# The association between lifestyle, socio-economic factors and depression-diabetes co-morbidity

A Project report submitted in partial fulfillment of the requirements for the award of the degree of

***MASTER'S OF TECHNOLOGY***

**in**

***ELECTRONICS AND COMMUNICATION ENGINEERING***

by


**Riya Parikh**

**MIS No: 202216007**


**Semester: I**



**ELECTRONICS AND COMMUNICATION ENGINEERING**

**Indian Institute of Information And Technology Pune**

**Near Bopdev Ghat, Kondhwa Annexe, Yewalewadi, Pune, Maharashtra 411048**


**FEBRUARY 2021**

# BONAFIDE CERTIFICATE

This is to certify that the project report entitled **"The association between lifestyle, socio-economic factors and depression-diabetes co-morbidity"** submitted by **Riya Parikh** bearing the **MIS No: 202216007**, in completion of his project work under the guidance of **Ms. Yesoda Bhargava** is accepted for the project report submission in partial fulfillment of the requirements for the award of the degree of Master of Technology in Electronics and Communication Engineering in the Department of Electronics and Communication Engineering, Indian Institute of Information Technology,Pune, during the academic year 2020-21.

**Ms. Yesoda Bhargava**
Project Guide
Teaching Assistance
Department of CSE
IIIT Pune

**Dr. Nagendra Kushwaha**
Head of the Department
Professor
Department of ECE
IIIT Pune

Project Viva-voce held on 10/02/2021

**Internal Examiner**

**External Examiner**

# ACKNOWLEDGEMENT

This project would not have been possible without the help and cooperation of many. I would like to thank the people who helped me directly and indirectly in the completion of this project work.

First and foremost, I would like to express my gratitude to our beloved director, **Dr.Anupam Shukla**, for providing his kind support in various aspects.

I would like to express my gratitude to my project guide **Ms. Yesoda Bhargava**, Teaching assistance, Department of CSE, for providing excellent guidance, encouragement, inspiration, constant and timely support throughout this M.Tech project.

I would like to express my gratitude to the head of department **Dr. Nagendra Kushwaha**, Professor, Department of ECE, for providing his kind support in various aspects.

I would also like to thank all the faculty members in the Dept. of ECE, the Dept. of CSE and my classmates for their steadfast and strong support and engagement with this project.

# Abstract

**Background:** Diabetes and depression are major contributors to health burden globally. Diabetes and depression are associated with each other, and often coexist. This diabetes and depression co-morbidity (DDC) tends to reduce the quality of life of a diabetic individual and impedes with the clinical treatment. Thus, early identification and diagnosis of DDC is crucial to improve the health outcomes among the diabetic patients.

**Methods:** This work explores the association between of demography, lifestyle factors and social economic position with DDC. Logistic Regression is used to explore this association.

**Results:** Women were found to have higher odds of DDC. Adjusted for other variables, higher BMI, absence of exercise and lower socio-economic position was found to be associated with higher odds of DDC.

**Discussion:** Most research around diabetes and depression co-morbidity focus on lifestyle but our study underscores the importance of considering the socio-economic position for a more holistic understanding of DDC. The insights from the study could potentially help in extending the discussions on disproportionate burden of DDC in the lower socio-economic background population.

***Keywords :*** Diabetes, Depression, Co-morbidity, Socio-economic position, Logistics Regression, Machine Learning,

# TABLE OF CONTENTS

# List of Figures

# List of Tables

# Chapter 1

# Introduction

The global burden of Diabetes is rising rapidly [1]. Diabetes prevalence was projected to reach 366 million by 2030 [2], but by the year 2014 it had already crossed the projection affecting 422 million [3, 4]. Diabetes severely impacts patients' quality of daily life [5] and has a negative effect on their psychological well-being [6]. In fact, the prevalence and risk of depression and depressive symptoms increases significantly with diabetes [7, 8, 9, 6]. On the other hand, diabetes is also a consequence of chronic depression as demonstrated by recent longitudinal studies [3, 10, 11]. Not only this, depression worsens the diabetic patients' health outcomes, such as higher level of A1c hemoglobin is observed in a diabetic individual with depression [7, 12]. [1]. This coexistence of diabetes and depression, is often referred to as the *Diabetes-Depression Comorbidity* (DDC) [13].

DDC is associated with higher risks of physical disability [14], morbidity [9], increased health care costs [8] and mortality [15]. Additionally, it often causes loss of functional role later in life leading to physical limitations, triggers a sense of helplessness and impacts the patient social well-being negatively [6]. Moreover, the presence of both health conditions presents challenges to clinical treatment and demands a more mindful and holistic approach to manage it.

Given the rising burden of DDC and its adverse effects on patients health, it is vital to explore the risk factors associated with it. Such exploration could help in gaining actionable knowledge to mitigate the onset of, and complications associated with DDC. To this end, in this we aim to explore the association between DDC and demographic,

[1] A1c test measures the amount of glucose attached to the hemoglobin in the bloodstream

lifestyle and socio-economic factors to understand how these may explain the variation in the risk of DDC. Rest of the work is organised as following.

Chapter 1 provides a general introduction to the thesis.

Chapter 2 explains motivation behind pursuing the project .

Chapter 3 describers and discusses the research background and synthesizes findings from the past literature.

Chapter 4 explains our proposed methodology.

Chapter 5 discusses results and their interpretation.

Lastly, Chapter 6 presents the conclusion of the research and briefly discusses the future work.

