184.833) |  |
| 11-12 | 0.066 | −.042 | −.256∗ | −1.604∗∗ | −6.693∗∗ | −195.061 |  |
|  | (.180) | (.156) | (.141) | (.742) | (3.094) | (160.761) |  |
| 13-14 | 0.042 | 0.186 | −.218 | −1.389 | −4.626∗∗∗ | −167.675 |  |
|  | (.183) | (.126) | (.140) | (1.168) | (1.190) | (147.716) |  |
|  |  |  |  |  |  |  |  |
| Female sample |  | −.015∗∗ | −.035 | −.468 | −4.036 | −322.767∗ |  |
| 0 | 0.102 |  |
|  | (.157) | (.007) | (.032) | (.884) | (3.229) | (171.460) |  |
| 1-2 | −.104∗∗∗ | −.031∗∗ | −.019∗ | −.419 | −.727 | −98.608∗ |  |
|  | (.034) | (.013) | (.011) | (.349) | (.683) | (56.443) |  |
| 3-4 | −.110∗∗ | −.022 | −.012 | −.756∗∗ | −.896 | 42.743 |  |
|  | (.056) | (.015) | (.016) | (.378) | (1.000) | (67.154) |  |
| 5-6 | −.095 | −.049 | 0.007 | −1.012∗∗∗ | −2.293∗∗ | −49.270 |  |
|  | (.072) | (.038) | (.018) | (.309) | (1.021) | (84.604) |  |
| 7-8 | −.219∗∗ | 0.014 | −.000 | −1.385∗∗∗ | −3.238∗∗∗ | −76.316 |  |
|  | (.090) | (.032) | (.013) | (.391) | (.962) | (102.021) |  |
| 9-10 | −.261∗∗ | 0.024 | −.001 | −.794 | −.240 | −12.562 |  |
|  | (.124) | (.035) | (.025) | (.572) | (2.056) | (134.903) |  |
| 11-12 | −.209∗ | −.070 | −.002 | −.676 | −4.068∗ | −2.327 |  |
|  | (.111) | (.053) | (.009) | (.973) | (2.462) | (152.643) |  |
| 13-14 | −.178 | −.026 | −.001 | −.001 | 0.056 | −301.362∗∗∗ |  |
|  | (.164) | (.018) | (.027) | (.708) | (2.411) | (94.674) |  |

*Notes* Other control variables: age squared, region, urban, education, han, marital status, urbanization index,time dummies, health insurance status, household expenditures. N=23443 (male sample), N=23702 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗. *p <* 0*.*01

Table 46: Analysis of the eﬀect of time since diabetes diagnosis on employ-ment status and behavioural outcomes using random eﬀects (dura-tion groups)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  | −.034 |  |  |  |  |  |
| 0 | 0.123∗ | 0.051 | 0.381 | 3.652∗ | 2.069 |  |
|  | (.068) | (.097) | (.150) | (.707) | (2.075) | (203.971) |  |
| 1-2 | −.005 | −.067∗ | −.142∗∗∗ | −.276 | −.392 | −223.036∗∗∗ |  |
|  | (.038) | (.037) | (.036) | (.224) | (.766) | (78.475) |  |
| 3-4 | −.048 | −.052 | −.081∗ | −.316 | −1.318∗ | −155.191∗∗ |  |
|  | (.044) | (.048) | (.045) | (.304) | (.769) | (72.913) |  |
| 5-6 | −.133∗ | −.071 | −.084 | −.759∗∗ | −.403 | −75.706 |  |
|  | (.076) | (.069) | (.058) | (.344) | (1.148) | (104.001) |  |
| 7-8 | 0.093 | −.208∗ | −.194∗ | −.434 | −1.172 | −272.523∗∗ |  |
|  | (.075) | (.112) | (.102) | (.485) | (1.703) | (109.241) |  |
| 9-10 | −.018 | −.028 | 0.122 | −1.804∗∗ | −5.786∗∗ | −234.745 |  |
|  | (.142) | (.134) | (.142) | (.749) | (2.609) | (166.358) |  |
| 11-12 | 0.012 | −.071 | −.209 | −1.360∗ | −5.108∗ | −90.369 |  |
|  | (.166) | (.160) | (.132) | (.726) | (2.790) | (158.103) |  |
| 13-14 | 0.008 | 0.206∗∗ | −.152 | −.985 | −2.776∗∗ | −14.049 |  |
|  | (.157) | (.093) | (.142) | (1.225) | (1.122) | (101.033) |  |
|  |  |  |  |  |  |  |  |
| Female sample |  |  | −.035∗∗ |  | −1.037 | −145.397 |  |
| 0 | 0.034 | 0.003 | 0.097 |  |
|  | (.145) | (.025) | (.017) | (.842) | (3.375) | (139.781) |  |
| 1-2 | −.135∗∗∗ | −.028∗∗∗ | −.026∗∗∗ | −.025 | 0.857 | −44.182 |  |
|  | (.031) | (.011) | (.004) | (.337) | (.631) | (52.022) |  |
| 3-4 | −.169∗∗∗ | −.018 | −.015 | −.379 | 0.901 | −3.834 |  |
|  | (.049) | (.014) | (.014) | (.372) | (1.005) | (57.700) |  |
| 5-6 | −.129∗∗ | −.038 | −.005 | −.612∗∗ | −.317 | −43.769 |  |
|  | (.063) | (.033) | (.018) | (.305) | (.992) | (69.632) |  |
| 7-8 | −.225∗∗∗ | 0.024 | −.018∗ | −1.015∗∗∗ | −1.357 | −69.287 |  |
|  | (.075) | (.034) | (.010) | (.377) | (.908) | (105.179) |  |
| 9-10 | −.286∗∗ | 0.026 | −.018 | −.515 | 1.421 | 98.605 |  |
|  | (.111) | (.042) | (.024) | (.572) | (1.937) | (127.672) |  |
| 11-12 | −.195∗ | −.060 | −.020∗∗∗ | −.265 | −2.043 | 31.945 |  |
|  | (.117) | (.043) | (.005) | (.948) | (2.622) | (137.113) |  |
| 13-14 | −.152 | −.022∗ | −.018 | 0.503 | 2.325 | −301.291∗∗∗ |  |
|  | (.152) | (.013) | (.026) | (.773) | (2.541) | (91.369) |  |

