The relationship between socio-economic factors and type 2 diabetes prevalence among older adults in Ireland during 2009 & 2015 – data from The Irish Longitudinal Data on Ageing (TILDA)

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ACRONYMS USED

AIHW	Australian Institute of Health and Welfare
ADA	American Diabetes Association
AOR	Adjusted Odds Ratio
BMI	Body Mass Index
CBS	Centraal Bureau voor de Statistiek
CI	Confidence Interval
CSO	Central Statistics Office
GDP	Gross Domestic Product
GNI	Gross National Income
IDDM	Insulin Dependent Diabetes Mellitus
IDF	International Diabetes Federation
IFG	Impaired Glucose Fasting
ISSDA	Irish Social Science Data Archive
IPH	Institute of Public Health
NIDDM	Non-Insulin Dependent Diabetes Mellitus
NSEP	Neighbourhood Socioeconomic Position
OR	Odds Ratio
SEP	Socioeconomic Position
SES	Socioeconomic status
TILDA	The Irish Longitudinal Data on Ageing
T2DM	Type 2 Diabetes Mellitus
WHO	World Health Organization

ABSTRACT

Objective: This study investigated the concurrent inconclusive associations between socio-economic indicators and Type 2 diabetes among adults 50 years and above using two population-based cohort surveys conducted in the Republic of Ireland in 2009 and 2015 by the Irish Longitudinal Data on Ageing (TILDA).

Design: Nationwide, population based, cross sectional survey

Setting: The Irish Longitudinal Data on Ageing, 2009 (Wave 1) and 2015 (Wave 3).

Participants: Adults aged 50 years and older living within the population in Ireland; 8,504 individuals in 2009 cohort and 6,400 individuals in the 2015 cohort.

Main outcome measures: The prevalence of T2DM between 2009 and 2015, and the effect of age, gender, socioeconomic indicators and behavioural/ biological variables on T2DM prevalence. Changes in patterns between 2009 and 2015 were also examined.

Results: There was an increase in the prevalence of T2DM between 2009 (7%) and 2015 (16.3%). In 2009, there was an inverse relationship between socio-demographic characteristics and the prevalence of T2DM with a corresponding association of most behavioural/biological factors. In 2015, there was no relationship between the socio-demographic characteristics, except employment status (a direct relationship was found), and no association observed of behavioural and biological factors to T2DM prevalence.

Conclusion: There was an inverse relationship between socioeconomic indicators and T2DM observed in Ireland, consistent with most other European and high-income countries due to unhealthy behaviours being more common amongst lower SES groups and high SES groups being more receptive of preventive advice.

CHAPTER 1: INTRODUCTION

1.1 **Diabetes Mellitus background**

Diabetes mellitus is a global public health problem that affects all nations, particularly the developing countries impacting the lives of the affected and creating a burden on personal and national economies – the global economic burden of diabetes in adults was roughly 1.31 trillion USD in 2015 (Xu et al., 2018). Diabetes is a disease that results from a lack, or an insufficiency of the insulin hormone which is produced by the pancreas for transmission of glucose from the blood stream into cells for breakdown and energy supplementation (Diabetes Ireland, 2019). The deficiency of insulin in diabetic patients results in an accumulation of glucose in their blood stream, therefore causing high blood sugar and increasing the likelihood of the development of related diseases such as diabetic retinopathy, cancer and cardiovascular diseases (Diabetes Ireland, 2019).

There are different types of diabetes mellitus: type 1 diabetes also known as Insulin Dependent Diabetes Mellitus (IDDM) which occurs in childhood or early adolescence. Type 1 diabetes (T1D) is auto immune and results from cells attacking the insulin producing beta cells. This condition is not preventable. The second and most common type of diabetes is the type 2 diabetes mellitus (T2DM) otherwise known as the Non-Insulin Dependent Diabetes Mellitus (NIDDM). This type of diabetes is progressive and develops in adults over 40 years of age. Type 2 can be prevented through healthier lifestyle choices such as good diet and exercise. Like type 1, type 2 is treated using medicines and/or insulin injections (Diabetes Ireland, 2019a). Unlike type 1, type 2 diabetes is associated with excessive body weight and lifestyle choice (Diabetes UK, 2019).

1.2. **Known factors linked to the development of Type 2 diabetes and sociological postulates**

The development of T2DM is known to be linked to lifestyle factors – it is a progressive condition that results from prior exposures to certain modifiable and non-modifiable risk factors during earlier stages in life that eventually lead to insufficiency of insulin. Some of the modifiable risk factors linked to the development of T2DM include alcohol consumption, smoking habits, high carbohydrate / imbalanced diets, ethnicity, low birth weight or overweight at birth, obesity and physical inactivity. Results from various studies show that with an increase in the occurrence of obesity, there is an increase in the occurrence of T2DM (Boles, Kandimalla and Reddy, 2017). Hence, physical activity is recommended for glycemic control, improvement of cardiovascular health and prevention of diabetes-related complications (Melmer, Kempf and Laimer, 2018).

Sociology literatures contain the “critical period life course model with later effect modifiers” which suggests that later life factors modify the effect of an early exposure and may enhance or diminish the effects of the exposure. For example, low socioeconomic status can result in low education, poor diet and increased exposure to passive smoking among other risk factors which could result in diabetes and other diseases. A survey in Ireland conducted in year 2000 had shown that low socioeconomic status often results in higher smoking levels and lower cessation rates. (Layte and Whelan, 2008). The results of a study performed among the elderly population in Yantai City showed that age, smoking, drinking habits, monthly income, cultural standard and past job category are all influencing factors for the development of T2DM (Mi et al., 2016). Many studies support these findings by reporting that socioeconomic status (SES) is linked to T2DM development through influencing exposures to the factors and a lifestyle that increases the likelihood of T2DM development.

However, the results of studies investigating the link between T2DM and SES have been inconsistent across and within different countries. In some countries, it was discovered that the relationship between SES and T2DM changes over time - this will be discussed further in literature review (Chapter 3).

1.3. **The Irish economy and the prevalence of T2DM**

In May 2018, an article in the Irish Times reported that every month, 1,000 new people are diagnosed with T2DM in Ireland. According to their reports, 1 in 15 people in Ireland are living with diabetes – 10% of which have T1D (Harris, 2018).

The Republic of Ireland is a high-income country and presented a T2DM prevalence rate of 3.2% in year 2000, which grew to 6.5% by 2013 (International Diabetes Foundation, 2013). Healthy Ireland stated that currently, 854,165 adults over 40 years in Ireland have been diagnosed with T2DM while a study using The Irish Longitudinal study on Ageing (TILDA) revealed that more than 15,600 adults 80 years and older living in Ireland have T2DM and reported a prevalence rate of 11.9% in adults over 75 years (Diabetes Ireland, 2019b). This trend presents an economic burden on the healthcare budget in Ireland – 10% of the national health budget is being invested in the treatment of diabetes (Diabetes Ireland, 2019b).

In 2008, the Republic of Ireland experienced severe economic recession and entered an economic depression by 2009; during this period the unemployment rates increased to 16% and property prices fell by 60%. Ireland has undergone rapid economic growth since 2010 when the GDP rose from 167.1 billion euros in 2010 to 255.8 billion euros by 2015; making its economy, one of the fastest growing in the European union (Central Statistics Office, 2018).The GDP growth rates went from -0.0% in 2011 to 26.3% by 2015 while the gross national income (GNI) improved from -4.0% in 2011 to 18.7% (Central Statistics Office, 2018).

1.4. **The link between socio-economic status and diabetes**

The increasing occurrence trend of T2DM makes it important to explore the determinants of the disease beyond the traditional risk factors such as sedentary lifestyle – socioeconomic status is one of these determinants.

SES refers to the social position of a person relative to other member of their society. In social epidemiology and health economics literatures, SES is measured based on three main indicators: income, education and occupation. However, smoking, body mass index (BMI), access to health care services, ethnicity, insurance coverage, living area, physical activity and social capital are variables considered when observing SES (Kunst, Bos and Mackenbach, 2001).

As a result of the inconsistencies in the description of the relationship between SES and T2DM within countries and the lack of research in this area for Ireland, this study was performed to address the gap in research for Ireland. The aim of this research was to define the relationship between individual SES and T2DM in Ireland among the adult population and investigate the longitudinal relationship between 2009 and 2015; considering the change in the nation's economy from depressed to stable.

1.5. **Methodology overview**

This research was based on a secondary data set obtained from the Irish Longitudinal Study on Ageing (TILDA). The dataset contained the information of adults aged 50 years and older in Ireland derived using a structured questionnaire. This study observed two waves of the TILDA dataset (Waves 1 and 3) and is categorised as a cross-sectional study within a longitudinal cohort. We explored the link between the socio-economic indicators (household income, highest education achieved and employment status) and the development of T2DM at an individual level. A descriptive analysis was performed for each wave of the TILDA population in terms of the relevant factors being observed. Comparisons of subcategories within each wave was then performed using Chi-square test. Multivariable logistic regression was used to calculate odds ratios and confidence intervals of variables that showed a relationship from the Chi-square analysis. The methodology is described in detail in Chapter 4.

1.6. **Results overview**

This study found an increase in T2DM prevalence between 2009 and 2015. Observing socio-demographic, behavioural and biological variables across both waves, there was an overall inverse relationship observed between SES and T2DM prevalence in 2009 and a corresponding association with biological factors. This overall relationship was not present in the 2015 cohort, neither was there an association between biological or behavioural factors and T2DM prevalence. Employment status was found to have a direct relationship with T2DM in 2015. The results are presented in detail in Chapter 5 and are thoroughly discussed in Chapter 6.

CHAPTER 2: BACKGROUND AND CONTEXT

2.1. Burden of type 2 diabetes

Global reports show that approximately 1 in 11 adults have diabetes (estimated 415 million people); out of which 90% have type 2 diabetes mellitus (T2DM) making it the most common form of diabetes (Diabetes UK, 2019). The International Diabetes Federation (IDF) stated that nearly 87 – 91% of diabetics in high income countries have type 2 diabetes, 7 – 12% have type 1 diabetes, while 1 – 3 % have other subtypes of diabetes (Xu et al., 2018). Diabetes and its related diseases result in a decrease in the quality of life of those affected.

In 2016, the World Health Organization (WHO) released a list of the top 10 global causes of death as displayed in figure 1 – diabetes mellitus ranked seventh accounting for approximately 2 million deaths around the world in 2016 (WHO, 2018).

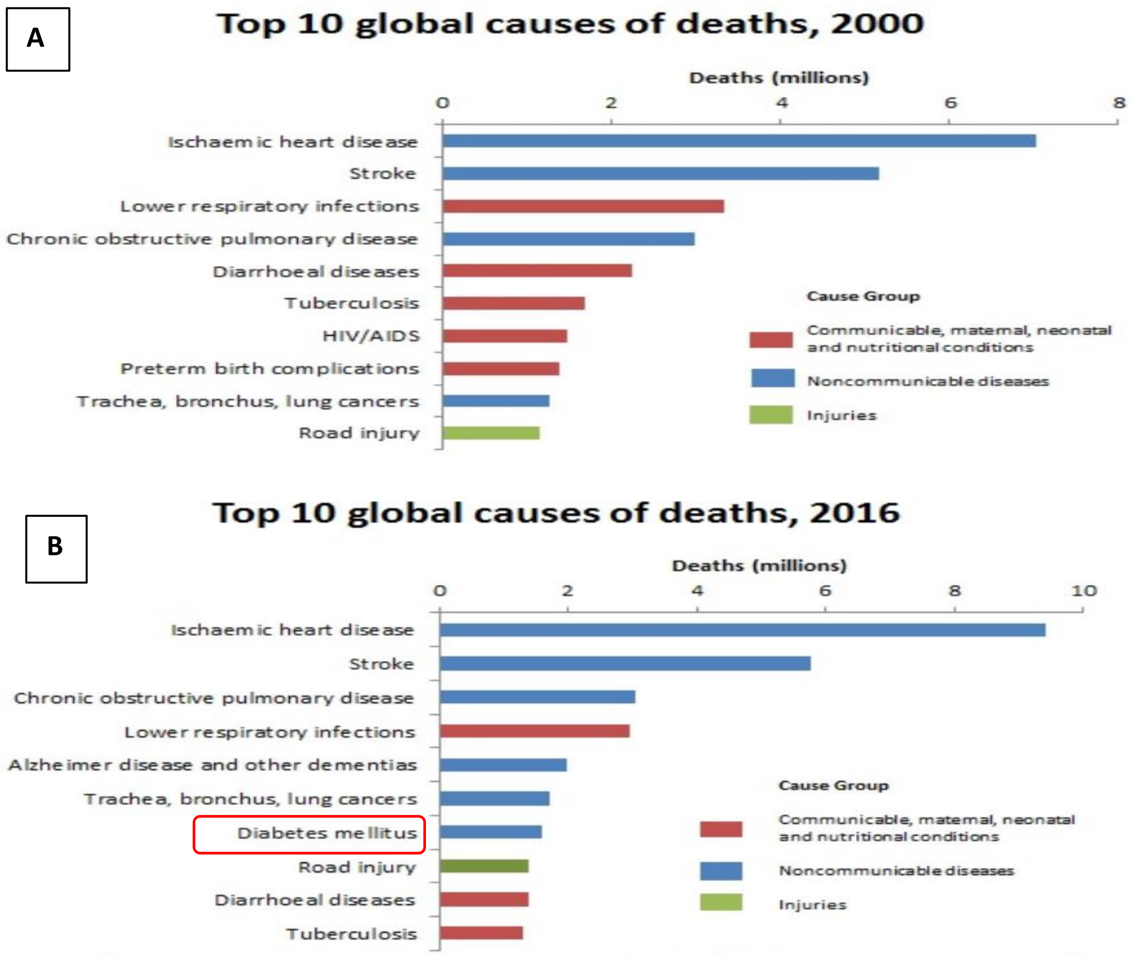


Figure 1. *The top global causes of deaths in **A**) 2000 and **B**) 2016 [Adapted from: WHO, 2018].*

As shown in Figure 1, comparing the list of the 10 leading global causes of death released in year 2000 to that of year 2016, diabetes was not considered to be as much a burden in 2000;

indicating that between 2000 and 2016, there has been an increase in the occurrence of diabetes and its impact as a health problem became significant.

In the global report on diabetes, WHO reported that the age-standardized global prevalence of diabetes has nearly doubled since 1980 – rising from 4.7% to 8.5% among the adult population (WHO, 2016). The increasing occurrence trend (incidence and/ or prevalence) of diabetes over the years has been seen to exist at a national level as well as reported by various countries, shown in Figure 2.