# Chapter 2

# Motivation

Individuals with Diabetes-Depression comorbidity (DDC) often rate their health lower as compared to those with other chronic conditions [3, 16]. Moreover it impairs their quality of life, increases complications and often leads to poor health management. DDC precipitates physical disability, increases morbidity and mortality burden and could cause catastrophic health expenditures [3, 17]. While in the clinical environment, DDC is diagnosed using several tests, in the non-clinical environment, it is important to understand how it may be related to physiological, lifestyle, and socio-economic factors. Such an understanding could potentially help in early identification of DDC or those at higher risk of it, thereby slowing down the deterioration in their quality of life. Moreover, it could also promote investigation of strategies related to treatment, management and prevention of DDC both at population and individual level. Thus, this research work attempts to explore the association between lifestyle, demographic and socio-economic factors and the diabetes-depression comorbidity.

# Chapter 3

# Literature Review

Diabetes and depression are often diagnosed together [7, 6] implying that diabetic individuals may be more prone to depression [9, 3, 18, 19] or depressive people are at a higher risk of diabetes [11, 8]. Many longitudinal studies [9, 14, 15, 20, 19] and systematic reviews [3, 8] suggest a causal relationship between diabetes and depression. Some of which focused on the precedence of depression to the onset of diabetes [18, 19, 15, 14] and vice-versa [11, 14] . Whereas [19, 8] found diabetes to be risk factor to subsequent depression. Nonetheless, the evidence reflects that the co-existence of diabetes and depression, referred to as the diabetes depression comorbidity (DDC) is quite prevalent.

Existing studies have demonstrated the relationship of DDC with age, gender [6, 9, 14, 15, 20, 19, 11, 18] marital status, education attainment [6, 9, 15, 20, 19, 18, 11], ethnicity [20, 18] and BMI [20, 11]. However, the role of socio-economic factors remains unclear and under-explored. Taking account of socio-economic factors in DDC is vital because it is significantly related to patients' health outcomes and comorbidities presence [21, 22]. Marmot [23] has shown that the health of a person is considerably influenced by environment in which he/she grows up and works. Hence, it is crucial to investigate how the socio-economic position (SEP) may be associated with DDC, adjusting for other lifestyle and demographic factors.

Even though few studies have attempted to explore SEP with DDC, the metric used by them to measure/indicate SEP appears to be conceptually weak. For instance, [20] cursorily assessed participants' SEP by measuring the respondents' ability to meet his/her family expenses. However, from the suggestions on SEP measurement provided by sys-

tematic mapping review by Leone, et. al [21], the indicator used by [20] appears weak. It is argued that, SEP indicator of an individual requires knowledge about income, education, employment status, house ownership, and food availability [22, 24, 21].

Taking cue from the existing evidence on adverse impact of DDC on diabetic patients and limited attention to socio-economic position in DDC research, in this work, we attempt to assess the relationship between lifestyle, demographic, SEP factors and DDC

# Chapter 4

# Methodology

## 4.1 Study Design

The work is a cross-sectional data analysis to explore the association between lifestyle, socio- economic factors and diabetes-depression co-morbidity.

## 4.2 Data Source

The study is based on pooled survey data obtained from the Behavioral Risk Factor Surveillance System (BRFSS) [25], CDC, USA. BRFSS is an equal representation and cross sectional survey conducted annually by the Center of Disease Control and Prevention (CDC) , a main component of the United States Department of Health.

The dataset is based on telephonic interviews, over landlines and cellular phones. It is collection of data regarding risk behavior prevalence and preventive health practices that determine the health status [25]. Survey data for four years from 2012 to 2015 were used as these were the years for which the variables, required for the study were available.

## 4.3 Data Cleaning

Cases with valid values for all values were included, rest were removed and filtering for valid values for each variable was done. The Fig 4.1 describes the process of data cleaning and preparation in detail. Respondents aged above 30 years were selected because diabetes prevalence is mostly classified as type 2 Diabetes among them [26]. BMI range was selected as [17.49, 46.06] as beyond this range almost negligible data points remained.