*Notes* Other control variables: age, age squared, region, urban, education, han, marital status, urbanizationindex, time dummies, health insurance status, household expenditures. N=23443 (male sample), N=23702 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

**Robustness checks**

**[MSMs](#page14) using truncated weights**

Table 47: Analysis of the eﬀect of a diabetes diagnosis on employment sta-tus and behavioural outcomes using marginal structural models with truncated stabilized weights at 1st and 99th percentile

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Diabetes* | |  |  |  |
| Male sample | −.022 | −.070∗∗ | −.094∗∗∗ | −.732∗∗∗ | −1.637∗∗∗ | −175.662∗∗∗ |  |
| Diabetes |  |
| Female sample | (.023) | (.032) | (.036) | (.179) | (.532) | (51.574) |  |
| −.132∗∗∗ | −.015∗ | −.029∗∗ | −.178 |  | −47.980 |  |
| Diabetes | 0.186 |  |
|  | (.029) | (.008) | (.012) | (.248) | (.638) | (34.319) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Years since diagnosis* | |  |  |  |
| Male sample | −.006 | −.010∗∗ | −.016∗∗ | −.133∗∗∗ | −.326∗∗∗ | −26.261∗∗∗ |  |
| Time since diagnosis |  |
| Female sample | (.004) | (.005) | (.006) | (.033) | (.095) | (9.160) |  |
| −.019∗∗∗ | −.002 | −.004 | −.044 | −.016 | −9.096 |  |
| Time since diagnosis |  |
|  | (.006) | (.001) | (.003) | (.042) | (.112) | (5.681) |  |

*Notes* Robust standard errors in parentheses. Other control variables: baseline values of age, age squared, re-gion, urban, education, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 48: Eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes using MSM with truncated stabilized weights (1st and 99th percentile; imputed)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  | −.047 |  | −1.107∗∗ | −.326 |  |  |
| 0 | 0.089 | 0.031 | 83.518 |  |
|  | (.061) | (.135) | (.143) | (.522) | (1.909) | (236.282) |  |
| 1-2 | −.002 | −.072∗ | −.121∗∗∗ | −.472∗ | −.962 | −197.071∗∗ |  |
|  | (.034) | (.041) | (.033) | (.254) | (.843) | (82.739) |  |
| 3-4 | −.042 | −.073 | −.088∗∗ | −.654∗∗ | −2.113∗∗∗ | −189.546∗∗ |  |
|  | (.038) | (.050) | (.040) | (.299) | (.693) | (77.787) |  |
| 5-6 | −.107∗ | −.091 | −.094∗ | −1.022∗∗∗ | −.954 | −151.346 |  |
|  | (.063) | (.074) | (.053) | (.360) | (1.013) | (107.678) |  |
| 7-8 | 0.054 | −.222∗ | −.127 | −.863∗ | −2.157 | −264.374∗∗ |  |
|  | (.063) | (.118) | (.078) | (.462) | (2.034) | (115.620) |  |
| 9-10 | −.075 | −.024 | 0.122 | −2.270∗∗∗ | −5.774∗∗ | −289.988∗ |  |
|  | (.117) | (.136) | (.148) | (.700) | (2.424) | (174.301) |  |
| 11-12 | −.024 | −.028 | −.167 | −.888 | −3.275 | −8.651 |  |
|  | (.126) | (.127) | (.112) | (.713) | (2.467) | (163.025) |  |
| 13-14 | −.053 |  |  |  |  |  |  |
|  | (.142) |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Female sample |  |  |  |  |  | −102.210 |  |
| 0 | 0.068 |  |  | 0.541 | 0.219 |  |
|  | (.134) |  |  | (1.136) | (4.359) | (139.467) |  |
| 1-2 | −.114∗∗∗ |  |  | 0.130 | 0.472 | −28.298 |  |
|  | (.040) |  |  | (.359) | (.723) | (53.113) |  |
| 3-4 | −.208∗∗∗ |  |  | −.298 | 0.866 | −31.300 |  |
|  | (.064) |  |  | (.457) | (1.193) | (61.496) |  |
| 5-6 | −.097 |  |  | −.319 | 0.103 | −60.088 |  |
|  | (.063) |  |  | (.347) | (1.084) | (66.056) |  |
| 7-8 | −.184∗∗ |  |  | −.979∗∗ | −1.522 | −94.059 |  |
|  | (.089) |  |  | (.449) | (1.074) | (107.062) |  |
| 9-10 | −.344∗∗ |  |  | −.975 | 0.637 | 71.060 |  |
|  | (.168) |  |  | (.827) | (2.541) | (133.178) |  |
| 11-12 | −.119 |  |  | −.432 | −3.355 | −12.232 |  |
|  | (.113) |  |  | (1.070) | (2.603) | (141.560) |  |
| 13-14 | −.106 |  |  |  |  |  |  |
|  | (.152) |  |  |  |  |  |  |