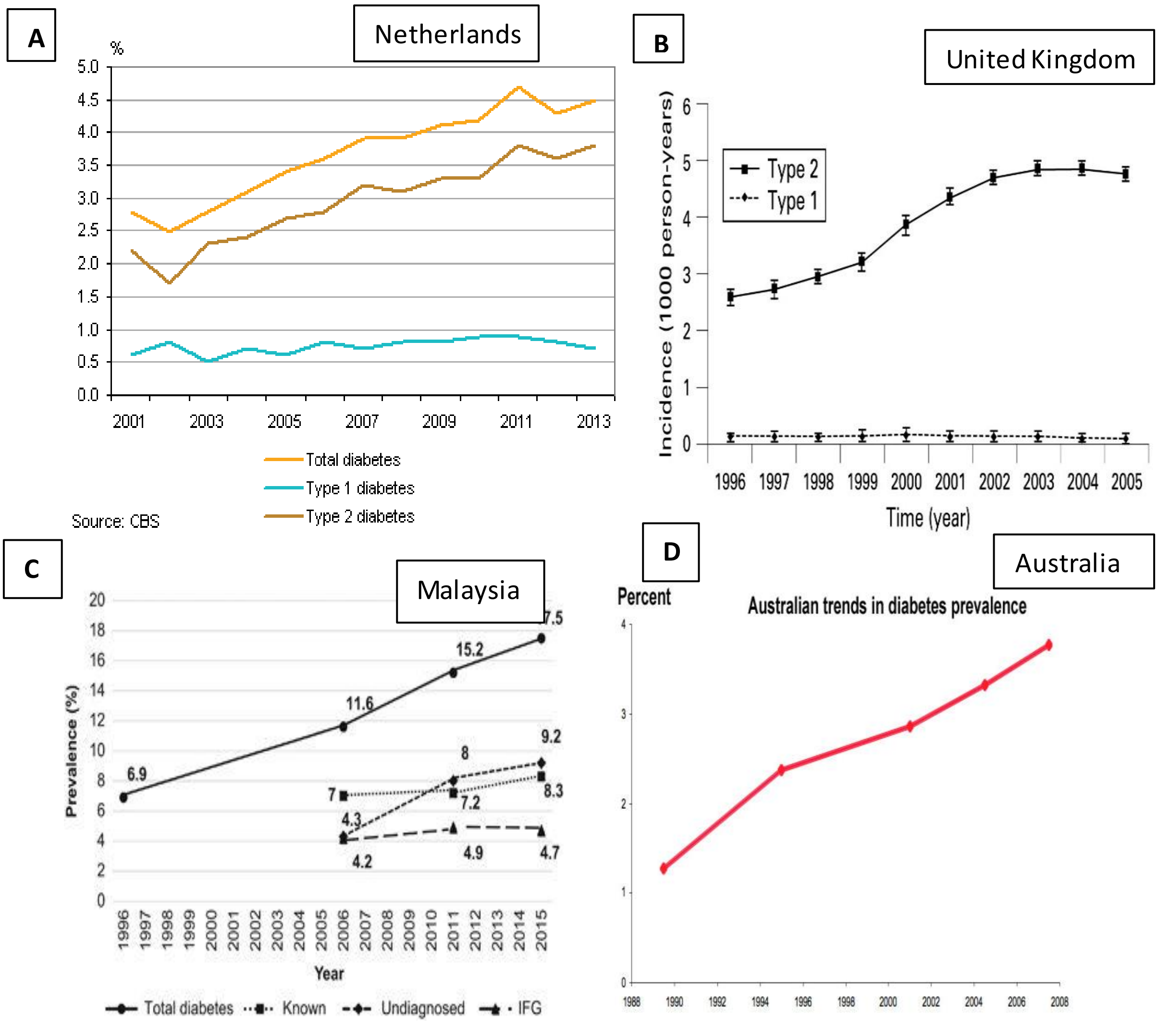


***Figure 2**. **A**) The prevalence of diabetes in Netherlands between 2001 and 2013 expressed in percentage [Adapted from: Centraal Bureau Voor De Statistiek, 2014]. **B**) Age and sex standardized incidence trend of diabetes (1000 person- year) between 1996 and 2005 in the United Kingdom [Adapted from: Masso Gonzalez, Johansson, Wallander and Garcia Rodriguez, 2009]. **C**) The prevalence trend of diabetes (total: known and undiagnosed, undiagnosed, known and impaired glucose fasting) in Malaysia between 1996 and 2015 [Adapted from: Tee and Wap, 2017]. **D**) The age-standardized prevalence trend of T2DM in Australia between 1990 and 2008 expressed in percentage [Adapted from: Australian Institute of Health and Welfare, 2010].*

As displayed in figure 2A, 2.8% of the population in Netherland was diagnosed with diabetes and this value increased to 4.5% by 2013 – T2DM (3.8 percent) was five times more common than T1D (0.7 percent) (CBS, 2014). Likewise, in figure 2B, 2C and 2D there was an increasing trend of diabetes occurrence in the UK, Australia and Malaysia.

As a progressive disease, T2DM manifests in adulthood which is why age is considered as a risk factor. The occurrence rates become increasing prevalent among adults from 50 years and older as shown in figure 3.

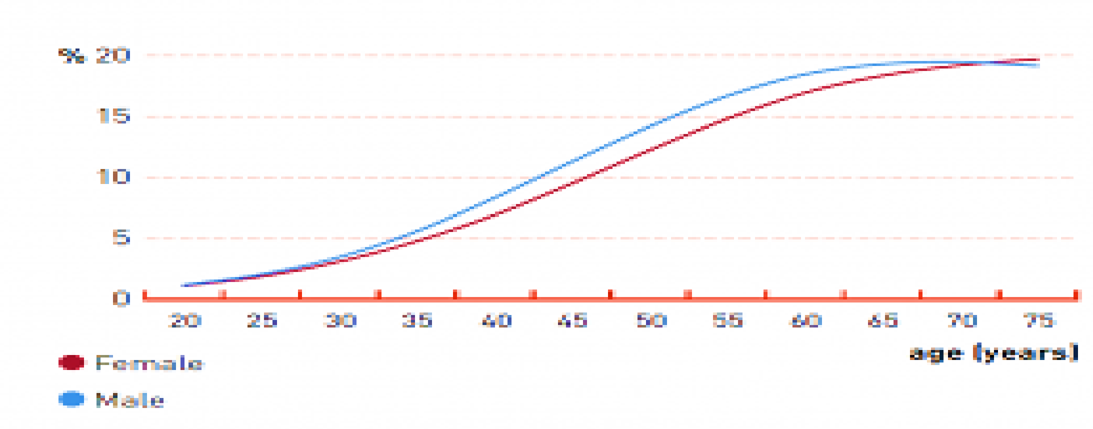


Figure 3. *The global prevalence rate of diabetes among different ages and gender in 2013 [Adapted from: IDF Diabetes Atlas, 2013].*

2.2. <u>Sociological ideologies relating to socio-economy and T2DM</u>

There are different theories in sociology describing the underlying reasons for the development of type 2 diabetes in adulthood as shown in figure 3. The "Barker" hypothesis states that the environment programmes an individual's system during utero development producing long term consequences in adulthood (Hendrina and Harding, 2006). This hypothesis is supported by the findings in Eriksson et al., (2003) who found that small birth size and high body mass index (BMI) and adiposity rebound in later life is associated the development of T2DM. Many studies support these findings and show that birth size is linked to diabetes in later life due to foetal programming by nutritional stimuli or elevated foetal glucocorticoid exposure differing from the exposure in post-natal life (Stein et al., 1996).

In addition, a study using the Leningrad siege population showed that people exposed to starvation during utero development and those exposed during infancy showed no difference in glucose tolerance, insulin concentration, lipid concentration or coagulation factors – the findings therefore suggest the development of T2DM is also linked to post-delivery exposure (Stanner and Yudkin, 2001). The second hypothesis states that disease outcomes in later life are influenced by complex non-linear processes and exposures at different stages in life that can accumulate and result in long term diseases (Halfon et al., 2014). The third hypothesis states that long term outcomes result from a trajectory; and an exposure sets an individual on a specific pathway, but only adult experiences are related to health outcomes (Kuh et al., 2003).

2.3. Diabetes and national economy

Research was performed to investigate the global prevalence trends for diabetes in countries according to age and the world income groups as shown in Figure 4 based on data from IDF Diabetes Atlas. The research was to establish the trend between type 2 diabetes occurrence and economy among age groups.

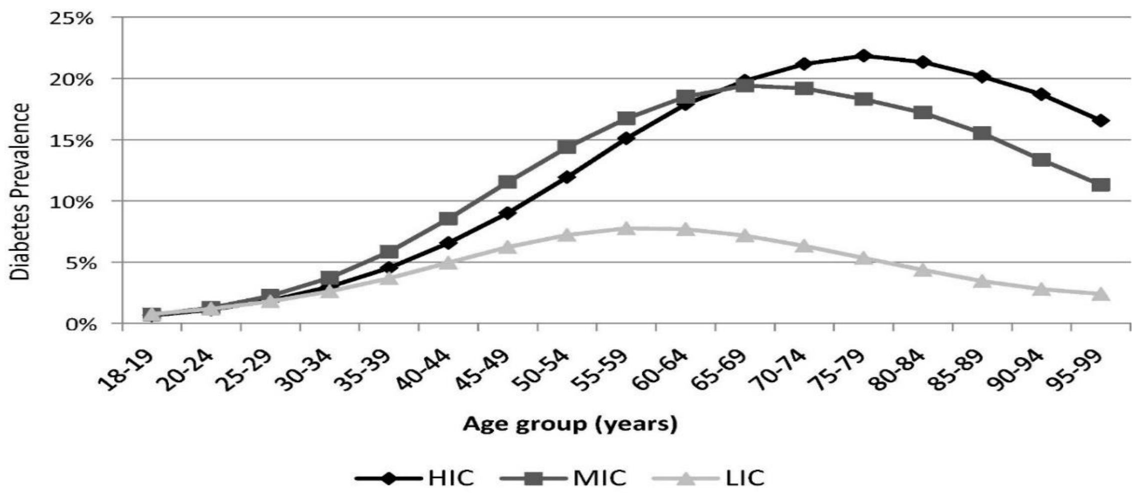
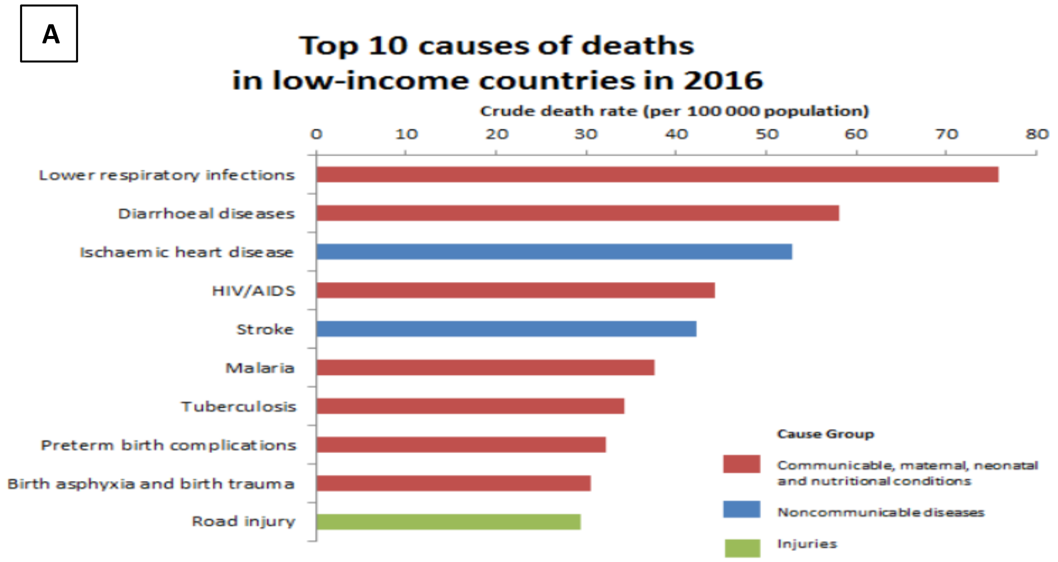
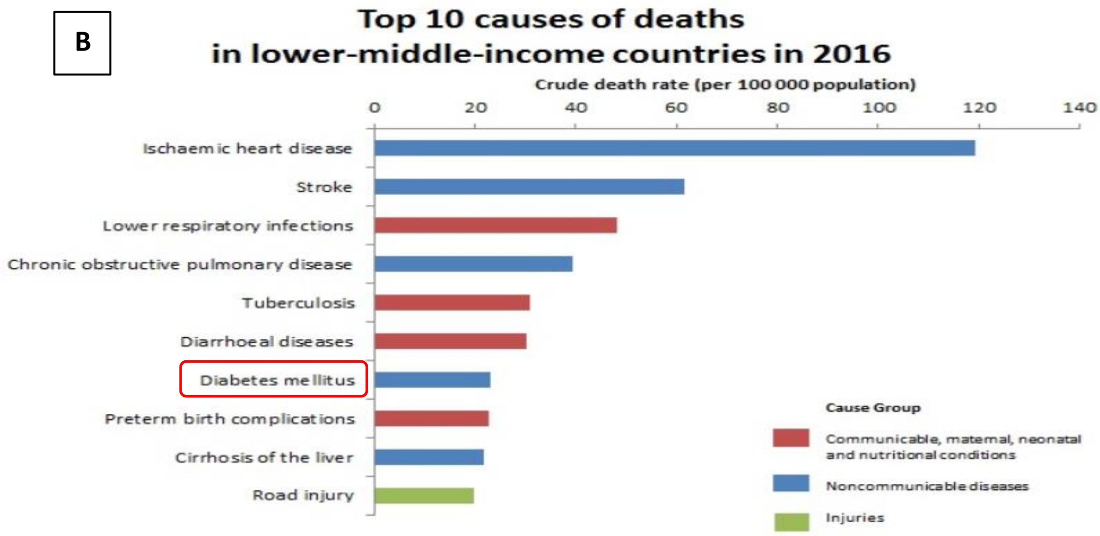


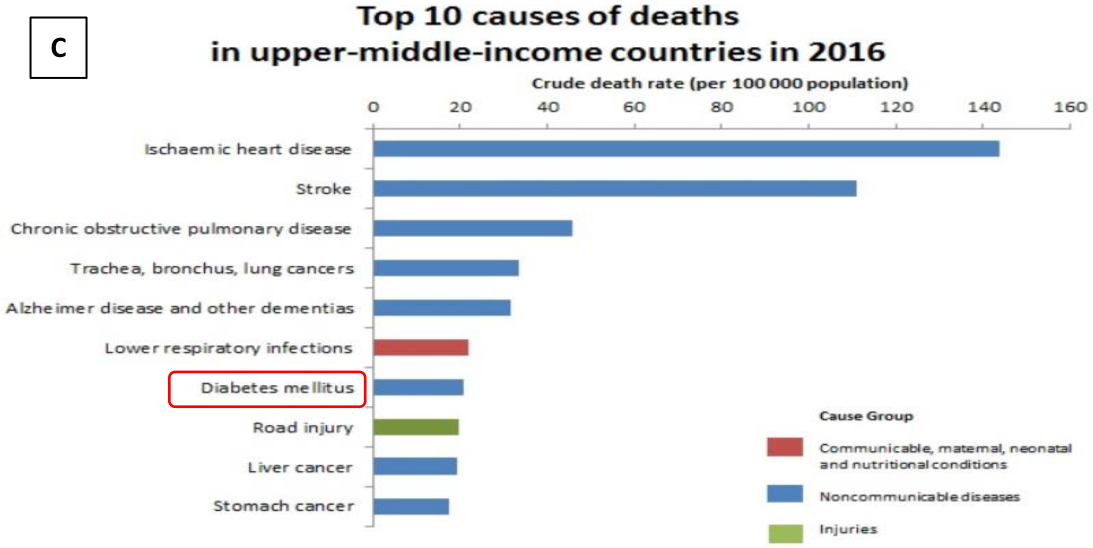
Figure 4. *The age-specific prevalence of diabetes by age and World income group in 2017 expressed in percentage [Adapted from: Cho et al., 2018].*

Figure 4 illustrates that high income countries exhibited a peak in diabetes prevalence within the 75-79 age bands (22%); in the middle-income countries, prevalence peaked at age 60 -74 years (19%) while in low-income countries, prevalence peaked at the 55 – 64 age group (8%). These results suggest that T2DM is more prevalent in high income countries compared to lower income countries. However, the apparent decline in the oldest age groups may be an ascertainment issue or due to increased mortality rates in older age groups.

World Health Organization (WHO) released the causes of deaths according to nation's income group as presented in Figure 5.