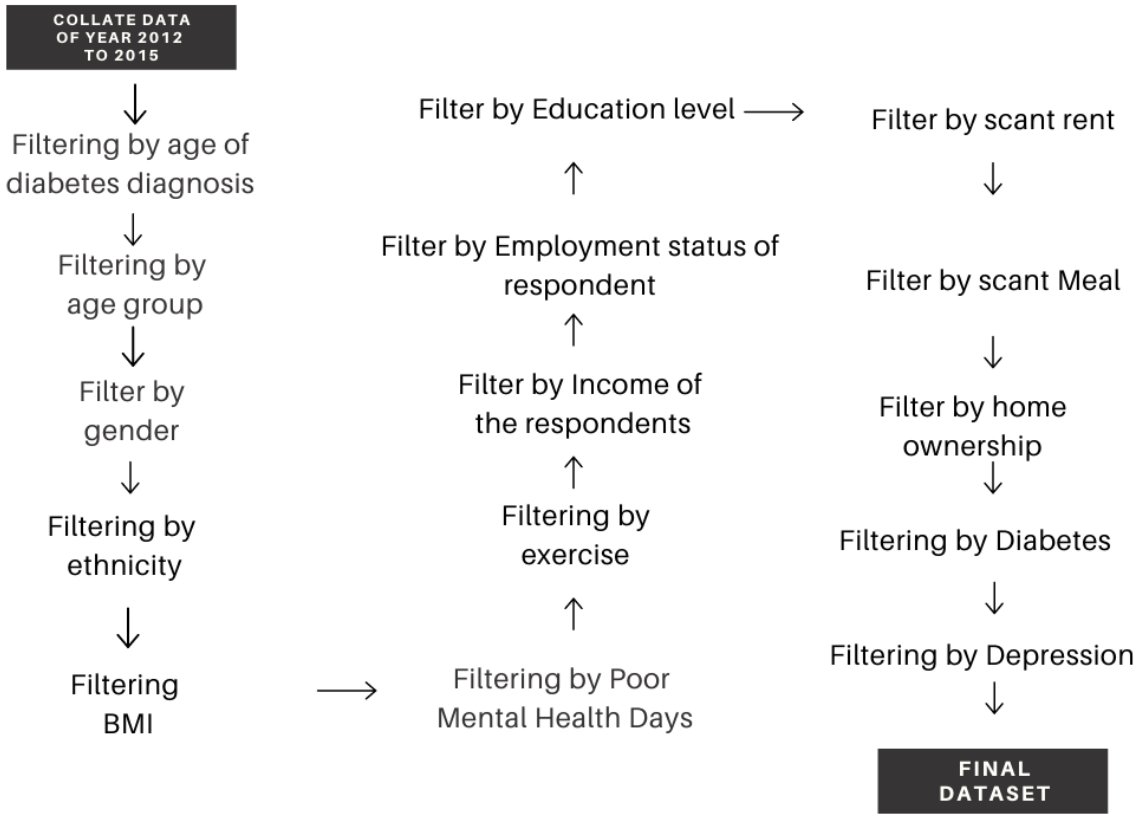


Figure 4.1: The figure explains the process of filtering employed to clean the datasets.

## 4.4 Study Parameters

### 4.4.1 Independent variable

The demographic measures (Age, Gender, ethnicity), the lifestyle measures (BMI, mental health not good, exercise) and Socio-economic position (SEP) measure are chosen as independent variables based on their association with DDC [9, 6, 22, 24]. SEP is included, as it is related to the overall health of a person [22, 27, 28, 24, 29]. It is computed from the variables in the BRFSS code-book as shown in equation (4.1). Variables relating to income [28], education [22], home ownership [30], food affordability [20] and home-rent paying ability [24] were used based on evidence of their relationship with socio-economic background of a person. Our intention was to have an indicator which could be used to categorise the respondents into the lower, middle, and upper socio-economic position categories as explained by Fig 4.2 and Table 4.1. In this a study a higher value of SEP reflects a better socio-economic position. The detailed creation of SEP can be found in the appendix.

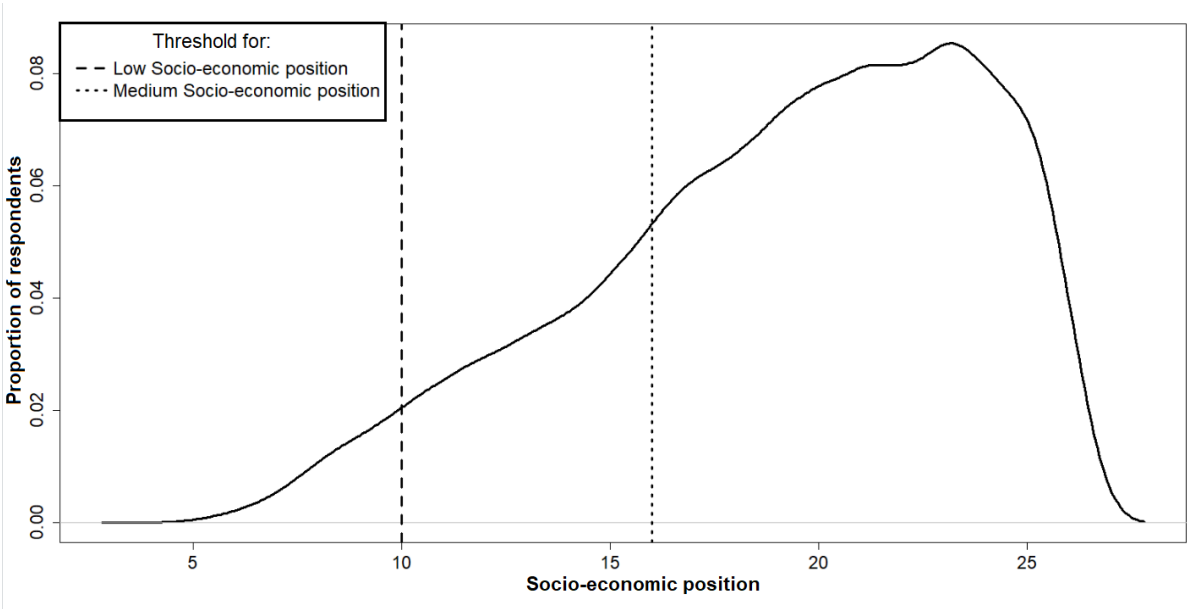


Figure 4.2: The figure represents socio-economic position of respondents in the dataset

$$SEP = INCOME + \frac{1}{HOME\ \ OWNERSHIP} + EDUCATION\ \ LEVEL + SCANT\ \ MEAL + SCANT\ \ RENT + \frac{1}{EMPLOYMENT} \quad (4.1)$$

### 4.4.2 Dependent variables

The variables: Diabetes: (Ever told) you have diabetes, and Depression: *(Ever told) you have a depressive disorder, including depression, major depression, dysthymia, or minor depression* were used to create the DDC variable. DDC was assigned '1' if the respondent had both diabetes and depression and a '0' if the respondent had diabetes but not depressed. Equation (4.2) summarizes this concept.

$$Comorbidity = \{0,\ No\ Depression\ and\ Diabetic;\ 1,\ Depression\ and\ Diabetic\} \quad (4.2)$$

## 4.5 Data Analysis

The outcome variable of DDC is binary (equation 4.2) hence, binomial logistics regression is employed to explore association between the independent measure of SEP, lifestyle and demographic factors to dependent DDC measure. After obtaining the coefficients, odds ratios were computed.

To assess the association of SEP with the outcome variable two models were created: 1) Model I and Model II. Model I takes into account Age, Gender, Ethnicity, Exercise, BMI, socio-economic position and poor mental health as input. Model I is graphically explained by Fig 4.3.