*Notes* Robust standard errors in parentheses. Other control variables: baseline values of age, age squared,region, urban, education, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

**Results using non-imputed data**

Table 49: Analysis of the eﬀect of a diabetes diagnosis on employment status and behavioural outcomes using MSM, FE and RE (no imputation)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Marginal structural model* | |  |  |  |
| Male sample |  | −.054 | −.118∗∗ | −.601∗∗∗ | −1.290 | −205.746∗ |  |
| Diabetes | 0.049 |  |
| Female sample | (.043) | (.040) | (.053) | (.229) | (.859) | (109.375) |  |
| −.087∗ | −.026∗ |  | −.637 | −1.043 | −45.166 |  |
| Diabetes | 0.000 |  |
|  | (.047) | (.016) | (.) | (.402) | (.865) | (56.543) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Fixed eﬀects* | |  |  |  |
| Male sample |  | −.004 | −.103∗∗∗ | −.844∗∗∗ | −2.463∗∗∗ | −152.316∗∗ |  |
| Diabetes | 0.024 |  |
| Female sample | (.030) | (.033) | (.036) | (.169) | (.508) | (67.898) |  |
| −.110∗∗∗ | −.024∗∗ | −.015 | −.634∗∗ | −1.105∗ | −81.340∗ |  |
| Diabetes |  |
|  | (.034) | (.012) | (.012) | (.288) | (.636) | (49.016) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Random eﬀects* | |  |  |  |
| Male sample | −.023 | −.045 | −.109∗∗∗ | −.569∗∗∗ | −1.163∗∗ | −143.470∗∗∗ |  |
| Diabetes |  |
| Female sample | (.027) | (.030) | (.029) | (.166) | (.482) | (51.625) |  |
| −.164∗∗∗ | −.020∗∗ | −.021∗∗∗ | −.309 |  | −59.269∗ |  |
| Diabetes | 0.494 |  |
|  | (.026) | (.009) | (.005) | (.269) | (.583) | (35.037) |  |
|  |  |  | | | |  |  |
| Male sample |  | *Robust Hausman test of fixed eﬀects vs. random eﬀects* | | | |  |  |
| 449.597 | 230.700 | 99.211 | 299.581 | 230.399 | 51.810 |  |
| *Chi*2 |  |
| p-value | *<*0.001 | *<*0.001 | *<*0.001 | *<*0.001 | *<*0.001 | *<*0.001 |  |
| Female sample | 337.522 | 52.231 | 27.422 | 251.371 | 149.501 | 51.005 |  |
| *Chi*2 |  |
| p-value | *<*0.001 | *<*0.001 | 0.017 | *<*0.001 | *<*0.001 | *<*0.001 |  |

*Notes* Robust standard errors in parentheses. Other control variables for FE/RE: age squared, region, urban,education, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures. RE additionally controls for age. MSM controls for baseline values of the same variables as the FE/RE models additionally to baseline values of age, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. FE/RE: N=22135 (male sample), N=23143 (female sample), MSM: N=10006 (male sample), N=11471 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 50: Analysis of the eﬀect of time since diabetes diagnosis on employ-ment status and behavioural outcomes using MSM, FE and RE (non-imputed)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Marginal structural model* | |  |  |  |
| Male sample |  | −.019 | −.036∗ | −.203∗∗ | −.550∗ | −85.203∗∗ |  |
| Time since diagnosis | 0.019 |  |
| Female sample | (.017) | (.015) | (.022) | (.081) | (.310) | (38.378) |  |
| −.028 | −.008 |  | −.338∗ | −.579∗ | −14.298 |  |
| Time since diagnosis | 0.000 |  |
|  | (.017) | (.006) | (.) | (.178) | (.333) | (21.193) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Fixed eﬀects* | |  |  |  |
| Male sample | −.001 |  | −.016∗∗ | −.158∗∗∗ | −.516∗∗∗ | −18.202 |  |
| Time since diagnosis | 0.003 |  |
| Female sample | (.007) | (.006) | (.007) | (.039) | (.118) | (12.059) |  |
| −.023∗∗∗ | −.002 | −.001 | −.103∗∗ | −.177 | −9.987 |  |
| Time since diagnosis |  |
|  | (.008) | (.002) | (.001) | (.045) | (.127) | (7.788) |  |
|  |  |  |  | |  |  |  |
|  |  |  | *Random eﬀects* | |  |  |  |
| Male sample | −.007 | −.003 | −.015∗∗∗ | −.120∗∗∗ | −.317∗∗∗ | −20.749∗∗ |  |
| Time since diagnosis |  |
| Female sample | (.006) | (.006) | (.006) | (.038) | (.101) | (9.382) |  |
| −.026∗∗∗ | −.002 | −.003∗∗∗ | −.065 |  | −7.041 |  |
| Time since diagnosis | 0.043 |  |
|  | (.006) | (.002) | (.001) | (.044) | (.124) | (6.479) |  |