A
Top 10 causes of deaths
in low-income countries in 2016
Crude death rate (per 100 000 population)
0 10 20 30 40 50 60 70 80
Lower respiratory infections
Diarrhoeal diseases
Ischaemic heart disease
HIV/AIDS
Stroke
Malaria
Tuberculosis
Preterm birth complications
Birth asphyxia and birth trauma
Road injury
Cause Group
Communicable, maternal, neonatal and nutritional conditions
Noncommunicable diseases
Injuries


B
Top 10 causes of deaths
in lower-middle-income countries in 2016
Crude death rate (per 100 000 population)
0 20 40 60 80 100 120 140
Ischaemic heart disease
Stroke
Lower respiratory infections
Chronic obstructive pulmonary disease
Tuberculosis
Diarrhoeal diseases
Diabetes mellitus
Preterm birth complications
Cirrhosis of the liver
Road injury
Cause Group
Communicable, maternal, neonatal and nutritional conditions
Noncommunicable diseases
Injuries


C
Top 10 causes of deaths
in upper-middle-income countries in 2016
Crude death rate (per 100 000 population)
0 20 40 60 80 100 120 140 160
Ischaemic heart disease
Stroke
Chronic obstructive pulmonary disease
Trachea, bronchus, lung cancers
Alzheimer disease and other dementias
Lower respiratory infections
Diabetes mellitus
Road injury
Liver cancer
Stomach cancer
Cause Group
Communicable, maternal, neonatal and nutritional conditions
Noncommunicable diseases
Injuries

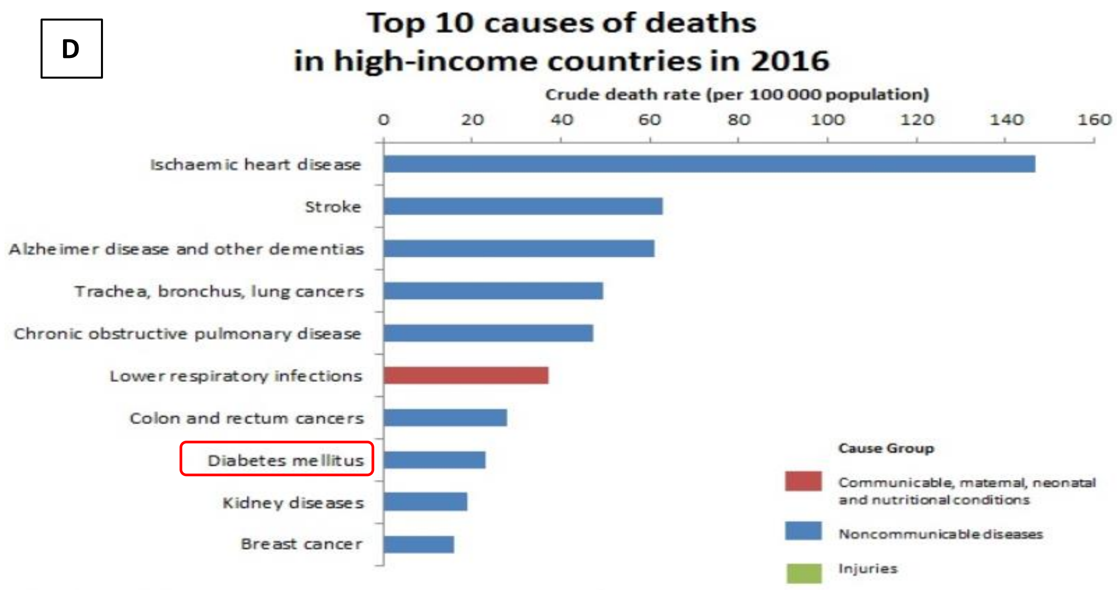


Figure 5. *A 2016 report of the top 10 causes of deaths in* ***A****) Low income countries,* ***B****) Lower-middle income countries,* ***C****) Upper-middle income countries,* ***D****) High income countries [Adapted from: WHO, 2018].*

As shown in figure 5A, diabetes is not a major contributor to mortality in low income countries which are more plagued with communicable diseases compared to the lower-middle (figure 5B), upper-middle (figure 5C) and high income countries (figure 5D) which have diabetes as a major cause of death.

2.4. <u>The link between socio-economic status and diabetes</u>

Study results like those displayed in Figures 4 and 5 contribute to the misconception that that T2DM is “a disease of the wealthy”. The former President of the IDF, Sir Michael Hurst, declared that this is a fallacy (Bird et al., 2015). Contrary to the popular ideology, meta-analysis by recent studies in various countries suggest that despite westernization, individuals of a lower socio-economic status in certain regions have increased risk of developing T2DM – this is discussed in detail in Chapter 3. The relationship between individual SES and T2DM was perceived to change over time within certain countries regardless of national income group – the inconsistencies are discussed in the literature review in Chapter 3.

CHAPTER 3. LITERATURE REVIEW

3.1. **Literature Search Strategy**

Socioeconomic status is a determinant of health. In chapter 1, it was briefly mentioned that there has been no definite conclusion on the exact description of the relationship between T2DM and SES on an individual level. Thus, a literature review for study articles addressing the relationship between SES and prevalence of T2DM was performed. Relevant peer-reviewed systemic reviews published cohort and case-control studies published between 2009 and 2019 were included. The search strategy focused primarily on PubMed and Google Scholar as the main databases and UCD's One Search for access to restricted articles. The keywords and Medical Subject Headings (MeSH) terms for the search include: "type 2 diabetes", "prevalence" and "social class" with the keywords being combined using the "AND" or "OR" operators. The titles and abstracts of the literature found were screened and the bibliography for the literature was also used to identify potential studies as displayed in figure 6.

The articles included in this search were screened according to the following criteria: (1) cross-sectional or longitudinal study or systematic review, (2) studies including both males and females, (3) adequate information was reported in the methods, (4) prevalence evaluations reported for adults aged 18 years and above, (5) relevant to the topic being addressed. Studies focusing on complications from diabetes or other diabetes-related diseases were excluded from this review. If multiple articles gave information on a single study, the article with the most inclusive information was selected.

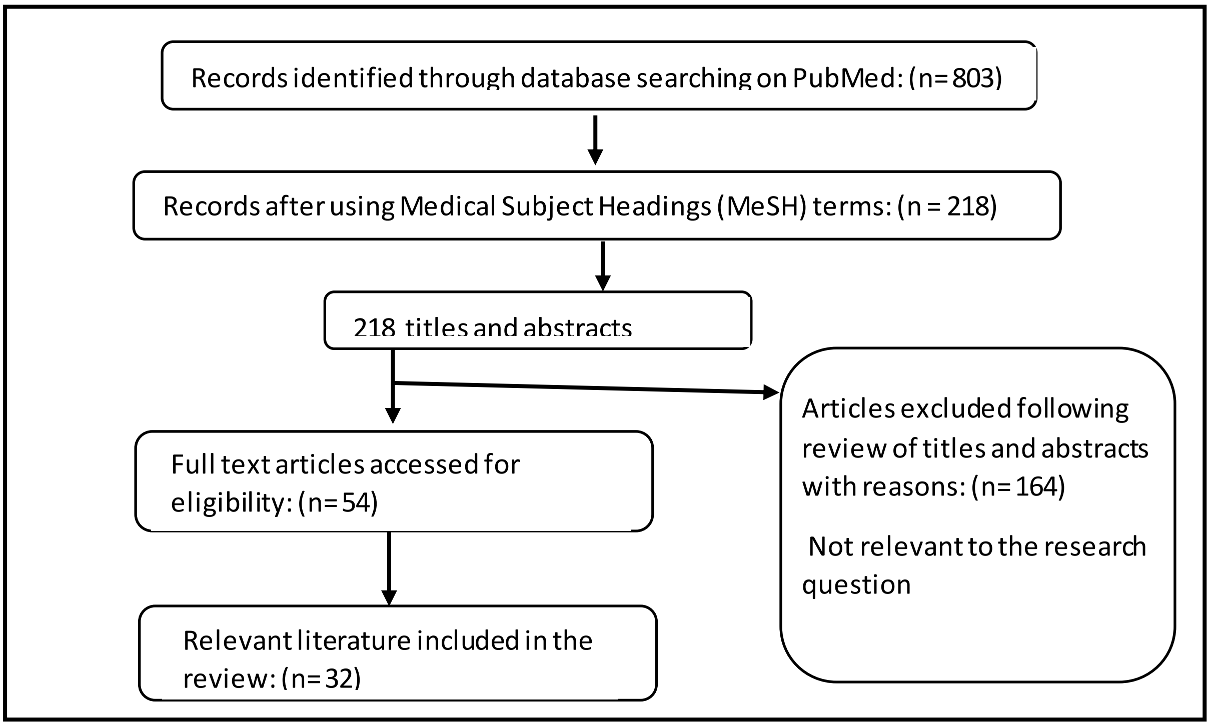


Figure 6. *Flow chart showing the results of the search and reasons for exclusion of studies for systemic review.*

3.2. <u>Relationship between SES and T2DM</u>

3.2.1. **Global observations of SES and T2DM**

Agardh et al (2011) conducted a systematic review to summarize studies describing the global relationship between SES and T2DM prevalence and found that in high-, middle- and low-income countries there existed an increased risk of T2DM among low SES groups in terms of education [RR = 1.4, 95%CI: 1.3–1.5], income [RR = 1.4, 95% CI: 1.0–1.9] and occupation [RR = 1.3, 95% CI: 1.1 –1.6]. Similar to these findings, Sommer et al (2015) reviewed 22 articles and found that having a low SES and living in low- or middle-income countries increases the risk of developing T2DM. However, these findings are not consistent with the results of certain countries.

3.2.2. **Regional deprivation trends**

Sayeed et al. (1997) conducted a study examining the effect of SES on diabetes prevalence using an individual-based investigation of the rich and poor aged 20 and above in rural and urban populations in **Bangladesh** which is generally a lower middle-income country. The study compared individuals inhabiting rural and urban regions in Bangladesh and found that there was a higher prevalence of T2DM in the richer socioeconomic populations [OR 5.6, 95%CI: 3.0 -11.0] in both urban and rural areas than amongst the poorer populations but also found higher levels of impaired glucose tolerance (IGT) among those living in rural areas (Sayeed et al., 1997). The study also found that in **Bangladesh**, T2DM prevalence among indigenes between ages 30–64 was higher in urban regions [8.0% with 95%CI: 6.2-9.8] as opposed to those in rural regions [3.8%, 95%CI: 2.6 - 5.1]. These findings indicate that the prevalence of IGT and T2DM is affected by finance but not affected by regional deprivation.

A longitudinal study by Garcia et al. (2015) researched the relationship between T2DM and neighbourhood socioeconomic position (NSEP) in older Mexican-Americans in **Mexico**, the results of the study found that higher NSEP increased the risk of developing T2DM [HR=1.7, 95% CI=1.1 to 2.4] while low NSEP had a protective effect [HR=0.6, 95% CI=0.3 to 1.0]; while Latinos with diabetes belonging to higher NSEP were less likely to deteriorate to a worse state (Garcia et al., 2015). These results not only confirm a relationship between regional socioeconomic status and prevalence of T2DM but present the possibility of associations between SES and T2DM being influenced by culture.

Considering that the study by Sayeed et al (1997) was performed much earlier than the more recent study by Garcia et al (2015), it is possible that compared to those times when there was narrow inequality trends compared to recent times, there has been a change in the dynamics of regional deprivation and its link to T2DM prevalence. Furthermore, the study populations used for both studies are different as that of Abu Sayeed et al. (1997) included young adults from 20 years while Garcia et al. (2015) used an older population. The studies were conducted in different settings and there is a possibility of confounding factors such as culture, ethnicity, and national income group interfering with the outcomes. It is therefore necessary to explore this relationship across different settings because there is increased likelihood of individuals belonging to similar SES groups in current times to live within the same communities and share a similar lifestyle.

3.2.3. **Relationship between SES and T2DM prevalence within middle-income countries**

Exploring the relationship in other countries, we reviewed a study by Asadi-Lari et al (2016) which estimated the prevalence of T2DM in **Tehran, Iran** and determined its relationship with socioeconomic factors. The population-based study found that using educational level and living region as determinants for socioeconomic status, people belonging to low SES were more at risk of developing T2DM. On the contrary, those living in less deprived regions (more affluent) had a higher chance of developing T2DM because they were less likely to make use of health services (Asadi-Lari et al., 2016). Therefore, their findings on income and T2DM correspond to the findings of Sommer et al (2015) while their findings on regional impact on T2DM differ from any previously discussed, reason being the culture in Iran. In a systematic review, Peykari et al (2015) compared 15 relevant articles to determine the SES-T2DM relationship within Iran as a whole: they essentially found that in **Iran**, there is an inverse relationship between social class and T2DM but the control of diabetes complications were more common among the higher education groups; supporting the results of Asadi-Lari et al. (2016).

3.2.4. **Relationship between income and T2DM prevalence in high-income countries**

Several studies have investigated the relationship between SES and T2DM in high income countries. A couple of studies have observed this relationship within the population in **Canada**. An old study showed that lower household income groups were more likely to have higher fat intake (Pomerleau et al., 1997). Bird et al (2015) performed a cross-sectional study using population-based data and found that the prevalence of T2DM is inversely related to household income, therefore, people belonging to a higher socioeconomic status were less likely to develop T2DM (Bird et al., 2015). The results from Bird et al (2015) in **Saskatchewan, Canada** correlate with an earlier study by Lysy et al. (2013) performed using the population-based diabetes registry in **Ontario, Canada** who used household income to determine SES. Lysy et al (2013) found diabetes to be a greater risk to those belonging to lower income brackets; an inequality they found to be more significant among younger people and females. Dinca-Panaitescu et al (2011) performed a cross-sectional analysis on the data from the Canadian Community Health survey out of which 8,200 from 98,298 cases reported T2DM. From the results, it was revealed that the prevalence of T2DM was 4.14 times higher among the low-income group compared to the high-income group (9.1% vs. 2.2%) - they found a decreasing pattern in prevalence with increasing income even with socio-economic demographics, housing, BMI and physical activity considered as expected from a high income country and correlating to the subsequent results of Lysy et al (2013).

Exploring other high income countries, a study in the **United Kingdom (UK)** by Connolly et al (2000) aimed to establish whether there was a relationship between socioeconomic status and age-specific diabetes using patients from a diabetes registry developed from primary care and hospital records in Middlesbrough and East Cleveland, **United Kingdom**. The researchers found no association between type 1 diabetes and SES but found a higher prevalence of T2DM among those in deprived areas [17.2, 95%CI: 15.5 - 18.9] compared to those in affluent areas [13.4, 95%CI: 11.5 - 15.4]. In a more recent study by Imkampe and Gulliford (2011), their cross-sectional analysis in the **UK** confirmed an increase in the prevalence of diabetes between 1994 and 2006. They found no relationship between SES with educational level as a determinant and prevalence of T2DM in 1994, but in 2006, they discovered a negative association between SES and T2DM among women of low SES but no link among the men in **England**. There are several possible reasons for these results including information bias, chance, confounding factors not considered and the possibility of a true causal link. Compared to Connolly et al. (2000), the study by Imkampe and Gulliford (2011) was restricted to England which is only one region of the United Kingdom. Evans et al (2000) investigated the association between SES and type 1 and type 2 diabetes in **Tayside, Scotland** using data from the Diabetes Audit and research in Tayside database with 366,849 participants. The cross-sectional analysis by the authors showed a higher amount of type 2 diabetics in deprived areas but found no relationship between SES and type 1 diabetes (Evans et al, 2018).

Shahar et al. (2005) performed a study in **Israel** where 116 participants were randomly selected from high SES groups and 206 from low SES groups and the analysis of their data showed that unhealthy lifestyle was more common among the low SES who were dominated by elderly people who were less educated, less physically active. Although this is a small sample size and cannot be generalized, the results of their study aimed to explain the reasons for higher prevalence of T2DM among low SES in this population and similar populations.

Kim et al. (2015) evaluated the relationship between SES and T2DM in the **Korean society** which is knowingly industrialized and experiencing higher prevalence rates of T2DM. With data from the fifth Korea National Health and Nutrition Examination Survey conducted between 2010-2012, the study used household income and education level as a determinant of socio-economic status and found an overall inverse relationship between SES and T2DM. Prevalence of T2DM was higher in lower socio-economic groups in terms of education and household income. Results from the article showed that those with a lower educational level had OR: 8.02 (4.5–14.4) while for those with lower household income had OR: 4.96 (2.9–8.6). This indicates that in **Korea**, the lower SES groups have almost doubled likelihood of developing T2DM compared to the high SES individuals. In the **United States**, observation of data from a national survey showed that there was a higher prevalence of T2DM among adults belonging to lower education level, lower family income level and higher BMI (Xu et al., 2018a).