Model II also takes Age, Gender, Ethnicity, Exercise, BMI, SEP and poor mental health as input. But unlike Model I, the SEP is divided into three categories: low, medium and high. The second model is developed to investigate how the three SEP categories may be associated with DDC. The division was made after seeing the distribution of SEP

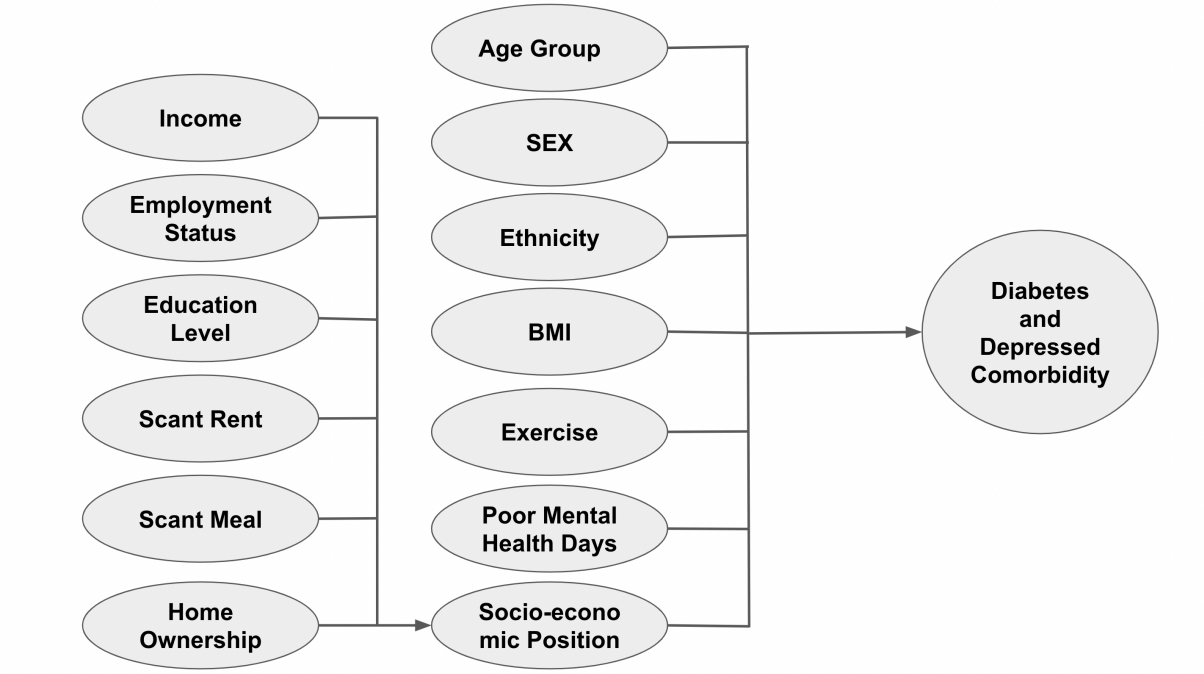


Figure 4.3: The figure represents Model I with independent variables and dependent diabetes depression comorbidity

| Category | Value of SEP |
|---|---|
| Low | Less than 6 |
| Medium | 6 to less than 10 |
| High | 10 or above |

Table 4.1: Table explains the categorization of SEP into three categories: Low, Medium and High

in the dataset and median values represented by Fig.4.2, further mentioned in the Table 4.1. Model II is graphically described in Fig. 4.4

The analysis was done on R studio version 4.0.3.

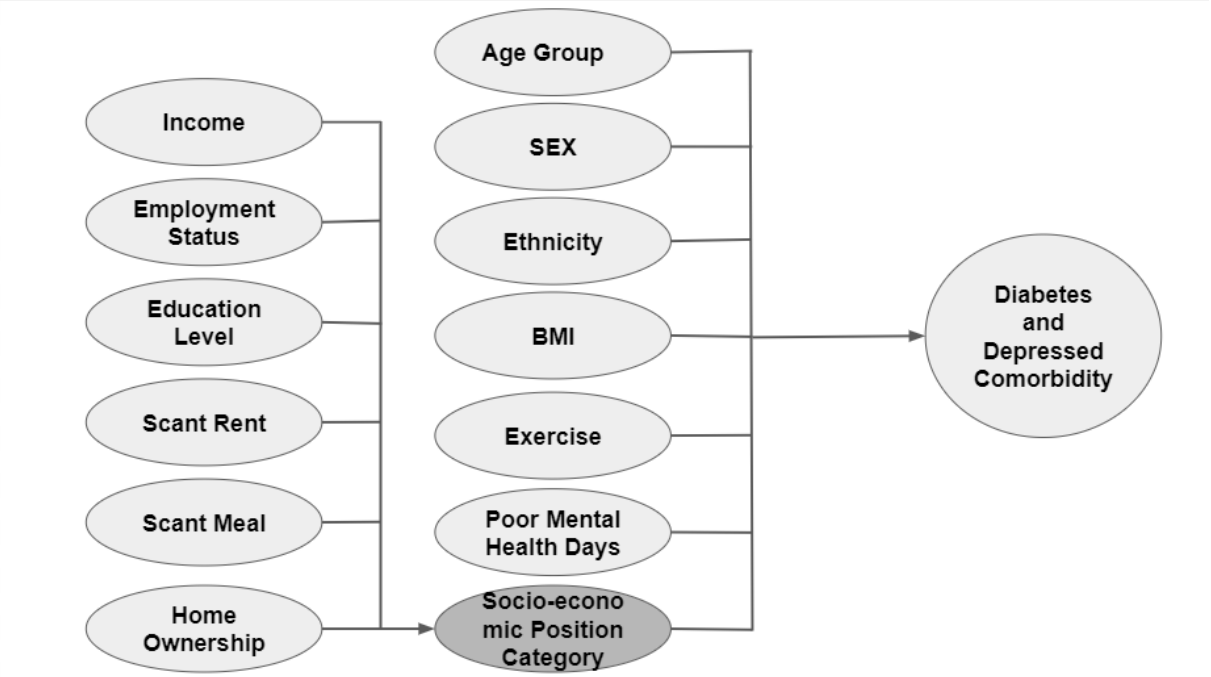


Figure 4.4: The figure represents Model II with independent variables and dependent diabetes depression comorbidity