*Notes* Robust standard errors in parentheses. Other control variables for FE/RE: age squared, region, urban,education, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures. RE additionally controls for age. MSM controls for baseline values of the same variables as the FE/RE models additionally to baseline values of age, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. FE/RE: N=22117 (male sample), N=23130 (female sample), MSM: N=10028 (male sample), N=11465 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 51: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes using marginal structural models (duration groups) (non-imputed)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  |  |  | −.942 |  |  |  |
| 0 | 0.119∗ | 0.053 | 0.010 | 0.596 | 459.443 |  |
|  | (.070) | (.170) | (.156) | (.589) | (.934) | (474.665) |  |
| 1-2 | 0.026 | −.055 | −.137∗∗∗ | −.571∗∗ | −1.270 | −182.199 |  |
|  | (.044) | (.046) | (.043) | (.273) | (1.040) | (121.087) |  |
| 3-4 | 0.000 | −.043 | 0.131 | −1.013∗∗ | −3.347 | −782.090∗∗∗ |  |
|  | (.) | (.153) | (.156) | (.450) | (2.116) | (177.206) |  |
|  |  |  |  |  |  |  |  |
| Female sample |  |  |  | −.136 | −1.772 | −101.086 |  |
| 0 | 0.123 | 0.000 | 0.000 |  |
|  | (.188) | (.) | (.) | (1.488) | (5.608) | (203.293) |  |
| 1-2 | −.083 | −.018∗∗ | −.053∗ | −.613 | −.685 | −40.447 |  |
|  | (.067) | (.009) | (.028) | (.489) | (1.026) | (65.853) |  |
| 3-4 | 0.000 | 0.000 | 0.000 | −5.530∗ | −8.510∗∗∗ | 0.676 |  |
|  | (.) | (.) | (.) | (3.260) | (1.787) | (257.875) |  |

*Notes* Due to Robust standard errors in parentheses. Other control variables: baseline values of age, agesquared, region, urban, education, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures, alcohol consumption, smoking status, BMI, waist circumference and calorie consumption. N=10028 (male sample), N=11465 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗

*p <* 0*.*01..

Table 52: Analysis of the eﬀect of time since diabetes diagnosis on employment status and behavioural outcomes using fixed eﬀects (duration groups) (non-imputed)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  | −.013 |  | −.013 |  | −268.541 |  |
| 0 | 0.126∗ | 0.081 | 1.444 |  |
|  | (.073) | (.084) | (.156) | (.704) | (1.883) | (213.448) |  |
| 1-2 | 0.046 | −.019 | −.135∗∗∗ | −.817∗∗∗ | −2.298∗∗∗ | −225.905∗∗ |  |
|  | (.039) | (.039) | (.042) | (.199) | (.637) | (90.437) |  |
| 3-4 | 0.013 | 0.035 | −.052 | −.786∗∗ | −3.016∗∗∗ | −107.317 |  |
|  | (.046) | (.054) | (.055) | (.325) | (.819) | (98.624) |  |
| 5-6 | −.134∗ | 0.028 | −.134∗∗ | −1.159∗∗∗ | −1.715 | 34.167 |  |
|  | (.079) | (.077) | (.065) | (.343) | (1.178) | (117.774) |  |
| 7-8 | 0.162∗∗ | −.138 | −.270∗∗ | −.692 | −2.555 | −305.553∗∗ |  |
|  | (.078) | (.117) | (.117) | (.429) | (1.726) | (133.202) |  |
| 9-10 | −.018 | 0.044 | 0.082 | −1.938∗∗∗ | −8.278∗∗∗ | −196.802 |  |
|  | (.136) | (.123) | (.131) | (.667) | (2.262) | (201.492) |  |
| 11-12 | 0.063 | 0.089 | −.177∗∗ | −1.743∗∗ | −5.843∗∗ | −22.708 |  |
|  | (.178) | (.134) | (.082) | (.736) | (2.828) | (140.771) |  |
| 13-14 | 0.060 | 0.222∗∗ | −.164 | −1.508 | −4.207∗∗∗ | −119.852 |  |
|  | (.194) | (.113) | (.111) | (1.202) | (1.063) | (178.187) |  |
|  |  |  |  |  |  |  |  |
| Female sample |  | −.014∗∗ | −.046 | −.778 | −3.920 | −358.037∗∗ |  |
| 0 | 0.101 |  |
|  | (.154) | (.007) | (.040) | (.909) | (3.420) | (173.529) |  |
| 1-2 | −.100∗∗∗ | −.029∗∗ | −.023∗ | −.329 | −.558 | −118.162∗∗ |  |
|  | (.033) | (.012) | (.012) | (.363) | (.671) | (56.839) |  |
| 3-4 | −.148∗∗ | −.017 | −.025∗ | −.822∗ | −.824 | 49.550 |  |
|  | (.059) | (.013) | (.014) | (.442) | (1.148) | (82.984) |  |
| 5-6 | −.122∗ | −.043 | 0.002 | −1.028∗∗∗ | −1.616 | −69.012 |  |
|  | (.073) | (.041) | (.020) | (.325) | (1.016) | (96.779) |  |
| 7-8 | −.235∗∗∗ | 0.023 | −.004 | −1.327∗∗∗ | −3.174∗∗∗ | −90.185 |  |
|  | (.090) | (.027) | (.008) | (.390) | (.978) | (111.004) |  |
| 9-10 | −.247∗∗ | 0.031 | −.010 | −.981 | −.260 | −64.808 |  |
|  | (.118) | (.039) | (.009) | (.621) | (2.131) | (134.146) |  |
| 11-12 | −.239∗∗ | −.070 | −.005 | −.715 | −3.440 | −25.527 |  |
|  | (.103) | (.056) | (.009) | (1.021) | (2.512) | (173.367) |  |
| 13-14 | −.199 | −.023 | −.008 | −.111 | 0.693 | −366.259∗∗∗ |  |
|  | (.166) | (.018) | (.009) | (.665) | (2.153) | (87.213) |  |