In summary, most studies for the high-income countries, showed a similar trend of higher prevalence rates of T2DM among the lower SES, corresponding with the findings of Sommer et al. (2015).

3.2.5. **T2DM prevalence and country of birth**

Shamshirgaran et al (2013) investigated the relationship between SES, country of birth and prevalence of T2DM using 266,848 residents of **New South Wales and Australia**. Education level, work status and income were used to determine SES and their results showed higher risk of T2DM in people born in countries outside **Australia**, prevalence was also higher in those with lower educational level than a university degree and those who were retired or unemployed. In general, prevalence of T2DM was higher amongst those with lower income. The results of their study indicated that alongside SES, country of birth plays a role in the risk of developing T2DM (Shamshigaran et al., 2013).

Addo et al (2017) compared the relationship between SES and prevalence of T2DM among **Ghanaians in Europe** versus **Ghanaians in Ghana** using data from the multicentre Research on Obesity and Diabetes among African Migrants (RODAM) study of Ghanaian adults aged 25–70 years residing in Europe (Amsterdam, Berlin and London) and in urban and rural Ghana. The authors used education level and occupation level to identify SES while diabetes was defined as fasting plasma glucose ≥7.0 mmol/L, treatment for diabetes or self-reported diabetes. The result of their analysis with 5,290 participants showed a lower prevalence of T2DM among the Ghanaians with a higher education level in both Europe and urban regions of Ghana; the authors also observed an increase in prevalence among the Ghanaians of higher educational level in the rural part of Ghana (Addo et al., 2017). The authors found no association between occupational level and prevalence of T2DM (Addo et al., 2017).

The results of Addo et al, (2017) indicate that education level and regional deprivation play a role in the prevalence of diabetes compared to country of birth. This partly contradicts the results in Shamshirgaran et al (2013). However, confounding factors such as ethnicity could be contributing to the difference.

3.2.6. **Longitudinal relationship between SES and T2DM**

Several scholars have researched the relationship between socioeconomic status (SES) and the prevalence of type 2 diabetes (T2DM). Longitudinal studies have suggested the possibility for the relationship between SES and T2DM in a region to change over time due to westernization and increasing GDP.

China is an upper-middle income country. In 2000, studies had shown that there was an inverse relationship between SES and T2DM in **China** - higher prevalence of T2DM among the lower SES groups (Xu et al, 2018b). Xu et al (2018b) performed a study to determine whether the relationship between SES and T2DM had changed between 2000 and 2011; as had been the case in several developed countries. Their study was carried out in **Nanjing, China** and SES was measured using monthly household income. The results showed that the relationship between SES and T2DM remained inverse (Xu et al., 2018b). This suggests that although previous studies indicate that T2DM prevalence could possibly be altered by nation's economy, the relationship with SES appear unchanged over time probably through the influence of other confounding factors.

In **Spain**, using education level as a determinant, Espelt et al. (2012) found that although the prevalence of T2DM increased, there was a high prevalence among the lower SES groups in 1987 and 2006 - 5.0% (1987)-12.6% (2006) in men, and 8.4% (1987) -13.1% (2006) in women compared to the higher SES groups (6.3-8.7% in men and 3.8 - 4.0% in women).

3.2.7. **Different relationship within countries**

Contrary to the findings for the general Chinese population shown in the study by Xu et al. (2018), a study in **Northwest China** by Zhu et al (2015) examined the relationship between SES, lifestyle factors and the prevalence of T2DM using education, occupation and income to determine SES. The authors found an increased risk of T2DM among those belonging to higher SES [$\chi^2 = 52.4$, $P < 0.01$] with corresponding higher levels of alcohol use, unhealthy diet, and higher BMI among those in a higher SES. This result suggested a negative relationship between SES and T2DM in this region and indicated the need for intervention among the population with higher SES (Zhu et al., 2015). However, Xu et al (2018) had limited their analysis to income only.

Conversely, a population-based study by Zhang et al. (2013) who performed a cross-sectional analysis of data from Tianjin Diabetes Mellitus project in 2005 with 7,315 participants found that people of lower income groups had a higher prevalence of T2DM. Fu et al (2011) analysed the relationship this relationship in **rural China** which is not as developed as the other parts of China. The authors used a cross-sectional analysis of 4 rural communities of Deqing County located in Eastern China and described the relationship using 4506 participants observed through 2006 and 2007. Fu et al (2011) found that those with a higher SES had a higher risk of T2DM. Le et al (2011) performed a similar cross-sectional study aiming to describe the relationship between SES and T2DM in **rural southwest China** which is also underdeveloped like the study population in Fu et al (2011). The authors interviewed 10,007 people and used household income to determine SES. The results of their research found that there was no relationship between household income and T2DM but found an inverse relationship between education level and the prevalence of T2DM (Le et al. 2011). Reviewing these articles proved the possibility of the SES-T2DM relationship to differ across regions within the same country.

3.2.8. **The relationship between SES and T2DM in European countries**

Dalstra et al (2005) gave an overview of the effect of SES on prevalence of T2DM in **Europe** using educational level as a determinant and found large inequalities [OR = 1.6 (1.4 – 1.8)]. Through comparison of surveys from eight European countries, their study revealed that diabetes and most other diseases, except cancer, kidney diseases and skin disease; had higher prevalence among lower education groups in Europe (Dalstra et al., 2005). Similarly, findings resulted from the study by Espelt et al. (2013) using data on people over 50 years in Europe between 2004 and 2006. The study included 11 European countries: Austria, Belgium, Denmark, France, Germany, Greece, Italy, Spain, Sweden, Switzerland and The Netherlands using data from the Survey of Health, Ageing and Retirement in Europe (SHARE). Education level was used to measure socio-economic position (SEP) and result of their study showed that the prevalence rate was highest among women of lower education level [1.6, 95%CI: 1.4 - 1.9] and incidence rate was also highest among these same group of women [1.88, 95%CI: 1.4–2.6] (Espelt et al., 2013). Their results also showed that overall the prevalence rates of T2DM were highest among those of lower SEP in European countries (Espelt et al., 2013).

Contrary to the findings in certain studies including Abu Sayeed et al (1997) who indicated that there is no relationship between regional deprivation and prevalence of T2DM, Maier et al (2013) found that among **the German population**, habitants of the most deprived areas had the highest risk of developing T2DM [OR 2.1, 95%CI: 1.3-3.6]. Likewise, Grundmann et al (2011) carried out a cross-sectional study using data from the German Index of Multiple Deprivation (GIMD) to investigate the association between prevalence of T2DM and area deprivation, controlling for individual SES which they defined using income and education level. The researchers found a significant relationship between area deprivation at a municipal level and prevalence of T2DM especially when all individual variables such as age, sex and physical activity were controlled [OR 1.4; 95% CI 1.1 - 1.6] (Grundmann et al., 2011). Larranaga et al (2005) investigated the SES-T2DM relationship using results from a cross-sectional survey with 65, 651 people across 61 general practitioners (GPs) in **Spain** out of whom 2,985 people had been diagnosed with T2DM. Similar to the findings of other high income countries, they found that there was a higher prevalence of T2DM among patients with lower socio-economic status [OR: 2.2, 95%CI: 1.8 – 2.3] and corresponding higher trends of obesity, sedentary lifestyle and abnormal levels of low-density lipoprotein (LDL) cholesterol and HbA1c among those in the lower SES (Larranga et al, 2005). Similarly, another study performed in **Greece** by Tentolouris et al (2012) using information of participants found that in rural, urban and suburban Greek populations showed that there is a higher prevalence of T2DM among those with low SES.

3.2.9. **The effect of SES on T2DM development in Ireland**

In **Ireland**, which is a high-income country, Tracey et al. (2016) performed a systematic review to define the epidemiological trends of diabetes in Ireland between years 1998 – 2015 and assess any changes in diagnosis over time. The results from their review showed there had been a significant increase in the prevalence of diabetes diagnosis among adults in Ireland, however, no research was performed as to what factors could have contributed to this increase over time. Leahy et al (2017) carried out a study using data from TILDA to investigate the relationship between childhood and adult SEP and the development of T2DM in the Irish population. The study analysed one wave from the TILDA dataset and found that low SEP in childhood [OR: 1.8, 95% CI: 1.0–3.4] and adulthood [OR: 1.8, 95% CI: 1.0–3.1] resulted in increased risk of T2DM especially in women.

3.3. **Gap in the literature**

The relationship between SES and Type 2 diabetes has been inconclusive due to its complicated nature and ability to differ in the same setting at different stages of a country's economic development. Nevertheless, majority of research has found that as SES increases, the prevalence of T2DM decreases, especially in high-income countries. Some of the key studies included in this review are summarised in Table 1. Evident from the literature review, there is no published study on the longitudinal SES-T2DM relationship in Ireland. This highlighted the need for research to characterise any existing relationship between SES and T2DM within Ireland in order to identify inequalities that would need to be addressed for progress in the battle against diabetes and possibly other non-communicable diseases.

Table 1 Characteristics of studies included in the literature review reporting the relationship between socio-economic status and the prevalence of type 2 diabetes mellitus

Country	Lead Author (Year)	Study design	National / Regional	Setting	Study Population	Sampling	Sample size	SES-T2DM Relationship
Bangladesh	Abu Sayeed et al (1997)	Cross-sectional	National	Interviews and examinations	General population	Stratified	2,371	⬆
Canada	Dinca-Panaitescu et al (2011)	Cross-sectional	National	Database	General population	Total	98,298	⬇
Canada	Lysy et al (2013)	Cross-sectional	Regional	Database	General population	Total	12,000,000	⬇
Canada	Bird et al (2015)	Cross-sectional	Regional	Database	General population	Total	27,090	⬇
China	Fu et al (2011)	Cross-sectional	Regional	Interviews	General population	Stratified	4,506	⬆
China	Le et al (2011)	Cross-sectional	Regional	Questionnaire	General population	Stratified multistage	10,007	⬇ ⟷
China	Zhang et al (2013)	Cross-sectional	Regional	Interviews	General population	Total	7,315	⬇
China	Zhu et al (2015)	Cross-sectional	Regional	Interviews	General population	Multistage	3,243	⬆
Europe	Espelt et al (2013)	Cross-sectional	National	Database	General population	Total	21,323	⬇
Germany	Maier et al (2013)	Cross-sectional	National	Database	General population	Multistage	11,688	⬇

Greece	Tentolouris et al 2012)	Cross-sectional	National	Database	General population	Total	8740		⬇	
Iran	Asadi-Lari et al (2016)	Cross-sectional	Regional	Database	General population	Multistage	91,814		⬇	
Ireland	Leahy et al (2017)	Cross-sectional	National	Database	General population	Total	4,998		⬇	
Israel	Shahar et al (2005)	Cross-sectional	Regional	Questionnaire	General population	Random	322		⬇	
Korea	Kim et al (2015)	Cross-sectional	National	Database	General population	Total	14,123		⬇	
Mexico	Garcia et al (2015)	Cohort	Regional	Interviews	Mexican Americans	Stratified	1,777	⬆		
New South Wales and Australia	Shamshirgaran et al (2013)	Cross-sectional	National	Questionnaire	General population	Total	266,848		⬇	
Scotland	Evans et al (2000)	Cross-sectional	Regional	Database	General population	Total	366,849		⬇	
Spain	Larranga et al (2005)	Cross-sectional	Regional	64 GP Practices	Hospital patients	Stratified	65,651		⬇	
United Kingdom	Connolly et al (2000)	Cross-sectional	Regional	49 GP Practices	Primary care and hospital patients	Stratified	4,313			⟷
United States	Xu et al (2018)	Cross-sectional	National	Database	General population	Total	58,186		⬇	

⬆ = Direct relationship – Higher T2DM prevalence as SES increases

⟷ = No relationship between T2DM and SES

⬇ = Inverse relationship – Higher T2DM as SES decreases; where there is more than one arrow present, this indicates more than one relationship.

3.4. **Research question**

Is there a relationship between individual socioeconomic indicators and the prevalence of type 2 diabetes in the adult population aged 50 years and older in Ireland? If there is, does this relationship remain consistent between 2009 and 2015?

3.5. Hypothesis

The null hypothesis (Hϕ) is that there is no relationship between type 2 diabetes prevalence and socio-economic indicators among the adults aged 50 years and older in Ireland.

The alternative hypothesis (Ha) is that there is a relationship between type 2 diabetes prevalence and socio-economic indicators in Ireland.

3.6. **Aim**

To determine and compare the longitudinal effect of socioeconomic indicators on the prevalence of type 2 diabetes among adults aged 50 years and older in Ireland between year 2009 and 2015.

3.7. **Objectives**

The objectives of this study are as follows:

- To establish the prevalence trend of type 2 diabetes within the adult population aged 50 years and older in Ireland in 2009 and 2015.
- To describe the relationship between the prevalence of type 2 diabetes in adults older than 50 years living in Ireland and individual socio-demographics and biological variables in the 2009 and 2015 cohort using the TILDA study population.
- To determine whether the association between SES and T2DM changed between study periods: 2009 (Wave 1) and 2015 (Wave 3).

CHAPTER 4. RESEARCH METHODS

4.1. **TILDA Sampling strategy**

This study was an analytical cross-sectional study performed using nationally representative secondary data from The Irish Longitudinal Study on Ageing (TILDA). The TILDA dataset includes individual- based data on the adult population over 50 years in Ireland recorded in 2009 (Wave 1), 2011 (Wave 2) and 2015 (Wave 3). TILDA aims to understand the health, social and financial circumstances of the older Irish population and how these factors interact to influence the aging process making this dataset suitable for this research study.

The TILDA study was carried out using purposive multi-stage cluster sampling. The information for the dataset was collected using a structured questionnaire designed to collect all important information regarding the individual that could be applicable for research studies and stored in the Irish Social Science Data Archive (ISSDA). The TILDA dataset includes coded information on the age-eligible participating members of the population in Ireland which is the study population to be used for this descriptive research. In the TILDA study, the medical history, family history, lifestyle, living structure and location, education level and finance of each participating individual was observed and documented over the years.

The TILDA dataset allows for clear description of the health, social and financial circumstances of the older Irish population and how these factors interact to influence outcomes during ageing. This dataset was suitable for this research purpose considering the objective included observation of trends among this study population and understanding the implications of level of finance, education as determinants of socio-economic status on the development of T2DM.

4.2. **TILDA Study population**

The study population was the citizens in Ireland aged 50 years and older. The Institute of Public health (IPH) in Ireland reported that type 2 is the most common form of diabetes affecting those over 50 years (Institute of Public health in Ireland, 2016). The harmonized (Waves 1 and 2) and Wave 3 TILDA dataset was requested for from ISSDA. This dataset, spread over 2009 and 2015, contains the necessary longitudinal health, living situation and financial details of the target population for this study. Permission to access the dataset being stored by under ISSDA was granted. The forms used for application are attached in Appendix A.

4.3. **Data collection by TILDA and study instrument**

The study participants were age- eligible persons (50 years and older) and their spouses/partners living in residential addresses in the Republic of Ireland. It included only members of the population in Ireland who live within the community (i.e. they do not live in a long-term care institution). To generate the dataset, all postal addresses in Ireland were allocated to one of 3,155 geographic clusters, and a sample of 640 of these clusters was selected, organised by socio-economic group and location to maintain representativeness. Forty households were randomly selected from each cluster (it was estimated that 25,600 addresses in total would be required to achieve the required sample size of 8,000). The selection of geographic clusters was organised to allow equal numbers within bands from each of the three socio-economic groups (high, middle and low). The socio-economic status of a band was defined by the proportion of individuals within.

All individuals aged 50 or over and their partners (even if aged less than 50 themselves) in each selected household were invited to be included in the study; a household member was contacted to confirmed age-eligibility of any individual living in the selected address.