# Chapter 5

# Results and Discussion

## 5.1 Descriptive Statistics

Total records collected were, N=1,873,580. After cleaning, removing, missing values 15,649 remained. Table 5.1 provides the descriptive summary of variables in the dataset. In the datasets 25.95% (N=4047) were found to have Diabetes-depression co-morbidity (DDC). 19.81%(N=1426) Males and 31.20%(N=2621) female had DDC. Note that DDC prevalence was higher among women than in men (different in proportion: 11.39% , 95% CI (0.88-0.90), p<0.001). The mean age of the respondents was 62.70 [95% CI (62.54-62.87)] years indicating that most respondents were relatively elderly. Mean BMI was 31.03 [95% CI (30.94-31.12)] and median was 30.34 [95% CI (30.34-30.42)] indicating obese respondents on average in the sample. Among those who perform exercise only 22.67% had DDC, while 31.48% among those who reported no exercise [difference in proportion: 8.81%, 95 % CI(0.90-0.93), p<0.001]. This indicates that, sedentary respondents have a higher prevalence of DDC. Also, the mean SEP was 19.11 [95% CI(19.03 to 19.18)]. Also, variation of DDC across different ethnicity was observed: White (27.62%, N=2967), Black (20.38%, N=638), Hispanic (27.36%, N=200), Other race (21.66%, N=146) and multiracial (29.90%, N=96).

## 5.2 Result and Discussion

SEP, Age, BMI, Poor mental health, gender, exercise, ethnicity except multiracial were found to be statistically significant with DDC. The prevalence of DDC tends to decrease with increase in age. For every 5 year increase in age, the odds of DDC decrease by

| Variable | Mean | 95% CI | |
|---|---|---|---|
| Age | 62.700 | 62.530 to 62.870 | |
| BMI | 31.025 | 30.937 to 31.114 | |
| Poor Mental health days | 4.290 | 4.151 to 4.429 | |
| SEP | 19.107 | 19.034 to 19.180 | |
| | Total | N | % |
| Diabetes-depression Comorbidity | 15597 | 4047 | 25.95% |
| Male | 7196 | 1426 | 19.81% |
| Female | 8401 | 2621 | 31.20% |
| White | 10741 | 2967 | 27.62% |
| Black | 3130 | 638 | 20.38% |
| Hispanic | 731 | 200 | 27.36% |
| Other race | 674 | 146 | 21.66% |
| Multiracial | 321 | 96 | 29.90% |
| Exercise | 9800 | 2222 | 22.67% |
| No Exercise | 5797 | 1825 | 31.48% |

Table 5.1: Descriptive summary of the variable in the diabetes-depression comorbidity study.

12.1%[OR 0.86, 95% CI (0.86 to 0.90), $p < 0.001$]. Perhaps with gradual increase in age diabetic patients learn to manage their health condition [31] . Women were found to have 45.6% [OR 1.62, 95% CI(1.42 to 1.68), $p < 0.001$] higher DDC odds as compared to men. It appears that diabetic women are at a higher risk of poor mental health than diabetic men, which could be attributed to higher level of depressive behavior in women in general [32].

Ethnic groups of Black [OR 0.42, 95% CI (0.37 to 0.47), $p < 0.001$), Hispanic [OR 0.63, 95% CI (0.51 to 0.76), $p < 0.001$] and other race [OR 0.54, 95% CI (0.43 to 0.67), $p < 0.001$] and multiracial [OR 0.72, 95% CI (0.54 to 0.95)] are found to be have lower likelihood of DDC. Studies on depression indicate a higher level of prevalence among these ethnic groups [33, 34], but low adherence to treatment and under reporting depressive behaviour due to socio-cultural factors [35]. This could explain lower odds of DDC among

| Variable | Odd ratio | 95% CI | p-value |
|---|---|---|---|
| Age | 0.879 | 0.862 to 0.897 | < 0.001 |
| Gender[1] | | | |
| Female | 1.544 | 1.417 to 1.684 | <0.001 |
| Ethnicity[2] | | | |
| Black | 0.420 | 0.374 to 0.471 | <0.001 |
| Hispanic | 0.626 | 0.513 to 0.760 | <0.001 |
| Other race | 0.538 | 0.430 to 0.669 | <0.001 |
| Multiracial | 0.717 | 0.536 to 0.951 | <0.05 |
| BMI | 1.017 | 1.010 to 1.025 | <0.001 |
| Exercise | 0.889 | 0.816 to 0.969 | <0.05 |
| Poor Mental health | 1.096 | 1.090 to 1.101 | <0.001 |
| SEP | 0.919 | 0.911 to 0.928 | <0.001 |

1 Male is used as reference category
2 White is used as reference category

Table 5.2: Results of Logistic regression for Model I

the Black and Hispanic ethnic groups in the dataset. Presence of exercise was found to be associated with reduced odds of DDC by 11.1% (OR 0.89, 95% CI (0.82 to 0.97), $p < 0.001$). For a unit increase in BMI 1.02%[OR 1.02, 95% CI (1.01 to 1.03), $p < 0.001$] higher odds of DDC was found, but this is marginally significant for the given dataset. This could be indicating a more homogeneous distribution of BMI in the sample. For a unit increase in poor mental health days the DDC odds were found to increase by nearly 9.6% [OR 1.10, 95% CI (1.09 to 1.10), $p < 0.001$].