*Notes* Robust standard errors in parentheses. Other control variables: age squared, region, urban, educa-tion, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures. N=22117 (male sample), N=23130 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Table 53: Analysis of the eﬀect of time since diabetes diagnosis on employ-ment status and behavioural outcomes using random eﬀects (dura-tion groups) (non-imputed)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |  |
|  | Employment | Smoking | Any alcohol | BMI | Waist (cm) | Calories (kcal) |  |
|  |  |  |  |  |  |  |  |
| Male sample |  | −.043 |  |  |  | −28.615 |  |
| 0 | 0.094 | 0.065 | 0.148 | 2.276 |  |
|  | (.069) | (.087) | (.144) | (.610) | (1.683) | (188.201) |  |
| 1-2 | −.008 | −.053 | −.144∗∗∗ | −.533∗∗∗ | −1.045 | −203.986∗∗ |  |
|  | (.038) | (.038) | (.036) | (.195) | (.658) | (80.054) |  |
| 3-4 | −.041 | −.007 | −.070 | −.493 | −1.730∗∗ | −140.623 |  |
|  | (.045) | (.051) | (.051) | (.336) | (.809) | (87.834) |  |
| 5-6 | −.159∗∗ | −.012 | −.120∗∗ | −.866∗∗∗ | −.330 | −69.752 |  |
|  | (.077) | (.073) | (.060) | (.333) | (1.054) | (115.094) |  |
| 7-8 | 0.114 | −.213∗∗ | −.215∗∗ | −.473 | −1.072 | −243.936∗∗ |  |
|  | (.074) | (.108) | (.097) | (.431) | (1.538) | (105.320) |  |
| 9-10 | −.070 | 0.001 | 0.127 | −1.803∗∗∗ | −7.021∗∗∗ | −173.366 |  |
|  | (.134) | (.118) | (.132) | (.620) | (2.127) | (167.349) |  |
| 11-12 | 0.005 | 0.060 | −.160 | −1.446∗ | −4.339 | 92.244 |  |
|  | (.159) | (.144) | (.100) | (.767) | (2.681) | (148.282) |  |
| 13-14 | 0.029 | 0.234∗∗∗ | −.118 | −1.101 | −2.531∗∗∗ | 38.227 |  |
|  | (.161) | (.083) | (.128) | (1.263) | (.931) | (100.439) |  |
|  |  |  |  |  |  |  |  |
| Female sample |  |  | −.039∗∗ | −.238 | −1.178 | −123.300 |  |
| 0 | 0.025 | 0.003 |  |
|  | (.145) | (.025) | (.016) | (.874) | (3.554) | (139.671) |  |
| 1-2 | −.142∗∗∗ | −.028∗∗∗ | −.028∗∗∗ | 0.001 | 0.848 | −66.418 |  |
|  | (.031) | (.010) | (.004) | (.349) | (.622) | (49.483) |  |
| 3-4 | −.195∗∗∗ | −.020∗ | −.028∗∗∗ | −.481 | 1.064 | 43.196 |  |
|  | (.052) | (.012) | (.005) | (.433) | (1.090) | (68.580) |  |
| 5-6 | −.159∗∗ | −.034 | −.007 | −.647∗∗ | 0.445 | −52.781 |  |
|  | (.063) | (.035) | (.021) | (.315) | (.981) | (77.715) |  |
| 7-8 | −.247∗∗∗ | 0.029 | −.022∗∗∗ | −1.073∗∗∗ | −1.501∗ | −90.408 |  |
|  | (.070) | (.031) | (.003) | (.368) | (.886) | (116.975) |  |
| 9-10 | −.286∗∗∗ | 0.029 | −.024∗∗∗ | −.748 | 1.422 | 124.263 |  |
|  | (.099) | (.046) | (.003) | (.605) | (1.900) | (156.687) |  |
| 11-12 | −.214∗ | −.062 | −.022∗∗∗ | −.335 | −1.482 | 49.789 |  |
|  | (.114) | (.046) | (.005) | (1.000) | (2.752) | (155.171) |  |
| 13-14 | −.176 | −.022∗ | −.024∗∗∗ | 0.298 | 2.665 | −332.344∗∗∗ |  |
|  | (.153) | (.012) | (.006) | (.755) | (2.407) | (99.899) |  |