At the initial stage of data collection around 1% those between the ages of 65 and 74 were living in long-term care, this figure increased to 6% of those aged between 75 and 84 and 21% of those aged 85 and over. Wave 1 was conducted between 2009 and 2011 with 8,504 respondents out of which 8,175 individuals were aged 50 and over and 329 were the younger spouses or partners of participants while Wave 3 was conducted between 2014 and 2015 with 6,400 respondents. Data from any respondents who were new at Wave 2 and Wave 3, had passed away between the waves or who required a proxy interview were removed (n=499) to protect anonymity.

For each wave, data were collected through self-completed questionnaires, home interview and health assessments. Following granted consent, age-eligible participants were interviewed through a Computer aided personal interview (CAPI) using a structured questionnaire; and a 'self-completion questionnaire' including potentially sensitive questions was also left for the participants to fill in and return to TILDA by mail. For every household, the first respondent interviewed acted as the 'coverscreen respondent', providing the demographic information on each person in the household. Where two participants were married or were living together as if married, a 'financial respondent' and a 'family respondent' provided the information on family and financial circumstances respectively.

Respondents in Wave 1 and 3 also attended a health assessment centre for measurements such as blood pressure, weight, height and blood tests, or were measured at home by trained research nurses. Being as blood collection is an invasive procedure, both written and verbal consent was required. Blood samples were used to perform glycated haemoglobin testing (HbA1c). All results from the data were collected by TILDA, coded and stored under the Irish Social Science Data Archive (ISSDA).

4.4. Variable creation and data management

When questionnaires were completed (refer to Appendix C), a data dictionary with variables of interest was developed with coding on an excel spreadsheet (refer to Appendix D); this was imported to SPSS database for analysis.

For the purpose of this study, Wave 1 (2009 cohort) and Wave 3 (2015 cohort) data were used for comparative analysis allowing the observation of individual-based changes that could have occurred due to influence from increased industrialization and changes in the nation's economy. The dataset also allowed observation of other biological factors that contribute to T2DM development such as high cholesterol, BMI and certain individual lifestyle choices.

The determinants of SES used in this research include education level, employment status and household income. New variables were created from the original dataset provided by TILDA for statistical analysis.

4.4.1. SES - Education level

For education level, the participants were asked to indicate their "highest education achieved". In Wave 1 participants had the options of "less than lower secondary school", "upper secondary and vocational training" or "tertiary"; while in Wave 3, the participants were coded as "primary", "secondary" or "third/ higher". In this study, it was assumed that primary, secondary and higher were equivalent to less than lower secondary, upper secondary and vocational training and tertiary respectively.

4.4.2. SES - Employment status

The harmonized categorical data for Wave 1, included the options of "employed/ self-employed", "retired" and "not-employed/self-employed/retired". For Wave 3, harmonized data included "retired", "employed/ self-employed" and "other". "Other" was specified to include "permanently sick or disabled", "looking after home or family", "in education or training" and "unemployed". In this study, it was assumed that the categories were equivalent for comparison.

4.4.3. SES - Household income

The data on household income were collected as the total couple level income within the household. This value accounted for all couples or individuals residing in the same house and shared living-related expenditures. The total couple income included the accumulated value of all income received from employment earnings, capital income, pensions and annuities, public pensions and other government transfers. The TILDA data received on household income for each wave were documented as a continuous number, expressed in Euros (€). For this study, they were categorized into tertiles: lower (<50%), middle (50% - 200%) and higher (>200%) for analysis. In Wave 1, the lower income band was defined as €14,999 and below, €15,000 - €60,000 for the middle, and €60,001 and above for the high-income band. In Wave 3, the lower income was €19,999 and below, €20,000 to €79,999 for the middle quartile and €80,000 and above for the high-income group. Assuming each group clearly defined the SEP of each cohort year, the groups were compared in this study.

4.4.4. Covariates

The covariates considered in this research included diabetes risk factors such as smoking, alcohol use, healthcare insurance, physical activity involvement, high cholesterol and body mass index (BMI).

Alcohol

Data on alcohol consumption were collected differently for the waves – Wave 1 was collected as "ever drinks any alcohol": "yes", "no" or "don't know" while Wave 3 was collected as "have you ever had drinks containing alcohol e.g wine, beer etc". The meaning of each question is different and could therefore affect the results, however, assuming they were equivalent, the two variables were compared in this study. Wave 3 also collected data on having an alcohol problem as categorised by the CAGE scale, but this was not included in the analysis.

High Cholesterol

Information on high cholesterol were consistently collected in both waves as "do you have any of these conditions – high cholesterol": "yes" or "no" and results were compared in this study.

BMI

BMI was also considered in this research as it is a diabetes-related factor. BMI was calculated as weight (kg) divided by height (m^2). Underweight = <18.5kg/m^2, normal = 18.5 – 24 kg/m^2, overweight= 25 – 30 kg/m^2 and obese= >30 kg/m^2. However, the data on BMI were collected differently in Wave 1 (continuous variable) and Wave 3 (categorical variable); likewise, the data on weight and height in Wave 3 so it was not possible to calculate BMI or use the BMI data provided.

Living area

The data on region of habitation of participants was another factor which was considered in this study; however, the data were only available in Wave 1 so analysis could not be performed on regional link to diabetes for Wave 3. Living area was categorised as "rural", "town excluding Dublin" and "Dublin".

Physical activity

Data on weekly involvement in physical activity were collected as a continuous variable. Low physical activity indicated the participant's frequency of light level of energy physical activity in the past 7 days such as walking, stretching or light gardening. Moderate physical activity indicated activities that cause participants to breathe slightly harder than normal such as cycling, tennis and carrying light loads in the past 7 days. Vigorous physical activity in the past 7 days included involvement in activities such as heavy lifting, digging, fast cycling, gym workouts or aerobics. The question was consistent across both waves. Each variable was categorised as "yes" to any amount of physical activity within that variable and "no" for the bivariate analysis. There was no data on physical inactivity for observation in either cohort.

Medical Coverage

In Wave 1, those who were registered as having both private and/or government medical insurance and/ or medical card were classified as "insured" while in Wave 3, data was available for those recorded to have private insurance and those who had a medical card. This was merged for the medical coverage analysis in Wave 3.

4.4.5. Type 2 Diabetes

The outcome variable in this study was type 2 diabetes. In the TILDA dataset, T2DM was identified in the two waves as follows:

Table 2. Identification of type 2 diabetes in TILDA data

Question	**Wave 1**	**Wave 3**
Has the doctor ever told you that you have any of the conditions – diabetes?	(n= 641) ✖	
Have any of the conditions on this card – diabetes or high blood sugar?		(n= 34) ✖
Currently doing any of the following – taking insulin medications?		(n= 95) ✖
Incident cases: Endocrine, nutritional and metabolic diseases		(n= 605) ✖
HBA1C test	Data not provided ✖	

✖ Indicates that question was asked

Participants that responded "yes" to the question, "has a doctor ever told you that you have diabetes of high blood sugar?", were categorised as having type 2 diabetes in Wave 1 (n=641).

In Wave 3, the participants that responded yes to the question "do you have any of the conditions on this card – diabetes or high blood sugar", and "are you currently doing any of the following – taking insulin medications?" were merged and categorised as having type 2 diabetes as those questions were more specific to T2DM (n=127). Out of 6,400 participants in Wave 3, 193 responded to "Have any of the conditions on this card – diabetes or high blood sugar?", and 34 out of 193 responded with a "yes". While 611 out of 6,400 responses for "Currently doing any of the following – taking insulin medications?" were recorded, and 95 out of the 611 responses was a "yes". Overlaps between participants who answered both questions were considered and the valid denominator for T2DM in Wave 3 was adjusted accordingly.

Out of 6,400 participants, 605 people responded "yes" to the question on endocrine diseases. However, the question included nutritional and metabolic diseases, so it was not included in the T2DM ascertainment for Wave 3. The results of the HBA1C test performed on participants was not made available for this research and therefore, not included.

4.5. **Ethics considerations**

TILDA is based at Trinity College Dublin and involves many scientific collaborators within Ireland and internationally. The TILDA organization is funded by the Department for Health and Children, Irish Life and The Atlantic Philanthropies. Ethical approval for each wave of data collection was granted by the Trinity College Research Ethics Committee. The research protocol for this study meets one or more of the criteria for exemption from review as detailed in Section 3 of *Further Exploration of the Process of Seeking Ethical Approval for Research (HREC Doc 7)* and application for exemption was applied for. The approval was granted from the UCD Human Research Ethics Committee (attached in Appendix B).

4.6. **Statistical analysis**

The dataset received were analysed using the IBM SPSS version 24.0 for Windows 10 software package. Descriptive statistics were presented to describe the characteristics and socio-demographic of the study population according to the variables of interest. Frequencies (%) are used in the presentation the characteristics. A chi-square test was used for bivariate analyses to investigate the presence of a relationship between socioeconomic indicators, behavioural and biological variables in each wave with type 2 diabetes prevalence. Binary logistic regression was used for multivariate analysis to define the nature of the relationship between diabetes prevalence of each socioeconomic indicator and behavioural or biological variable using adjusted odds ratios and 95% confidence intervals obtained. Independent t-tests were used to assess relationship for age. Statistical significance was defined as 5% ($p<0.05$).

CHAPTER 4. RESULTS

The TILDA study comprised of 8,504 participants in the Wave 1 cohort (2009) and 6,400 in the Wave 3 cohort (2015). Table 3 presents the descriptive characteristics of the TILDA study population in the Wave 1 (2009) and Wave 3 (2015) cohorts according to demographics and socio-economic indicators.

Table 3. Descriptive statistics of the adults aged 50 years and older in the TILDA STUDY collected in 2009 (Wave 1) and 2015 (Wave 3) in Ireland.

Variables	Wave 1 (2009)		Wave 3 (2015)	
	Valid Denominator		Valid Denominator	
Age Mean (±SD)	8,504	63 (9.4)	6,400	66.4 (8.9)
		n (%)		n (%)
Gender				
Male		3,780 (44.4)		2,825 (44.1)
Female	8,504	4,724 (55.6)	6,400	3,575 (55.9)
Highest education achieved				
Less than lower secondary		2,521 (29.6)		1,623 (25.4)
Upper secondary and vocational training		4,766 (56.0)		2,548 (39.8)
Tertiary	8,504	1,213 (14.3)	6,400	2,228 (34.8)
Employment status				
Employed / Self-employed		3,141 (36.9)		2,111 (33.0)
Retired		3,048 (35.8)		2,907 (45.4)
Unemployed*	8,504	2,209 (26.0)	6,400	1,371 (21.4)
Household Income				
Lower		3,503 (41.2)		1,564 (24.4)
Middle		3,017 (35.5)		3,370 (52.7)
Higher	8,504	1,984 (23.3)	6,400	365 (5.7)

*Not employed, not retired, in education or receiving vocational training

Table 3 showed that the gender distribution across both surveys are similar. The 2009 cohort comprised of 44.4% males and 55.6% females while the 2015 cohort contained 44.1% males and 55.9%. It also showed that less percentage of people had less than lower secondary and upper secondary and vocational training in the 2015 cohort than in the 2009 cohort. There was a greater percentage of participants with tertiary education by 2015. Likewise, as expected, there was a lower percentage of unemployed participants following the recovery from the recession in the 2015 cohort compared to the 2009 cohort. There was also a lower percentage of employed participants in 2015 and a higher percentage of retired participants. There was an increase in the percentage of middle-income participants by 2015 and decreased percentage of low-income group. There was a loss of follow up by Wave 3 and 1,101 participants did not respond to questions on household income.

The overall prevalence change on T2DM based on these responses (refer to Table 2 in Chapter 3) were presented in Figure 7 to show the prevalence change between the cohort study periods.

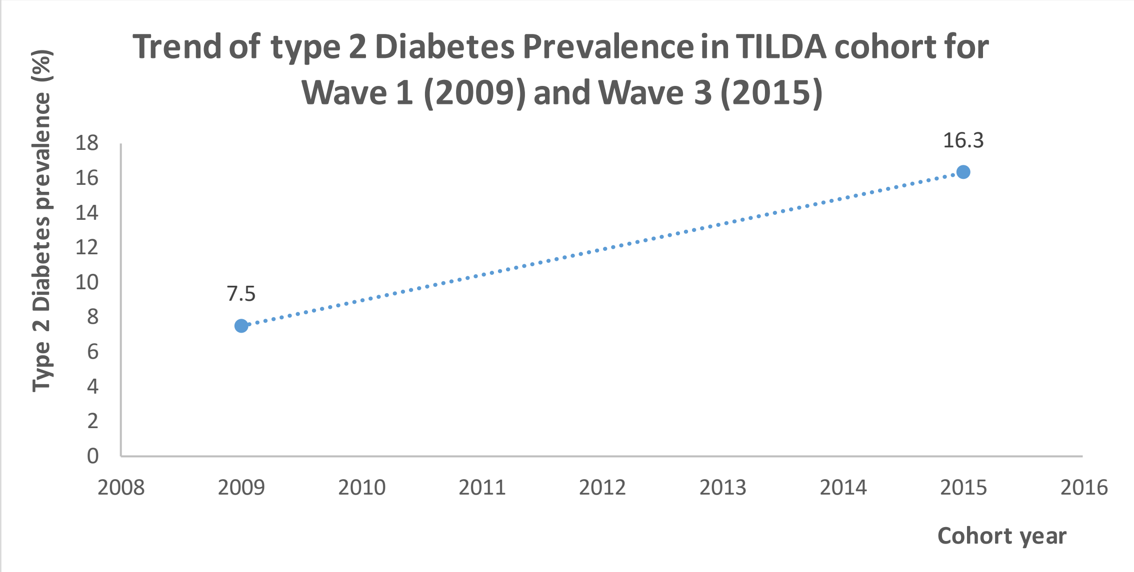


Figure 7. *The prevalence of type 2 diabetes mellitus (T2DM) in TILDA study population in wave 1 cohort (2009) and wave 3 cohort (2015) expressed in percentage.*

Figure 7 shows an increase in the prevalence of T2DM between the Wave 1 and the Wave 3 cohorts which correlates with reported trends on the prevalence of T2DM over time. This indicates that there was an 8.8% absolute increase and a 54% relative increase compared to the baseline in the prevalence of T2DM between 2009 and 2015.

Bivariate analyses identified an association between socio-demographic characteristics, biological and behavioural factors in the TILDA study with the prevalence of T2DM and logistic regression modelling described the nature of the relationships found to type 2 prevalence.

Table 4 shows the description of the association between socio-demographic characteristics and T2DM prevalence in the 2009 cohort.