For every unit increase in SEP the odds of DDC decrease by factor of 8.1% [OR 0.92, 95% CI (0.91 to 0.93), p < 0.001], indicating a gradient association between the two. On categorising into high, medium and low, it was found that respondents in high SEP and medium SEP categories have 62.1% [OR 0.38, 95% CI (0.31 to 0.46), p < 0.001] and 24.7% [OR 0.75, 95% CI (0.61 to 0.92), p << 0.05] reduced odds of DDC respectively as compared to those belonging to low SEP. This indicates that even within a particular SEP category, those having lower SEP have higher odds of DDC as compared to those with higher SEP value.

| Variable | Odd ratio | 95% CI | p-value |
|---|---|---|---|
| Age | 0.888 | 0.870 to 0.906 | <0.001 |
| Gender[1] | | | |
| Female | 1.617 | 1.485 to 1.762 | <0.001 |
| Etnicity[2] | | | |
| Black | 0.436 | 0.388 to 0.489 | <0.001 |
| Hispanic | 0.662 | 0.543 to 0.804 | <0.001 |
| Other race | 0.544 | 0.435 to 0.675 | <0.001 |
| Multiracial | 0.733 | 0.547 to 0.973 | <0.05 |
| BMI | 0.018 | 1.010 to 1.025 | <0.001 |
| Exercise | 0.856 | 0.786 to 0.933 | <0.001 |
| Poor Mental health | 1.099 | 1.094 to 1.104 | <0.001 |
| SEP[3] | | | |
| Medium SEP | 0.753 | 0.613 to 0.924 | <0.05 |
| High SEP | 0.379 | 0.311 to 0.462 | <0.001 |

1 Male is used as reference category
2 White is used as reference category
3 Low SEP is used as reference category

Table 5.3: Results of Logistic regression for Model II

# Chapter 6

# Conclusion and Future Work

To our knowledge, this is the first study which explores the association between of socio-economic factors and diabetes-depression comorbidity, adjusting for lifestyle and demographic factors. Higher socio-economic status was found to be associated with lower odds of diabetes-depression co-morbidity. Women, sedentary respondents, those who reported no exercise, reported poor mental health and had higher BMI were found to have higher odds of Diabetes-depression comorbidity. The findings reinforce the investigation related to socio-economic position of the patients with diabetes-depression comorbidity. Secondly, they point out the need to introduce programs and interventions which consider the socio-economic inequality among diabetic patients. Causal link could not be established between socio-economic position and DDC because the study is cross-sectional data analysis. Longitudinal studies could be more useful in this regard.

# Appendix

## Creation of Soci-economic position variable

The socio-economic position (SEP) of the respondents was created after careful consideration of the variable of BRFSS code book. Each individual variable was studies for it's definition and measure of SEP was created as mentioned in (equation 4.1). The definition of all the variables can be found in table 6.1

Income of the person was quantitative variable, ranging from 1 to 8 with increasing income of respondents. Making higher income [28] values associated to higher SEP. Employment status of the respondents, ranging from 1 to 8, was associated to higher SEP. Thus, quantitative variable of employment status which is showing decreased progression with increase in value, is negatively associated with higher SEP. Individual's highest level of education serves as a determinant factor for socioeconomic conditions [22, 27]. As higher education provides better access to employablement and in turn to the earn better. Education level being quantitative variable with range of 1 to 6, is positively co-related with higher SEP. Housing and accommodation status contribute significantly when it comes to gauge economic status of a household [24]. Thus, variable of home ownership with value of '1' if the respondent owns and '2' if the respondent rents his/her house, is negatively correlated to higher SEP. Also, respondents' ability to pay the rent and affordability of food are partial indicator of SEP [29]. Making quantitative variable of scant meal and scant meal, ranging from 1 to 5 based on decreasing affordability, positively co-related with higher SEP.

Finally, the measure of SEP was created from the past evidence form literature. In the given study, Income, education level, scant meal, scant rent were positively co-related with higher SEP, thus are taken as numerators. And home ownership, employment were negatively co-related with higher SEP, thus are taken as denominators. It is mathematically depicted by equation 4.1.

| Category | Variable | Value |
|---|---|---|
| Demography | Age group | 3=(30,34), 4=(35,39),5=(40,44),6=(45,49), 7=(50,54),8=(55,59), 9=(60,64), 10=(65,69), 11=(70,74), 12=(75,79), 13=80+ |
| | Gender | 1=Male, 2=Female |
| | Ethnicity | 1=White, 2=Black, 3=Hispanic, 4=Other race, 5=Multiracial |
| Lifestyle | BMI | 17.49 to 46.06 |
| | Exercise | 1=yes, 0=No |
| Social and economic status | Education Level | 1=No school, 2=grade 1 to 8, 3=grade 9 to 11 4=grade 12, 5=College 1 to 3 years 6=College 4 years or more |
| | Employment Status | 1=Employed for wages, 2=self-employed, 3=Homemaker, 4=Student, 5=Out of work for $<$ 1 year, 6=Out of work for $>$ 1 year, 7=Retired, 8=Unable to work |
| | Income | 1=(<10,000), 2=(10,000 to 14,999), 3=(15,000 to 19,999), 4=(20,000 to 24,999) 5=(25,000 to 34,999), 6=(35,000 to 49,999) 7=(50,000 to 79,999), 8=(>75,000) |
| | Scant Rent | 1=always, 2=Usually, 3=Sometimes, 4=Rarely, 5=Never |
| | Scant Meal | 1=always, 2=Usually, 3=Sometimes, 4=Rarely, 5=Never |
| | Home ownership | 1=Own, 2=Rent |
| Comorbidity | Diabetes | 1=yes, 3=no |
| | Depression | 1=yes, 2=no |

Table 6.1: Table representing definition of all the variables used in the study

# Bibliography


[1] *Facts & figures*. URL: https://www.idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html (visited on 02/20/2021).