*Notes* Robust standard errors in parentheses. Other control variables: age, age squared, region, urban, ed-ucation, Han ethnicity, marital status, urbanization index, time dummies, health insurance status, household expenditures. N=22117 (male sample), N=23130 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

**Overweight and obesity results**

Table 54: Analysis of the eﬀect of a diabetes diagnosis on overweight and obe-sity using MSM, FE and RE

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Males |  |  | Females |  |  |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Overweight | Obese |  | Overweight | Obese | |
|  |  | | | |  |  |
|  | *Marginal structural model* | | | |  |  |
| Diabetes | −.000 | −.024 |  | −.031 | −.009 | |
|  | (.031) | (.015) | (.034) | | (.014) |  |
|  |  |  | | |  |  |
|  |  | *Fixed Eﬀects* | | |  |  |
| Diabetes | −.041 | −.035 |  | −.095∗∗∗ | −.034 | |
|  | (.035) | (.025) | (.036) | | (.027) |  |
|  |  |  | | |  |  |
|  |  | *Random Eﬀects* | | |  |  |
| Diabetes | 0.014 | −.006 |  | −.070∗∗ | 0.028 |  |
|  | (.030) | (.023) | (.030) | | (.024) |  |

*Notes* Robust standard errors in parentheses. Other controlvariables for FE/RE: age squared, region, urban, education, Han ethnicity, marital status, urbanization index, time dum-mies, health insurance status, household expenditures. RE additionally controls for age. MSM controls for baseline val-ues of the same variables as the FE/RE models additionally to baseline values of age, alcohol consumption, smoking sta-tus, overweight status, obesity status and calorie consumption. FE/RE: N=23443 (male sample), N=23702 (female sample). MSM: N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10,∗∗ *p <* 0*.*05,∗∗∗ *p <* 0*.*01..

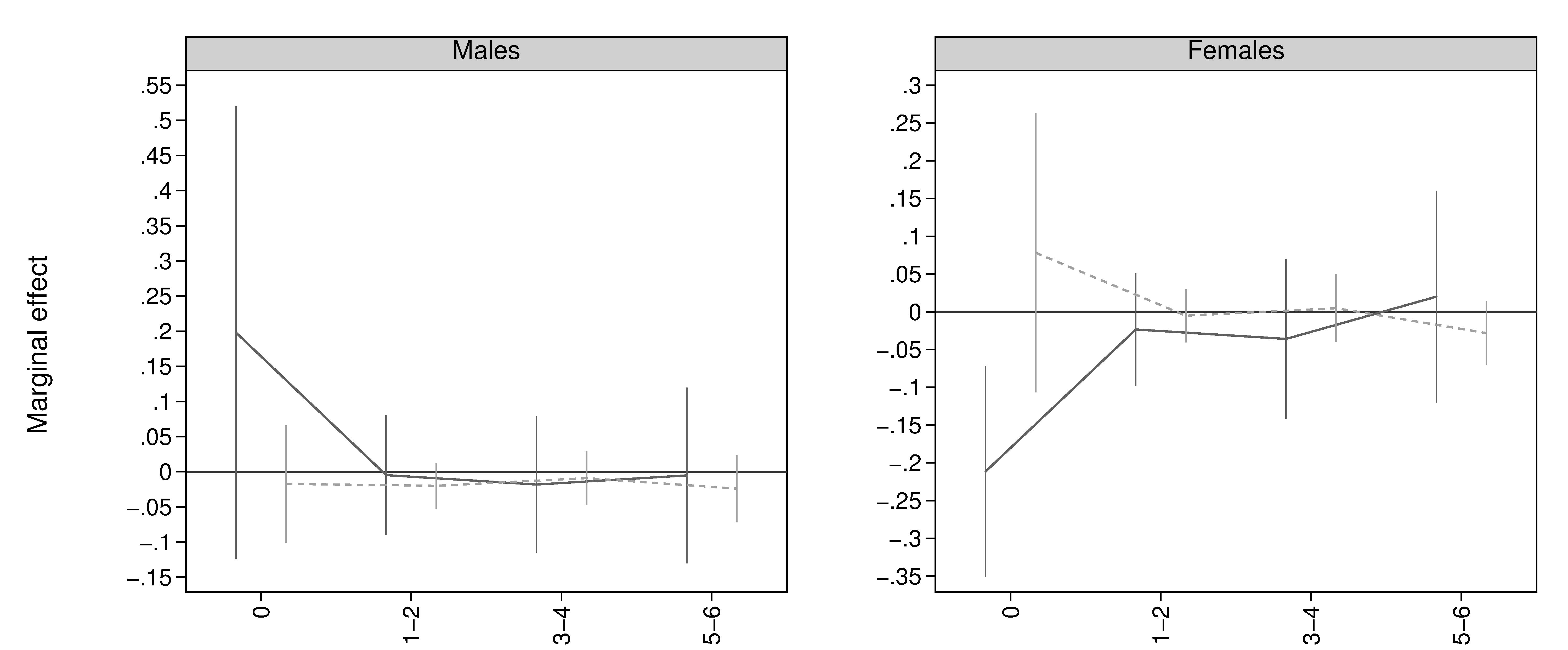
Table 55: Analysis of the eﬀect of time since diagnosis on overweight and obe-sity using MSM, FE, RE