Table 4. The relationship between socio-demographic characteristics of participants in the TILDA study with the prevalence of T2DM in the 2009 cohort (Wave 1)

	2009 (Wave 1) N = 8,504					
	Type 2 Diabetes (n=8,504)					
Characteristic	Yes (n= 641)	No (n= 7,863)		p- value	Adjusted OR (95% CI)	P – value
Age Mean (±SD) (N = 8,492)	66.4 (8.9)	62.7 (9.4)		*<0.001[a]	1.04 (1.03, 1.05)	<0.001[c]
	n (%)	n (%)	X^2			
Gender (n= 8,504)						
Male	369 (57.6)	3,411 (43.4)	48.3	*<0.001[b]	Ref	
Female	272 (42.4)	4,452 (56.6)			0.57 (0.48, 0.67)	*<0.001[c]
Highest Education Achieved (n= 8,500)						
Less than lower secondary	263 (41.0)	2,258 (28.7)			Ref	*<0.001[c]
Upper secondary and vocational training	310 (48.4)	4,456 (56.7)			0.60 (0.50, 0.71)	*0.001[c]
Tertiary	68 (10.6)	1,145 (14.6)	44.1	*<0.001[b]	0.51 (0.39, 0.67)	*0.001[c]
Employment status (n = 6,763)						
Employed	152 (30.7)	3,095 (49.4)			Ref	*<0.001[c]
Retired	316 (63.8)	2,732 (43.6)			2.36 (1.93, 2.88)	*<0.001[c]
Unemployed	27 (5.5)	441 (7.0)	76.7	*<0.001[b]	1.25 (0.82, 1.90)	*0.3[c]
Household Income (n= 8,504)						
Lower	282 (44.0)	3,221 (41.0)			Ref	*0.007[c]
Middle	242 (37.8)	2,775 (35.3)			1.00 (0.83, 1.19)	1.0[c]
High	117 (18.3)	1,867 (23.7)	10.0	*0.007[b]	0.72 (0.57, 0.90)	*0.003[c]
Medical Coverage (n=8,504)						
Yes	596 (93.0)	7,001 (89.0)			1.63 (1.20, 2.23)	
No	45 (7.0)	862 (11.0)	9.67	*0.002[b]	Ref	*0.002[c]
Living Area (n= 8,491)						
Rural area	281 (44.0)	3,811 (48.5)			-	
Town (exc. Dublin)	191 (29.9)	2,196 (28.0)			-	-
Dublin	166 (26.0)	1,846 (23.5)	4.9	0.08[b]	-	-

a = Independent t-test, b= Chi-square test, c= Binary logistic regression, *p<0.05 indicates significance, Ref= Reference

Considering the socio-demographic factors, the Chi-square analyses in Table 4 indicated that there was a significant association between socio-demographic characteristics such as age ($p<0.001$), gender ($\chi2 = 48.3$, $P<0.001$), highest education achieved ($\chi2= 44.1$, $p<0.001$), employment status ($\chi2= 76.7$, $p<0.001$), household income ($\chi2= 10$, $p= 0.007$) and medical insurance ($\chi2= 9.67$, $p=0.002$) with the prevalence of T2DM in the total 2009 cohort. Hierarchal logistic regression analyses described the effects on the socio-demographic characteristics on the prevalence of T2DM with significantly higher T2DM prevalence presented in the males compared to the females (adjusted odds ratio [AOR] 0.57, 95CI 0.48 – 0.67, $p<0.001$), participants with lower education compared to secondary (0.60, 0.50 – 0.71, $p<0.001$) and tertiary (0.51, 0.39 – 0.67, $p<0.001$), retired (2.36, 1.93 – 2.88, $p<0.001$) and unemployed (1.25, 0.81 – 1.90, $p=0.3$), lower and middle income groups compared to higher income members (0.72, 0.57–0.90, $p=0.003$) and participants with medical insurance (1.63, 1.20- 2.23, $p=0.002$). Age was significantly associated with T2DM prevalence (1.00, 1.03 – 1.05, $p<0.001$). There was no relationship found between living area ($\chi2= 4.9$, $p= 0.08$) with the prevalence of T2DM so they were not included in the subsequent logistic modelling.

Table 5 shows the relationship between biological and behavioural factors with the prevalence of T2DM in the 2009 cohort.

Table 5. The relationship between biological and behavioural variables of participants in the TILDA study with the prevalence of T2DM in the 2009 cohort (Wave 1)

	2009 (Wave 1) N = 8,504					
	Type 2 Diabetes (n= 8,504)					
Factors	Yes (n= 641)	No (n= 7,863)	X^2	p- value	Adjusted OR (95% CI)	P - value
	n (%)	n (%)				
Smoking (n= 8,504)						
Yes	111 (17.3)	1,453 (18.5)				
No	530 (82.7)	6,410 (81.5)	0.5	0.5[a]	-	-
Alcohol consumption (n= 7,161)						
Yes	335 (63.8)	5,014 (75.6)	35.5	*<0.001[a]	Ref	
No	190 (36.2)	1,622 (24.4)			1.75 (1.46, 2.11)	*<0.001[b]
Weekly Physical Activity (n= 7,678)						
Light	262 (49.5)	2,731 (38.2)			Ref	*<0.001[b]
Moderate	162 (30.6)	2,334 (32.6)			0.72 (0.59, 0.89)	*0.002[b]
Vigorous	105 (19.8)	2,084 (29.2)	31.8	*<0.001[a]	0.53 (0.42, 0.66)	*<0.001[b]
BMI Categories kgm^{-2} (n= 7,635)						
Underweight/ Normal	26 (4.4)	952 (13.5)			Ref	*<0.001[b]
Overweight	149 (25.0)	2,471 (35.1)			2.21 (1.45, 3.37)	*<0.001[b]
Obese	421 (70.6)	3,616 (51.4)	90.9	*<0.001[a]	4.26 (2.85, 6.38)	*<0.001[b]
High Cholesterol (n= 8,504)						
Yes	613 (95.6)	6,780 (86.2)			Ref	
No	28 (4.4)	1,083 (13.8)	46.2	*<0.001[a]	0.29 (0.20, 0.42)	*<0.001[b]

a = Chi-square test, b = Binary logistic regression, *p<0.05 indicates significance, Ref= Reference, BMI=Body Mass Index

The bivariate chi-square analyses in Table 5 illustrated that there was no significant relationship between T2DM prevalence and smoking ($\chi2$= 0.5, p=0.5) in the 2009 cohort so it was not included in the logistic modelling. Biological and behavioural factors including alcohol use ($\chi2$= 35.5, p<0.001), physical activity engagement ($\chi2$= 31.8, p<0.001), BMI ($\chi2$= 90.9, p<0.001) and high cholesterol ($\chi2$= 46.2, p<0.001) significantly associated with T2DM prevalence. With increased level of physical activity engagement, there was less prevalence of T2DM [Vigorous physical activity = AOR 0.53, 95CI 0.42 – 0.66, p<0.001]. T2DM was significantly more prevalent among participants who were overweight (AOR 2.21, 95CI 1.45-3.37, p<0.001), obese (4.26, 95CI 2.85-6.38, p<0.001) and had high cholesterol compared to those with normal cholesterol (0.29, 95CI 0.20 – 0.42, p<0.001). T2DM was more prevalent among non-users of alcohol (1.75, 95CI 1.46 - 2.11, p<0.001).

Table 6 shows the description of the association between socio-demographic characteristics and T2DM prevalence in the 2015 cohort. Only 779 participants responded to questions on T2DM identification in Wave 3.

Table 6. The relationship between socio-demographic characteristics of participants in the TILDA study with the prevalence of T2DM in the 2015 cohort (Wave 3)

	2015 (Wave 3) N = 6,400					
	Type 2 Diabetes (n= 779)					
Characteristic	Yes (n= 127)	No (n= 652)		p- value	Adjusted OR (95% CI)	p - value
Age Mean (±SD) (n = 6,399)	67.7 (9.6)	66.4 (8.9)		0.1[a]	-	-
	n (%)	n (%)	X^2			
Gender (n= 779)						
Male	66 (54.1)	358 (54.5)				
Female	56 (45.9)	299 (45.5)	0.006	0.9[b]	-	-
Highest Education Achieved (n= 779)						
Less than lower secondary	39 (32.0)	245 (37.3)				
Upper secondary and vocational training	48 (39.3)	233 (35.5)				
Tertiary	35 (28.7)	179 (27.2)	1.3	0.5[b]	-	-
Employment status (n = 778)						
Employed	25 (20.5)	153 (23.3)			Ref	*0.04[c]
Retired	58 (47.5)	363 (55.3)			1.02 (0.62, 1.70)	0.9[c]
Unemployed	39 (32.0)	140 (21.3)	6.6	*0.04[b]	0.59 (0.34, 1.02)	0.06[c]
Household Income (n= 650)						
Lower	35 (34.7)	187 (34.1)				
Middle	63 (62.4)	328 (59.7)				
High	3 (3.0)	34 (6.2)	1.7	0.4[b]	-	-
Medical Coverage (n=779)						
Yes	113 (92.6)	610 (92.8)				
No	9 (7.4)	47 (7.2)	0.008	0.9[b]	-	-

a = Independent t-test, b= Chi-square test, c= Binary logistic regression, *p<0.05 indicates significance, Ref = Reference

Table 6 shows that in the 2015 cohort, socio-demographic characteristics such as age (p=0.1), gender (χ2= 0.006, p=0.9), education achieved (χ2= 1.3, p=0.5), household income (χ2= 1.7, p=0.4) and medical coverage (χ2= 0.008, p=0.9) had no significant relationship with the prevalence of T2DM and were therefore not included in logistic regression analyses. However, employment status (χ2= 6.6, p= 0.04) was significantly associated with the prevalence of T2DM. Participants who were employed (AOR 1.00, p= 0.04) had equal chance of T2DM as the retired (1.02, 95CI 0.62-1.70, p = 0.9) which was insignificant, while those who were unemployed (0.59, 95CI 0.34-1.02) showed a decreased likelihood of having T2DM compared to those who were employed.

Table 7 shows the relationship between behavioural and biological factors with the prevalence of T2DM in the 2015 cohort.

Table 7. The relationship between biological and behavioural variables of participants in the TILDA study with the prevalence of T2DM in the 2015 cohort (Wave 3)

2015 (Wave 3) N= 6,400				
	Type 2 Diabetes (n= 779)		X^2	
	Yes (n= 127)	No (n= 652)		
Factors	n (%)	n (%)		p- value
Smoking (n= 778)				
Yes	17 (13.9)	107 (16.3)		
No	105 (86.1)	549 (83.7)	0.4	0.5
Alcohol consumption (n= 560)				
Yes	69 (86.3)	406 (84.6)		
No	11 (13.8)	74 (15.4)	0.1	0.7
Weekly Physical Activity (n= 71)				
Moderate	1 (12.5)	13 (20.6)		
Vigorous	7 (87.5)	50 (79.4)	0.3	0.6
BMI Categories kgm^{-2} (n=748)				
Underweight/Normal	63 (54.3)	398 (63.0)		
Overweight	47 (40.5)	213 (33.7)		
Obese	6 (5.2)	21 (3.3)	3.4	0.2
High Cholesterol (n= 193)				
Yes	6 (19.4)	16 (9.9)		
No	25 (80.6)	146 (90.1)	2.3	0.1

*p<0.05 indicates significance, BMI = Body Mass Index

There was no data available for living region in Wave 3, so it was not possible to investigate relationship between living area and T2DM prevalence. There were no participants categorised between the low physical activity level group and T2DM response. Table 7 indicates that there was no relationship between any of the biological and behavioural factors including smoking (χ2 = 0.4, p=0.5), alcohol use (χ2= 0.1, p=0.7), physical activity level (χ2= 0.3, p=0.6), BMI (χ2= 3.4, p=0.2) and high cholesterol (χ2= 2.3, p=0.1) with the prevalence of T2DM so they were not included in a logistic regression analyses to test for effects.

CHAPTER 5. DISCUSSION

5.1. Interpretation of results

The relationship between T2DM and socioeconomic status had been found to be inconclusive across regions and over time – in terms of whether the relationship exists, and whether it is a direct or an inverse relationship. This study aimed to describe and compare the longitudinal effect of socioeconomic indicators on the prevalence of type 2 diabetes among adults aged 50 years and older in Ireland between year 2009 and 2015 based on a nationally representative dataset from TILDA. The research question was whether there was a relationship between socio-economic indicators and the prevalence of T2DM in the adult population in Ireland, 50 years and older; and its consistency between year 2009 when Ireland was in economic depression and 2015 when the economy of Ireland had become stable. The study null hypothesis was that there was no relationship between SES and T2DM prevalence in Ireland and the alternative hypothesis was the existence of a relationship.

Firstly, this study examined the prevalence of T2DM in the 2009 cohort and compared to the prevalence in the 2015 cohort. The results showed an increase in the prevalence of T2DM in the 2015 cohort (16.3 %) compared to the 2009 cohort (7.5%). There was a relative increase in T2DM prevalence by 54% compared to the baseline. These results correlate with existing publications on the prevalence trend in Ireland and globally. However, the number of participants who responded to the questions for T2DM identification in 2009 (n=8,504) was much less than the number of people that responded in 2015 (n=779). As a result, the observations in the 2015 cohort study were performed using a much smaller sample compared to the 2009 cohort. The increase observed could be as a result of the use of a small sample who happen to have more diabetes cases but could also be due to changes in various socio-demographic characteristics and biological factors such as BMI, income, employment status and age among the cohort over the 6 year period. Since it is the same cohort, a decrease is unlikely because T2DM is a chronic disease. Those who previously had T2DM in 2009 should maintain diagnoses in 2015, but a prevalence increase indicates an increase in the amounts diagnosed compared to the previous cohort. Studies state that the increasing incidence of T2DM over the years is linked to an increase in the levels of obesity (Klonoff, 2009).

Secondly, the study assessed the relationship between the prevalence of type 2 diabetes in adults older than 50 years living in Ireland by examining individual socio-demographics and biological variables in the 2009 and 2015 cohorts. The socio-demographic factors observed were age, gender, medical insurance, highest education achieved, employment status and household income while the biological and behavioural variables were smoking, alcohol use, weekly physical activity, BMI category and high cholesterol. Finally, it was determined whether the association between SES and T2DM changed between 2009 (Wave 1) and 2015 (Wave 3).

Age is one of the most important risk factors for T2DM, and the risk is higher in older age groups (Selvin and Parrinello, 2013). The average age of participants with T2DM increased from 66 years in the 2009 cohort to 68 years by 2015; this could be due to increasing average age of the study population. However, in 2009, a relationship was shown to exist between age and T2DM prevalence while in 2015, age had no relationship to T2DM prevalence. Records show that males are more diagnosed with diabetes than females globally (Kautzky-WIller, Harreiter and Pacini, 2016). This corresponds with the results in 2009 where gender was found to be related to T2DM prevalence with the chances being greater among the males than the females (AOR 0.57, 0.48-0.67). In 2015, there was no relationship between gender and T2DM prevalence in the cohort.

Education level is the most universal approach to measuring SES but is subject to confounders including lifestyle, knowledge of health promotion, access to services etc. (Sacerdote et al, 2012). The analysis of the 2009 cohort showed that highest education achieved by the participants was associated with the prevalence of T2DM – participants who belonged to groups of higher levels of education like upper secondary, vocational training and tertiary education, presented a lower prevalence of T2DM. This indicated that there was an inverse relationship between highest education achieved and T2DM prevalence in 2009. Similar findings have been reported by Kim et al. (2015) and these results correlate with the findings in Dalstra et al (2005). This suggests that individuals in high-income countries like Ireland, with a higher education may be more receptive to health promotion messages and have increased ability to apply preventive advices. Furthermore, higher education groups are more likely to have access to and to use health care systems (Sacerdote et al., 2012). In 2015, level of education showed no relationship with T2DM prevalence. This was most likely due to the small sample size with an almost equal distribution of T2DM participants across each subcategory.

Employment status was recorded slightly differently across the two waves as mentioned. There was a decrease in the percentage of unemployed by 2015, this could be due to increased job availability by 2015 as nation's economy resumed its stability. There was also a lower percentage of employed participants in 2015 and a higher percentage of retired participants. This is most likely due to more of the participants reaching retirement age by 2015. In the 2009 cohort, the study found a relationship between employment status and T2DM prevalence. It was seen that participants who were retired and unemployed had a higher prevalence of T2DM compared to the employed. This is expected as participants who are retired, are more likely to be older and similar to the unemployed could engage in less physical activity. In 2015, the study found the relationship to be different from the relationship observed in 2009; the prevalence of T2DM was equal among retired and employed and less likely in the unemployed compared to the employed. This differs from expected results and could have been influenced by the makeup of the sample size. The possibility that the employed participants had jobs that entailed high levels of sedentary hours for computer use can be considered as a possible contributor to the high T2DM prevalence among the employed groups, nonetheless, further research is required to address that speculation. Considering that the percentage of employment had improved by 2015, the results observed might be through an amount of the previously unemployed with T2DM having progressed to the employed group while some of the previously employed would have moved to become retired.

Observing household income as a SES determinant, this study found that the prevalence of T2DM was less among participants belonging to the high-income group compared to the middle and lower groups in the 2009 cohort. This is similar to other findings by Bird et al (2015) and correlates with the results of Espelt et al (2015) for European countries. In 2015, like all the other socio-economic factors addressed including medical coverage, there was no relationship with prevalence of T2DM. Whereas in 2009, there was a relationship found between having medical insurance and the prevalence of T2DM. T2DM was more prevalent among participants with medical insurance coverage. This could be due to increased diagnosis through unrestricted access to medical centres. There was no relationship between living area and T2DM prevalence indicating that access to service based on living area would not be a factor and lifestyle causing T2DM is not controlled by living area. Overall, considering income, education and employment, there was an inverse relationship discovered between T2DM prevalence and the socio-economic indicators in 2009 and no relationship in 2015.