[2] S. Wild et al. "Global Prevalence of Diabetes: Estimates for the year 2000 and projections for 2030". en. In: *Diabetes Care* 27.5 (May 2004), pp. 1047–1053. ISSN: 0149-5992, 1935-5548. DOI: 10.2337/diacare.27.5.1047. URL: http://care.diabetesjournals.org/cgi/doi/10.2337/diacare.27.5.1047 (visited on 02/10/2021).

[3] Batholomew Chireh, Muzi Li, and Carl D'Arcy. "Diabetes increases the risk of depression: A systematic review, meta-analysis and estimates of population attributable fractions based on prospective studies". In: *Preventive Medicine Reports* 14 (Feb. 2019). ISSN: 2211-3355. DOI: 10.1016/j.pmedr.2019.100822. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6378921/ (visited on 12/25/2020).

[4] B Zhou et al. "Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4·4 million participants". en. In: *The Lancet* 387.10027 (Apr. 2016), pp. 1513–1530. ISSN: 0140-6736. DOI: 10.1016/S0140-6736(16)00618-8. URL: http://www.sciencedirect.com/science/article/pii/S0140673616006188 (visited on 02/04/2021).

[5] Jose M. Valderas et al. "Defining Comorbidity: Implications for Understanding Health and Health Services". In: *Annals of Family Medicine* 7.4 (July 2009), pp. 357–363. ISSN: 1544-1709. DOI: 10.1370/afm.983. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2713155/ (visited on 01/18/2021).

[6] M. Isabella Bisschop et al. "The longitudinal relation between chronic diseases and depression in older persons in the community: the Longitudinal Aging Study Amsterdam". en. In: *Journal of Clinical Epidemiology* 57.2 (Feb. 2004), pp. 187–194. ISSN: 0895-4356. DOI: 10.1016/j.jclinepi.2003.01.001. URL: http://www.sciencedirect.com/science/article/pii/S0895435603002932 (visited on 01/07/2021).

[7] Jaclynn Hawkins et al. "Racial/Ethnic Differences in Predictors of Mental Health Treatment in Persons with Comorbid Diabetes and Depression". eng. In: *Social Work in Public Health* 31.6 (Oct. 2016), pp. 511–519. ISSN: 1937-190X. DOI: 10.1080/19371918.2016.1160333.

[8] S. Ali et al. "The prevalence of co-morbid depression in adults with Type 2 diabetes: a systematic review and meta-analysis". eng. In: *Diabetic Medicine: A Journal of the British Diabetic Association* 23.11 (Nov. 2006), pp. 1165–1173. ISSN: 0742-3071. DOI: 10.1111/j.1464-5491.2006.01943.x.

[9] S. Aarts et al. "Diabetes mellitus type II as a risk factor for depression: a lower than expected risk in a general practice setting". In: *European Journal of Epidemiology* 24.10 (Oct. 2009), pp. 641–648. ISSN: 0393-2990. DOI: 10.1007/s10654-009-9385-0. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2762524/ (visited on 01/25/2021).

[10] R. J. Anderson et al. "The prevalence of comorbid depression in adults with diabetes: a meta-analysis". eng. In: *Diabetes Care* 24.6 (June 2001), pp. 1069–1078. ISSN: 0149-5992. DOI: 10.2337/diacare.24.6.1069.

[11] Anne Engum. "The role of depression and anxiety in onset of diabetes in a large population-based study". eng. In: *Journal of Psychosomatic Research* 62.1 (Jan. 2007), pp. 31–38. ISSN: 0022-3999. DOI: 10.1016/j.jpsychores.2006.07.009.

[12] Leonard E. Egede and Clara E. Dismuke. "Serious psychological distress and diabetes: a review of the literature". eng. In: *Current Psychiatry Reports* 14.1 (Feb. 2012), pp. 15–22. ISSN: 1535-1645. DOI: 10.1007/s11920-011-0240-0.

[13] Line Iden Berge and Trond Riise. "Comorbidity between Type 2 Diabetes and Depression in the Adult Population: Directions of the Association and Its Possible Pathophysiological Mechanisms". In: *International Journal of Endocrinology* 2015 (2015). ISSN: 1687-8337. DOI: 10.1155/2015/164760. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4589629/ (visited on 04/12/2021).

[14] Pei-Chun Chen et al. "Population-Based Cohort Analyses of the Bidirectional Relationship Between Type 2 Diabetes and Depression". en. In: *Diabetes Care* 36.2 (Feb. 2013). Publisher: American Diabetes Association Section: Original Research, pp. 376–382. ISSN: 0149-5992, 1935-5548. DOI: 10.2337/dc12-0473. URL: https://care.diabetesjournals.org/content/36/2/376 (visited on 02/07/2021).

[15] P. de Jonge et al. "Prevalent and incident depression in community-dwelling elderly persons with diabetes mellitus: results from the ZARADEMP project". en. In: *Diabetologia* 49.11 (Nov. 2006), pp. 2627–2633. ISSN: 1432-0428. DOI: 10.1007/s00125-006-0442-x. URL: https://doi.org/10.1007/s00125-006-0442-x (visited on 02/25/2021).

[16] S. Moussavi et al. "Depression, chronic diseases, and decrements in health: results from the World Health Surveys". In: *The Lancet* (2007). DOI: 10.1016/S0140-6736(07)61415-9.

[17] Till Seuring, Olga Archangelidi, and Marc Suhrcke. "The Economic Costs of Type 2 Diabetes: A Global Systematic Review". eng. In: *PharmacoEconomics* 33.8 (Aug. 2015), pp. 811–831. ISSN: 1179-2027. DOI: 10.1007/s40273-015-0268-9.

[18] Daniel Polsky et al. "Long-term risk for depressive symptoms after a medical diagnosis". eng. In: *Archives of Internal Medicine* 165.11 (June 2005), pp. 1260–1266. ISSN: 0003-9926. DOI: 10.1001/archinte.165.11.1260.