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Males |  |  | Females | | |
|  |  |  |  |  |  |  |
|  | (1) | (2) |  | (3) | (4) |  |
|  | Overweight | Obese |  | Overweight | Obese | |
|  | *Marginal structural model* | | | |  |  |
| Time since diagnosis | −.001 | −.005∗ |  | −.003 | −.003 | |
|  | (.005) | (.003) | (.005) | | (.002) |  |
|  |  |  | | |  |  |
|  |  | *Fixed Eﬀects* | | |  |  |
| Time since diagnosis | −.006 | −.007∗ |  | −.006 | −.009∗ | |
|  | (.007) | (.004) | (.006) | | (.005) |  |
|  |  |  | | |  |  |
|  |  | *Random Eﬀects* | | |  |  |
| Time since diagnosis | 0.002 | −.003 |  | −.006 | −.001 | |
|  | (.006) | (.003) | (.005) | | (.004) |  |

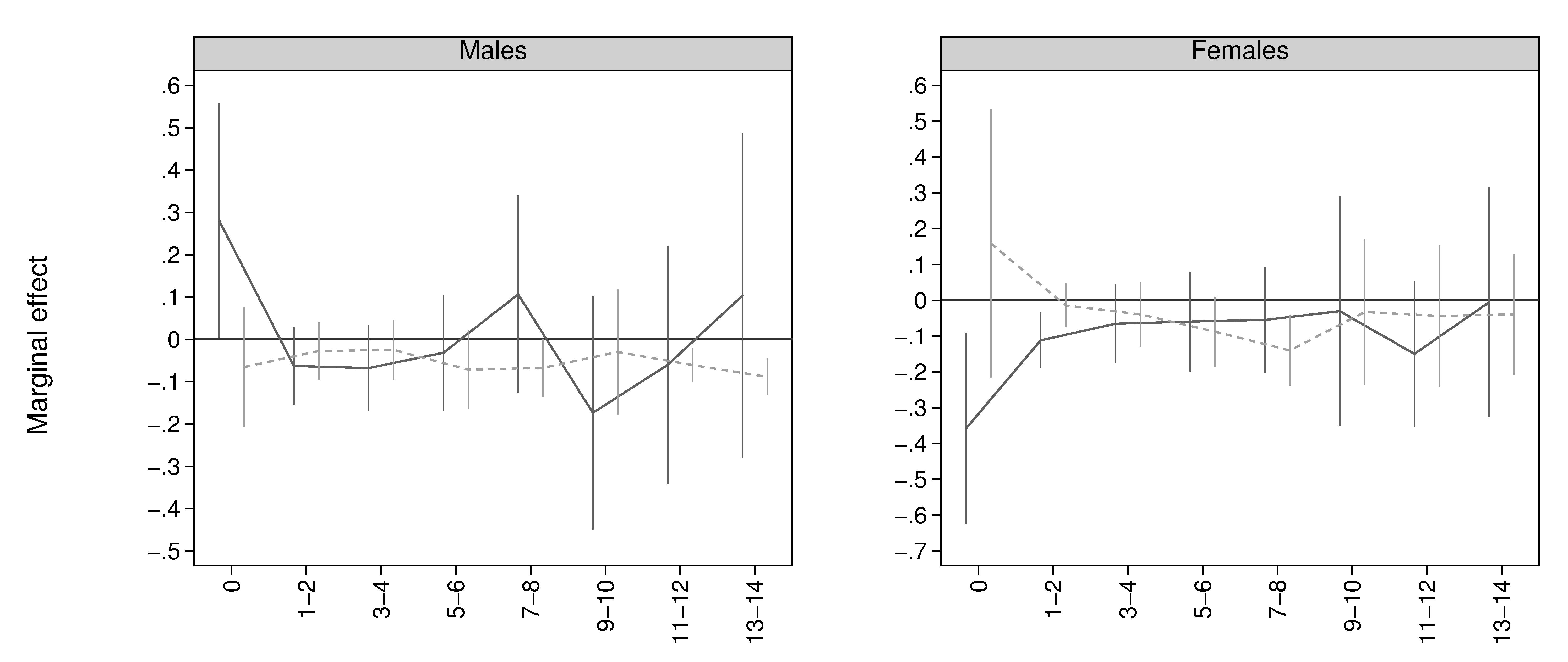
*Notes* Robust standard errors in parentheses. Other control variables forFE/RE: age squared, region, urban, education, Han ethnicity, marital sta-tus, urbanization index, time dummies, health insurance status, household expenditures. RE additionally controls for age. MSM controls for baseline values of the same variables as the FE/RE models additionally to base-line values of age, alcohol consumption, smoking status, overweight status, obesity status and calorie consumption. FE/RE: N=23443 (male sam-ple), N=23702 (female sample). MSM: N=16047 (male sample), N=16658 (female sample). ∗ *p <* 0*.*10, ∗∗ *p <* 0*.*05, ∗∗∗ *p <* 0*.*01..