Exploring the relationship between behavioural and biological variables with T2DM, the results showed that in 2009, there was no relationship between smoking and T2DM prevalence. However, the other biological/behavioural factors including alcohol use, weekly physical activity involvement, BMI and high cholesterol were all found to influence the prevalence of T2DM in the 2009 cohort. This corresponds with the reports that there are no “safe” amounts of alcohol; and any alcohol consumption increases risk to health (Alcohol Action Ireland, 2019). However, contrary to expectations, there was a higher prevalence of T2DM among non-users of alcohol. This could be due to ascertainment issues with the alcohol use variable – a positive response to “do you ever drink any alcohol?” used in the 2009 cohort does not determine whether the participant is a frequent alcohol user or consumes excessive amounts.

Participants who had high cholesterol and were overweight or obese had a higher prevalence of T2DM, confirming that these factors contribute to the development of T2DM. With increasing levels of physical activity, participants were less likely to develop T2DM. Supporting the theories that state that engaging in higher levels of physical activity and minimizing a sedentary lifestyle, reduces the chances of developing T2DM and other associated chronic lifestyle diseases. In

2015, there was no relationship found between any of the biological factors and T2DM prevalence. The small sample size could be a possible reason for no found associations. Overall in 2015, the results showed no relationship between biological factors and most socio-demographic characteristics with T2DM prevalence except the direct relationship found comparing employment status and T2DM prevalence with employed and retired participants having a higher T2DM prevalence.

5.2. Results in relation to other studies

The increasing trend of T2DM prevalence shown in the 2015 cohort study corresponds to the reports of an increase in T2DM prevalence among adults over 40 years in Ireland made by Diabetes Ireland in 2015 (Diabetes Ireland, 2015b). It also corresponds to the increasing trends reported globally and by other countries as discussed.

As shown in the literature review in Chapter 3, many studies have investigated the association between employment status, income level and education level with T2DM prevalence. They have found the overall trend of the T2DM and socioeconomic indicator relationship to be generally inverse especially in high income countries (Dalstra et al., 2005). Although in meta-analyses, it can be difficult to adjust for potential confounders. Further research including European countries also confirm these findings of an existing health inequality with regards to T2DM prevalence (Espelt et al., 2013).

Socio-economic health inequalities are associated to a range of factors including fetal or infant malnutrition, unhealthy behaviours, stress and limited access to preventive health care (Brown et al., 2004). As a lifestyle disease, the prevalence of T2DM has been found to be prevalent among lower SES groups because individuals belonging to a lower socioeconomic background are more likely to practice unhealthy behaviours such as excessive alcohol consumption and smoking (Fleischer et al., 2012; Shahar et al., 2005). Alcohol use contributes to T2DM development and the risks increases through excessive alcohol consumption. For this reason, organization such as Drink Aware have provided drinking guidelines for males and females as tolerance is sensitive to gender.

Obesity is a major risk factor for T2DM and has been found to be influenced by SES (Baltrus et al., 2005). Similar to the findings of other studies, this study found T2DM to be more prevalent among people with high cholesterol. Abnormal cholesterol levels are due to diabetes development instigating a decrease in high–density lipoproteins (HDLs) and raising the levels of low-density lipoproteins (LDLs) and triglycerides causing diabetic dyslipidemia which is often diagnosed prior to diabetes itself. Therefore, it is expected to find a higher prevalence of T2DM among people with high cholesterol, as was the case in the 2009 cohort. Considering household income as a socioeconomic indicator, the inverse relationship observed in the 2009 cohort study correlates with other articles discussed in the literature review. A study conducted in Canada showed that lower household income groups were inversely linked to fat intake (Pomerleau et al., 1997). This could explain why T2DM is more prevalent among the low-income groups; as increased fat intake would result in higher BMI and increased chances of development of lifestyle diseases.

As confirmed in the 2009 cohort study results, physical activity engagement is important for the prevention of T2DM as well as other lifestyle diseases. A study found that women of higher SES groups were more prone to engaging in physical activity than those in the lower SES groups, thereby contributing to the lower T2DM prevalence among the higher SES groups (Ford et al., 1991). Conversely, another study by Sacerdote et al (2012) found no relationship between physical activity and SES, like the 2015 cohort study results of this research.

This study found an inverse relationship between socio-economic indicators and T2DM in the 2009 cohort, with a corresponding association between certain behavioural/ biological characteristics. In the 2015 cohort, there was no relationship found when education and income were considered, and a direct relationship was found for employment status. This suggests that there could have been a change in the relationship between SES and T2DM over the 6-year period following stability after an economic depression. This is contrary to the study by Xu et al (2018b) discussed in the literature review which had found a consistent inverse relationship between 2000 and 2011 in Nanjing despite increasing urbanization over the years. However, the results in 2015 are not as generalizable as the results of 2009 due to the extreme loss of participants and small sample size by 2015 for T2DM observations.

5.3. Reasons for heath inequalities

Finding any relationship between socioeconomic status and health highlights the presence of health inequalities within that region. According to Sir Douglas Black, there are four possible explanations for health inequalities: 1) artefact – the relationship is not naturally present but appears as a result of investigation views, 2) social selection – health determines social class as people who are ill are less likely to work and have increased likelihood to drift down the social gradient due to health care costs and reduced income, 3) behavioural and cultural – social class determines health through differences in health behaviours and 4) materialistic – social class determines health through differences in life experiences and exposures which could be direct; for example, poorly maintained housing due to low SES leading to exposure to disease, or indirect, example, social capital limiting access to services (Geraint et al, 2014).

Health care accessibility, biological, physical, environmental, behavioural factors and socioeconomic determinants have a complex impact on health. The main cause of health inequalities is the exposures linked to socioeconomic status; these include where people live, work, type of jobs and the social norms within these fields. All the members of a society play a collective role in health outcomes within the society. This study presents social inequalities in T2DM risk which have been found to be consistent across most European countries and other high-income countries indicating that in order to address the increasing trend in T2DM occurrence, SES has to be considered.

5.4. Recommendations

Society is more than a simple aggregation of individuals but includes a shared behaviour through interaction that often results in similar outcomes; this behaviour needs to be understood in order to intervene. Other studies have shown that in areas of deprivation, there are increased chances of unhealthy habits existing as the social norm. This study did not find a relationship between living area and T2DM prevalence in the 2009 cohort, however, there is need for research to investigate for a relationship between regional deprivation and T2DM currently in the Republic of Ireland. For better observations, HBA1C tests should be used to ascertain T2DM diagnosis instead of self-reports. This is a more cost-intensive approach but with ethical approval, would increase the validity of the research.

Using the Danish Twin study, it was established that an estimated 20% of the average person's life is dictated by their genetic composition, whereas the remainder 80% is influenced by their lifestyle (Herskind et al., 1996). The Bullseye Model of Social Determinants of Health has shown that public health is dependent on the socioeconomic features of the nation, civil society health is dependent on the features of social organization such as social trust, institutional responsibility and access to health care and education whereas, individual health is dependent on personal economic situation and individual support network (Babones, 2009). Therefore, it can be deduced that SES changes people's conditions and affects their health beliefs. Furthermore, people and groups can modify the society through their responses to environmental factors that surround them through their education, occupations and lifetime.

The societal factors determine the nature of socioeconomic traits consequentially influencing health behaviour; which affects biological factors (Australian Institute of Health and Welfare, 2014). Therefore, based on the results of this study and other studies which show the presence of a relationship between SES and T2DM to be inverse, in order to address the increasing trend in T2DM occurrence, there is need for a nationwide intervention which would entail making modifications to certain public policies.

Lifestyle factors are an easier trait to identify and modify through interventions. This study's analyses of 2009 cohort confirmed the association of certain behavioural/ biological factors which relate to lifestyle with the prevalence of T2DM. There are inadequate amounts of research on tackling the wider social determinants of health such as social gradients, therefore, interventions would be based on evidence of effective measures that have been used to tackle the social determinants of health and health inequalities (Barreto et al., 2009).

A randomised control trial showed that targeting healthy middle-aged people through a lifestyle intervention resulted in a 49% risk reduction of diabetes and improvements in cardiovascular risk factors (Knowler et al., 2009). The Department of Health in Ireland would need to implement lifestyle intervention programmes to promote awareness on the burden of T2DM and the need for lifestyle amendments to lower LDL cholesterol and reduce T2DM incidence. Recommendations should include advice on the replacement of saturated and unsaturated fat intake with omega-3 fatty acids and fibre consumption. The lower SES groups would be the target audience for this programme as studies have shown that low SES groups have less access to prevention messages and be more prone to fat intake in diets. Environmental changes will also need to be made in order for these prevention advices to be applied. Informing the lower SES groups on the cost-benefit of consuming healthier food options compared to dealing with the burden of poor health in the long run and providing information of affordable options for fruits and vegetables purchase will allow for easier application of dietary advice. Including classes that educate school children on diabetes and other chronic conditions in relation to lifestyle as part of the Irish school programme, would result in cultivation of healthy habits from a younger age and gradually begin to shape social norms to reduce the risks of T2DM and other chronic diseases in later life. An evaluation of different levels of lifestyle intervention programmes for people with pre-diabetes in England showed that the English national policy of low-intensity lifestyle programmes had a positive impact on the nation's budget and proved to be cost-effective by preventing a fraction of cases of T2DM (Roberts et al., 2018).

As proposed by Diabetes Ireland, there is a need to ensure that people with diabetes have unrestricted access to public services through the Government Health Reform Programme and would need to be provided with insurance covers (Diabetes Ireland, 2016). In general, there should not be any barriers to health care services. With increased and equal access to health services, it becomes easier to identify people at risk of diabetes development regardless of social gradient. Pre-diabetes is a reversible condition which features impaired fasting glucose (IFG) and Impaired Glucose Tolerance (IGT) (Health Service Executive, 2018). Weight loss programs and increased levels of physical activity can result in the prevention of the progression of pre-diabetes to T2DM. In Ireland, East Coast Area Diabetes (ECAD) offers a diabetes prevention course including sessions with a diabetes nurse and a diabetes dietician; through early diagnosis, at risk members of the society can be referred to this programme.

In order to reduce the incidence of T2DM, it would be important to promote early detection; this would be more likely when there is increased access to health services. In most cases, T2DM is identified following the appearance of complications. Although early identification of T2DM can reduce the progression of the disease, there are no major diabetes guidelines recommending general screening (HSE, 2018). The American Diabetes Association (ADA) released recommendations of criteria for diabetes screening in asymptomatic adults which stated that testing should be considered among all adults who are overweight (25 kgm^{-2} and above) and have either physical inactivity, close relatives with diabetes, hypertension, dyslipidaemia, cardiovascular diseases, are Asian, African or Hispanic, travellers, pre-diabetic or have a history of gestational diabetes or insulin resistance. When additional risk factors are absent, screening should begin at age 45 and repeated at 3-year intervals where results are normal (HSE, 2016). A systematic review showed that the ADA recommendations are cost-effective when implemented based on observation of 56 studies from 20 countries (Li et al, 2010). Implementing these recommendations in Ireland would result in better control of T2DM and reduce the burden on individuals and the country. Therefore, policy makers in Ireland need to prioritize these recommendations.

Finally, this study highlights the need for further research focused on methods to improve the quality of life in Ireland with the members of the lower socioeconomic groups being a major consideration.

5.5. Strengths and limitations of this study

Strengths

The major strength of this study is the use of secondary dataset collected by TILDA which is a nationally representative data consisting of a large sample size; this makes the study generalizable. The use of secondary data also meant no cost intensiveness in the performance of this study. In the sampling and data collection phase of the data, selection and information bias were addressed. Considering that sample selection was randomized increased the reliability of the study. The interviewers sent out for data collection had previously been trained in order to reduce the chance of information bias. Consent and approval were granted prior to data collection making the dataset ethically acceptable. The socioeconomic exposures considered in this research were clearly described in the TILDA study allowing ease of analysis in this study. The TILDA database contained adequate information on the individual socio-demographic (age, sex, education level, employment status, living situation, area of residence, total monthly income of family and net worth), clinical (diabetes status, medication use, obesity and high cholesterol), lifestyle (smoking status, drinking habits, leisure-time physical activity, healthcare insurance status) allowing for consideration of factors relevant to the study's research question. This is the first study to examine and compare the relationship between prevalence of T2DM and socio-economic indicators using Waves 1 and 3 TILDA data.

Limitations

Certain limitations of this study include exclusion bias from post-randomization exclusion of vulnerable groups such as those living in residential care or who required a proxy interview. The study was also succumbed to loss of follow up for various reasons including resulting in a decrease in sample size by Wave 3. It is impossible to determine whether those excluded by Wave 3 would have influenced the result outcomes for that cohort. The data was also subjected to influence of re-call bias, for example with questions like "have you ever been told you have high cholesterol?" or "have you ever drank any alcohol?"; thereby affecting true ascertainment for the variables.

This study was comparing results across two cohort surveys, the TILDA surveys did not have a consistent questionnaire with structured questions across the waves making it difficult to compare the years and exposing certain ascertainment to assumptions. Altered methods of ascertainment of one variable across two years could influence the results. For example, medical insurance was collected as all forms of medical insurance in Wave 1 but was collected as private insurance and having a medical card in Wave 3.

Ascertainment of T2DM which was the outcome variable for this research also differed across the two surveys, making it difficult to determine the validity of the comparative results. It was also impossible to ascertain undiagnosed diabetes from the TILDA data which would have resulted in a higher prevalence of T2DM. Identification of T2DM was based on self-reports and self-reported recollection of previous diagnosis which makes it less reliable than if the results of HBA1C tests were used to ascertain T2DM across both waves.

5.6. Conclusion

This study provides estimates on the prevalence of T2DM among adults aged 50 years and older in Ireland. In conclusion, the findings from this study suggest that in Ireland, there are social inequalities with T2DM prevalence and a corresponding association to behavioural/ biological factors which are more prevalent among the lower socioeconomic groups. There was an overall inverse relationship between SES and T2DM prevalence in the 2009 cohort and no true relationship found in the 2015 cohort. The study suggests a shift in the relationship between

T2DM prevalence and employment from inverse to direct between 2009 and 2015; with diabetes being more prevalent among the employed by 2015. The null hypothesis of this study is therefore rejected while the alternative hypothesis is accepted, as there is a relationship between socio-economic status and the prevalence of T2DM in Ireland. There is need for lifestyle interventions to address any social inequalities contributing to the T2DM increase. Finally, further research is necessary to examine the current social inequalities in Ireland with a more reliable method for T2DM ascertainment used and consideration for confounders such as ethnicity.

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APPENDICES

APPENDIX A - Data Request form

DATA REQUEST FORM

SECTION 1: CONTACT DETAILS [Please type]

First name *	Chinyere Elizabeth	Last name *	Kalu
Address			
Country *	Ireland		
Institution/Company *	University College Dublin		
Email *	chinyere.kalu@ucdconnect.ie		
Phone	089423911 3		

SECTION 2: DATASET REQUESTED* [Please]

0053-03_TILDA_HARMONIZED_DOCUMENTATION

Please refer to the full list of datasets on the ISSDA website: www.ucd.ie/issda

Please provide as many details as possible

0053-03_TILDA Harmonized TILDA Documentation and Codebook (pdf)

0053-03_TILDA Harmonized.sav – SPSS - Harmonized data (Waves 1 and 2)

0053-04 Wave 3 data and documentation

Do you wish to be contacted if the dataset is updated or in the case of new releases of data?
Yes

☑Yes ☐No

SECTION 3: INTENDED USE OF DATA Research purposes for thesis

Subject area *	☐ Economics ☐ Education ☐ Engineering ☐ Environment/ Agriculture ☑ Health/ Sport ☐ Law ☐ Policy ☐ Social issues ☐ Well-being ☐ Other [please specify] ____________

Please provide a short description (approx. 100 words) of your intended use of the dataset/s*:

To determine the relationship between incidence of diabetes in the elderly population and level of income.