[19] Maria E. Garcia et al. "Diabetes Mellitus as a Risk Factor for Development of Depressive Symptoms in a Population-Based Cohort of Older Mexican Americans". en. In: *Journal of the American Geriatrics Society* 64.3 (2016). _eprint: https://agsjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/jgs.14019, pp. 619–624. ISSN: 1532-5415. DOI: https://doi.org/10.1111/jgs.14019. URL: https://agsjournals.onlinelibrary.wiley.com/doi/abs/10.1111/jgs.14019 (visited on 02/25/2021).

[20] Octaviana Hemmy Asamsama et al. "Bidirectional longitudinal study of type 2 diabetes and depression symptoms in black and white church going adults". In: *Journal of Diabetes and Metabolic Disorders* 14 (Apr. 2015). ISSN: 2251-6581. DOI: 10.1186/s40200-015-0150-5. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4404000/ (visited on 01/07/2021).

[21] Tiziana Leone et al. "Diabetes and depression comorbidity and socio-economic status in low and middle income countries (LMICs): a mapping of the evidence". In: *Globalization and Health* 8.1 (Nov. 2012), p. 39. ISSN: 1744-8603. DOI: 10.1186/1744-8603-8-39. URL: https://doi.org/10.1186/1744-8603-8-39 (visited on 02/26/2021).

[22] Alexander Darin-Mattsson, Stefan Fors, and Ingemar Kåreholt. "Different indicators of socioeconomic status and their relative importance as determinants of health in old age". In: *International Journal for Equity in Health* 16.1 (Sept. 2017), p. 173. ISSN: 1475-9276. DOI: 10.1186/s12939-017-0670-3. URL: https://doi.org/10.1186/s12939-017-0670-3 (visited on 01/26/2021).

[23] Michael Marmot and Jessica J. Allen. "Social Determinants of Health Equity". In: *American Journal of Public Health* 104.Suppl 4 (Sept. 2014), S517–S519. ISSN: 0090-0036. DOI: 10.2105/AJPH.2014.302200. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4151898/ (visited on 02/22/2021).

[24] Sediqe Shafiei et al. "Measurement components of socioeconomic status in health-related studies in Iran". In: *BMC Research Notes* 12 (Jan. 2019). ISSN: 1756-0500. DOI: 10.1186/s13104-019-4101-y. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6357485/ (visited on 01/27/2021).

[25] *CDC - 2019 BRFSS Survey Data and Documentation*. en-us. Aug. 2020. URL: https://www.cdc.gov/brfss/annual_data/annual_2019.html (visited on 01/19/2021).

[26] Ozougwu et al. "The pathogenesis and pathophysiology of type 1 and type 2 diabetes mellitus". english, English. In: *Journal of Physiology and Pathophysiology* 4.4 (Sept. 2013). Publisher: Academic Journals, pp. 46–57. ISSN: 2141-260X. DOI: 10.5897/JPAP2013.0001. URL: https://academicjournals.org/journal/JPAP/article-abstract/974E7B515872 (visited on 04/05/2021).

[27] *Education, Social Status, and Health*. en. Routledge, Sept. 2017. ISBN: 978-1-351-32808-1. DOI: 10.4324/9781351328081. URL: https://www.taylorfrancis.com/books/education-social-status-health-john-mirowsky-catherine-ross/10.4324/9781351328081 (visited on 01/26/2021).

[28] Mary C. Daly et al. "Optimal indicators of socioeconomic status for health research". eng. In: *American Journal of Public Health* 92.7 (July 2002), pp. 1151–1157. ISSN: 0090-0036. DOI: 10.2105/ajph.92.7.1151.

[29] Nobuko Murayama. "Effects of Socioeconomic Status on Nutrition in Asia and Future Nutrition Policy Studies". eng. In: *Journal of Nutritional Science and Vitaminology* 61 Suppl (2015), S66–68. ISSN: 1881-7742. DOI: 10.3177/jnsv.61.S66.

[30] Reginald A Noël. "Race, Economics, And Social Status". en. In: (), p. 12.

[31] Kara Zivin et al. "Trends in Depressive Symptom Burden Among Older Adults in the United States from 1998 to 2008". In: *Journal of General Internal Medicine* 28.12 (Dec. 2013), pp. 1611–1619. ISSN: 0884-8734. DOI: 10.1007/s11606-013-2533-y. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3832736/.

[32] Paul R. Albert. "Why is depression more prevalent in women?" In: *Journal of Psychiatry & Neuroscience : JPN* 40.4 (July 2015), pp. 219–221. ISSN: 1180-4882. DOI: 10.1503/jpn.150205. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478054/.

[33] Dorothy D. Dunlop et al. "Racial/Ethnic Differences in Rates of Depression Among Preretirement Adults". In: *American Journal of Public Health* 93.11 (Nov. 2003), pp. 1945–1952. ISSN: 0090-0036. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1199525/ (visited on 03/23/2021).

[34] David R. Williams et al. "Prevalence and Distribution of Major Depressive Disorder in African Americans, Caribbean Blacks, and Non-Hispanic Whites: Results From the National Survey of American Life". en. In: *Archives of General Psychiatry* 64.3 (Mar. 2007), p. 305. ISSN: 0003-990X. DOI: 10.1001/archpsyc.64.3.305. URL: http://archpsyc.jamanetwork.com/article.aspx?doi=10.1001/archpsyc.64.3.305 (visited on 03/23/2021).

[35] Rahn Kennedy Bailey, Josephine Mokonogho, and Alok Kumar. "Racial and ethnic differences in depression: current perspectives". In: *Neuropsychiatric Disease and Treatment* 15 (Feb. 2019), pp. 603–609. ISSN: 1176-6328. DOI: 10.2147/NDT.S128584. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6390869/ (visited on 02/11/2021).