Figure 13: Analysis of the eﬀect of time since diabetes diagnosis on overweight and obesity (duration groups)

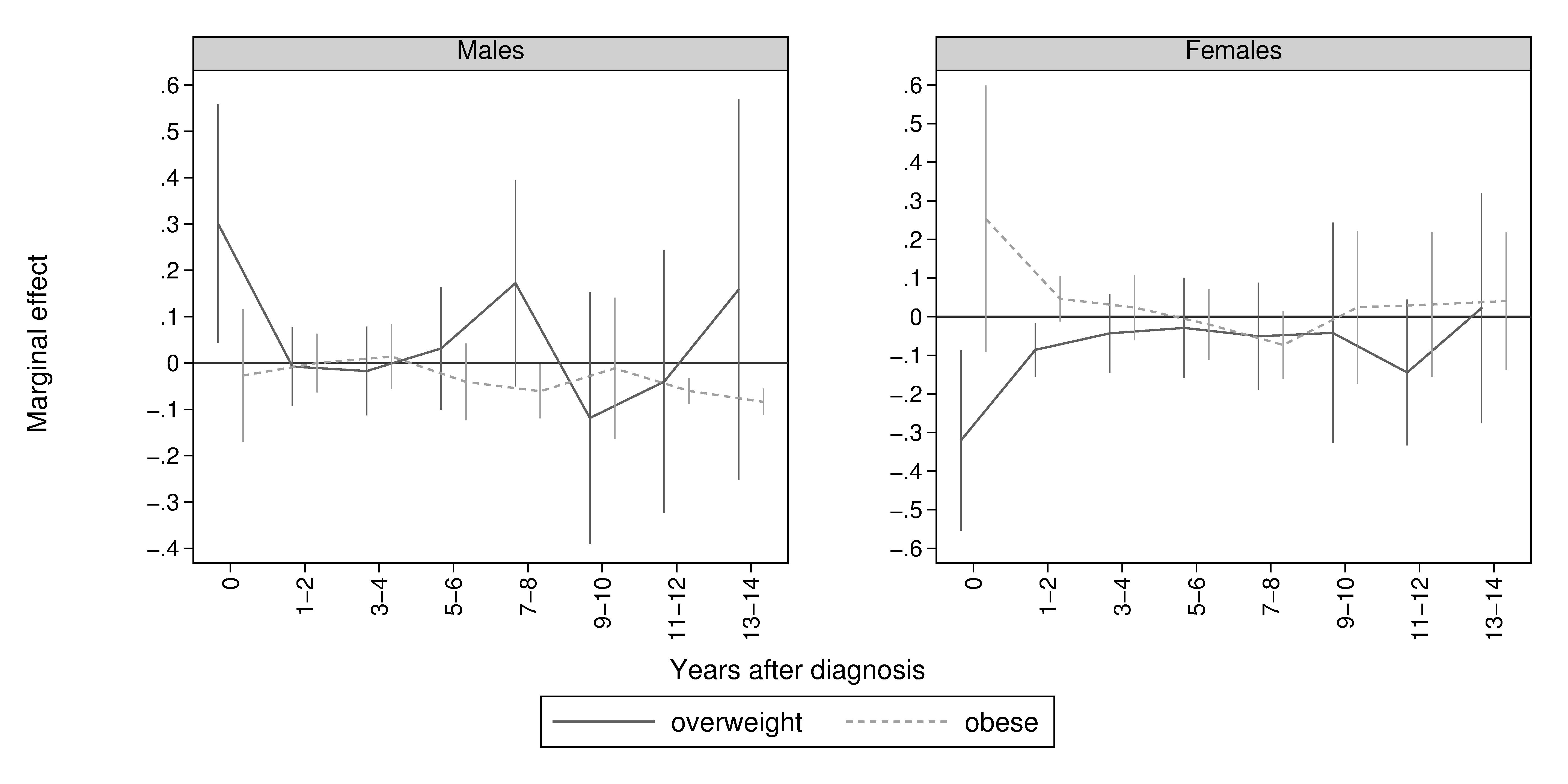
Marginal structural models



Fixed eﬀects



Random eﬀects



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