Seeking to investigate a relationship between diabetes incidence and level of income in different countries.

Type of user *	☐Academic ☐ Post Doc ☐ PhD ☑Masters ☐ Undergraduate ☐ Independent researcher ☐ Government/ Policy researcher ☐ Other [please specify] ____________
Estimated end date for this use (maximum 5 years from date of application) *	30 September 2019
Funder (where applicable)	

SECTION 4: REGISTER OF USE*

For office use only:
Request ID
Date Received
Date Sent

ISSDA would like to facilitate researchers using other datasets to collaborate, where appropriate. If you consent to allowing your details to be shared with other researchers and data providers, please tick one of the following options:

☑ Description of project, contact details and funder

☐ Description of project only

☐ No details

SECTION 5: PERSONS PERMITTED TO ACCESS THE DATA UNDER ARTICLE 3 OF TERMS OF USE*

Please list all users who will have access to and use of the data.

Chinyere Elizabeth Kalu (student) and Mary Codd (supervisor)

[These users are bound by the same terms and conditions as the End User.]

IRISH SOCIAL SCIENCE DATA ARCHIVE

End User Licence

This Agreement is made between [Chinyere Elizabeth Kalu] (the "End User") and the ISSDA in order to provide the "End User" with the right to use the data collections provided via the ISSDA according to the terms below:

TERMS OF USE

These terms of use cover the use of data files and all related material (hereafter "the data collections") supplied by ISSDA in accordance with the Data Request Form.

The End User undertakes and agrees:

1. To use and to make personal copies of any part of the data collections only for the purposes specified in the part on intended use of data. If it is wished to use the data for any other purpose enquiries should be made to the ISSDA.
2. That this Licence does not operate to transfer any interest in intellectual property from the data collection funders, the ISSDA, the original data creators or depositors, copyright or other right holders to the End User.
3. To ensure that strictly only the End User, and those persons listed in Section 5, have access to the data provided under this agreement. The End User shall be responsible for controlling access to the data.
4. To ensure that the means of access to the data collections (such as passwords) are kept secure and not disclosed to a third party (excluding those listed in Section 5) except by special written permission or licence obtained from the ISSDA.
5. Not to use the data collections to attempt to obtain or derive information relating specifically to an identifiable individual or household.
6. To be aware at all times of the risk of inadvertently disclosing information, which might result in the identification of an individual. All use of the data and production of all analysis and output should be sensitive to this risk.
7. To undertake to abide by the conditions laid out in the Statistics Act, 1993, and, in particular, Section 34 thereof. Please see http://www.irishstatutebook.ie/1993/en/act/pub/0021/index.html
8. To acknowledge, in any work based in whole or part on resources provided by the ISSDA, the original data creators, depositors or copyright holders and the ISSDA, and to declare, in any such work, that those who carried out the original analysis and collection of the data bear no responsibility for the further analysis or interpretation of it.
9. To ensure that all such works acknowledge that copyright and all other intellectual property rights in the data and associated documentation are vested in the original data creators or depositors. Please see the ISSDA website (www.ucd.ie/issda) for appropriate wording.
10. To ensure that all such works acknowledge the ISSDA in the following way: "Accessed via the Irish Social Science Data Archive - www.ucd.ie/issda".

11. To reference the recommended bibliographic citation in any publication that employs resources provided by the ISSDA.
12. To send to the ISSDA citations of any publication based in whole or part on resources provided by the ISSDA for inclusion in a database of related publications.
13. That ISSDA may submit details of the End User's research for statistical purposes to the original data creator or depositor.
14. To notify the ISSDA of any errors discovered in the data or accompanying documentation.
15. At the conclusion of the End User's research to offer for deposit (subject to the terms of the ISSDA standard Licence Agreement) in the ISSDA on a suitable medium and at the End User's own expense any new data collections which have been derived from the materials supplied or which have been created by the combination of the data supplied with other data, provided that such data are:
    - suitable for use in research and teaching
    - fall within the thematic scope of ISSDA's data collections
    - are in a form appropriate for re-use
    - are in an appropriately anonymised form
    - are in a form appropriate for archiving
    - include sufficient explanatory documentation to enable the new data collection(s) to be accessible to others

16. Any breach of any of the provisions of this Agreement will lead to immediate termination of the End User's access to all services provided by the ISSDA either permanently or temporarily, and may result in legal action being taken against the End User. The End User acknowledges that the data depositor will be notified in the event of a breach coming to the notice of the End User. Permission to use the data for the specified purpose may be withdrawn by the ISSDA at any time, without notice and without cause assigned, by written notice to the End User, signed by or on behalf of the Director of the ISSDA.

INDEMNITY

End User agrees to indemnify and shall keep indemnified each member of the ISSDA against any costs, actions, claims, demands, liabilities, expenses, damages or losses (including without limitation consequential losses and loss of profit, and all interest, penalties and legal and other professional costs and expenses) arising from or in connection with any third party claim made against any member of the ISSDA relating to End Users use of the data collections or any other activities in relation to the data collection where such use is in breach of this licence.

DISCLAIMERS

To the extent that applicable law permits:

a. The ISSDA bears no legal responsibility for the accuracy or comprehensiveness of the data supplied.

b. The ISSDA accepts no liability for, and the End User will not be entitled to claim against them in respect of, any direct, indirect, consequential or incidental damages or losses arising from use of

   the data collections, or from the unavailability of, or break in access to, the service, for whatever reason.

c. Whilst steps have been taken to ensure all licences, authorisation and permissions required for the granting of this Licence have been obtained, this may not have been possible in all cases, and no warranties or assurance are given in this regard. To the extent that additional licences, authorisations and permissions are required to use the data collections in accordance with this Licence, it is the End User's responsibility to obtain them.

I acknowledge that by signing my name below, I confirm that I have read, understood, and agree to abide by all of the terms and conditions in the ISSDA End User Licence (including the obligations imposed on the End User).

Signed ________________________ **Signed**

Administrator

Irish Social Science Data Archive **END USER**

Date ________________________ **Date** **13/11/2018______**

Definitions

"data collection funder" means the persons or organisations that funded the collection and/or creation of the data collections. The data collection funder for a particular data collection is identified in the metadata applicable to that data collection;

"original data creator or depositor" means the persons or organisations that originally collected, created or deposited the materials making up the data collections and/or who own the intellectual property rights in the data collections. The original data creator or depositor for a particular data collection is identified in the metadata applicable to that data collection;

"metadata" means any additional or bibliographic information about one or more of the data collections, as notified to the End User from time to time. Metadata may be supplied by electronic means

APPENDIX B – Ethics exemption

UCD School of Public Health, Physiotherapy and Sports Science
Taught Masters Research Ethics Committee

University College Dublin,
Health Sciences Centre
Belfield, Dublin 4, Ireland

Scoil na Sláinte Poiblí, Fisiteiripe agus na hEolaíochta Spóirt UCD
Múinte Coiste Eitice Taighde Máistreachta

An Coláiste Ollscoile, Baile Átha Cliath,
Ionad Eolaíocht Sláinte
Belfield, Baile Átha Cliath 4, Eire

tmrec-sphpss@ucd.ie
www.ucd.ie/sphpss

21st February 2019

Dear Associate Professor Codd

Application: Declaration of Ethical Review Exemption
Decision: Contingent acceptance (accepted, subject to implementation of recommended changes)
Ref: TMREC-19-39-Kalu-Codd
Applicant: Elizabeth Kalu
Supervisor/PI: Associate Professor Codd

Thank you for notifying the Taught Masters Ethics Committee - SPHPSS (TMREC) of *your declaration* that you are exempt from a full ethical review. Should the nature of your research change and, thereby, alter your exempt status you will need to submit an application for full ethical review. Please note for future correspondence regarding this study and its exemption that your Research Ethics Exemption Reference Number (REERN) is: TMREC-19-39-Kalu-Codd.

Please observe the following:

- Section B-3d and e: it is not clear whether another study is used besides TILDA. And if only TILDA is used – which is on Irish data only – how will the aims and objectives be reached using TILDA data only as the aims and objectives are about comparing data from multiple countries. If more than one data set is used, this needs to be included in the application.
- Section B 3e: which primary data will be used and how will this be collected?
- 5: ethical approval from another body; please complete this section.

Please revise your declaration according to the above.

All Exemptions from Full Review are subject to Research Ethics Compliance Review. Please ensure that the Exemption Form is signed by the student/s, supervisor (if applicable) and Head of School, and that this signed document is retained in your school as part of your record.

Kind regards,

Dr Hamish Fleming
Taught Masters Ethics Committee

Page 1 of 1

APPENDIX C – Case Report Form

Project Title: The relationship between socio-economic indicators and the prevalence of type 2 diabetes mellitus among adults aged 50 years and older in the Republic of Ireland (2009 & 2015) using the TILDA cohort study.

Investigators and Affiliations: Chinyere Elizabeth Kalu (UCD); Associate Professor Mary Codd and The Irish Institutional Study on Ageing (TILDA): Harmonized TILDA, 2016 and Wave 3 data from Irish Social Science Data Archive (ISSDA).

1. Administrative Data *For Official Use Only*

1.1. Individual Identifier ____________________

1.2. Date of interview ____________________

(dd/mm/yyyy)

2. Demographic Data

2.1. Age (years) ____________________

Please tick the appropriate boxes

2.2. Gender ☐ Male ☐ Female

2.3. Highest Education received ☐ Lower secondary school and less

☐ Upper secondary or vocational training

☐ Tertiary education

2.4. Marital status ☐ Married ☐ Partnered

☐ Separated ☐ Divorced

☐ Widowed ☐ Never married

2.5. If married / partnered, Age of partner ____________________

2.6. Employment Status ☐ Employed / Self-employed

☐ Retired

☐ Not employed/ not self- employed/ not retired

If "not employed/ not self-employed/ not retired" skip to 2.8

2.7. How many years did you work during employment? ____________

2.8. Nationality ____________________

3. Geographic Data

Please tick the appropriate boxes

3.1. Area of Residence ☐ Rural area

☐ Town / City (excluding Dublin)

☐ Dublin city / county

3.2. Were you born in Ireland? ☐ Yes ☐ No

3.3. How many years have you lived in Ireland for? ______________________

3.4. Have you ever lived outside Ireland longer than 6 months? ☐ Yes ☐ No

If "no" skip to 4.1

3.5. What country have you lived in the longest? ______________

4. Health Status Data

For each question, tick the box that applies

4.1. How would you rate your general health? ☐ Excellent ☐ Very good

☐ Good ☐ Fair

☐ Poor

4.2. Have you been told you have Diabetes by a doctor? ☐ Yes ☐ No

4.3. Do / did any of your primary/ first-degree relatives (mother, father, sister, brother, daughter or son) have any of these conditions:

Please tick the appropriate boxes

a) Diabetes / high blood sugar ☐ Yes ☐ No

b) Obesity ☐ Yes ☐ No

c) High cholesterol ☐ Yes ☐ No

4.4. How tall are you in metres? __________

4.5. How much do you weigh in kilograms? ____________

4.6. Latest result from glycated haemoglobin test (HbA1c) in mmol/mol ______________

5. Lifestyle Data

5.1. In the past 7 days, how many days did you engage in:

a) Vigorous physical activity ______________________
b) Moderate physical activity ______________________
c) Light physical activity ______________________

5.2. Do you drink any alcohol? ☐ Yes ☐ No

If "no" skip to 5.5

5.3. If yes, how often did you drink alcohol in the last 6 months?

Please tick one

☐ None in the last six months ☐ Once or twice a week

☐ Less than once a month ☐ 3 or 4 days a week

☐ Once or twice a month ☐ 5 or 6 days a week

☐ Almost everyday

5.4. How many drinks did you have on the days you drank alcohol? _____________

5.5. Have you ever smoked cigarettes for up to 1 year? ☐ Yes ☐ No

5.6. Do you currently smoke cigarettes? ☐ Yes ☐ No

If "no" skip to 6.1

5.7. How many cigarettes do you smoke on average per day? ____________

6. Living situation Data

Please tick one

6.1. Does any child live with you in your residence? ☐ No children co-residing

☐ 1+ child co-residing

6.2. How many people live in the household with you? ____________

6.3. Details of each household member living with respondent:

No.	Name	Relationship	Age (years)

7. Healthcare Utilization and Insurance Data

Please tick the appropriate boxes

7.1. Have you had a cholesterol test in the last 2 years? ☐ Yes ☐ No

7.2. Have you visited the doctor in the last 12 months? ☐ Yes ☐ No

If "no" skip to 7.4

7.3. If yes, how many times did you visit the doctor? ____________

7.4. Have you received any home care in the last 12 months? ☐ Yes ☐ No

7.5. Have you ever visited the hospital as an outpatient in the last 12 months?

☐ Yes ☐ No

7.6. Are you covered by government health insurance? ☐ Yes ☐ No

7.7. Are you covered by private health insurance? ☐ Yes ☐ No

8. Finance Data

8.1. Including mortgages, approximately what is the value of your joint assets and the sum of all you and your spouse's financial assets such as life insurance, mutual funds, pension schemes, bonds, shares, properties, investments and savings in euros? ______________

8.2. What is the combined value of all income you and your spouse have received from employment, income, pensions and government transfers in the past 12 months before tax or reductions in euros? ________________

APPENDIX D – Data Dictionary

Project Title:
The relationship between socio-economic indicators and the prevalence of type 2 diabetes mellitus among adults aged 50 years and older in the Republic of Ireland (2009 & 2015) using the TILDA cohort study.

Investigators and Affiliations:
Chinyere Elizabeth Kalu (UCD, Ireland); Associate Professor Mary Codd and The Irish Institutional Study on Ageing (TILDA): Harmonized TILDA and Wave 3 from Irish Social Science Data Archive (ISSDA)

no.	Abbreviation	Name of Variable	Definition of Variable	Source	Type of Variable	Level of Measurement		Coding Option
1	ID	Individual Identifier	Unique identifier for each respondent	Assigned	Numeric	NA	NA	
2	RwIWY_T	Interview year	Year of interview for individual	Date	Date	NA	NA	
3	RwAGEY	Age (years)	Age (years) of respondent at interview	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999 = Unknown
4	RaSEX	Sex	Self-explanatory	Questionnaire	Qualitative	Categorical	Nominal	1 = Male, 2 -=Female, 999 = Unknown
5	RAEDUCL	Education category	Level of education completed by respondent	Questionnaire	Qualitative	Categorical	Nominal	1 = less than lower secondary, 2 = upper secondary and vocational training, 3 = tertiary, 999 = Unknown
6	RwMSTAT	Marital Status	Respondent's marital status	Questionnaire	Qualitative	Categorical	Nominal	1 = married, 3 = partnered, 4 = separated, 5 = divorced, 7 = widowed,

								8 = never married, 999 = Unknown
7	R2LBRF_T	Labour force status	Employment status for the respondent	Questionnaire	Qualitative	Categorical	Nominal	1 = employed / self-employed, 2 = retired, 3=not employed/self-employed/retired, 999 = Unknown
8	DM014	Nationality	Nationality based on current passport	Questionnaire	Qualitative	Categorical	Nominal	1= Irish, 2 = Non – Irish, 999=Unknown
9	LIVINGAREA	Living region	Whether respondent lives in urban or rural area	Questionnaire	Qualitative	Categorical	Nominal	1 = rural area, 2 = town or city (excl. Dublin), 3 = Dublin city / county, 999 = Unknown
10	DM015	Country of Birth	Self-explanatory	Questionnaire	Qualitative	Categorical	Nominal	1 = Ireland, 2 = Others, 999=Unknown
11	DM016	Years lived in Ireland	Self-explanatory	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999 = Unknown
12	DM017	Lived abroad	Whether respondent has lived outside Ireland longer than 6 months	Questionnaire	Qualitative	Categorical	Nominal	1 = No, 2 = Yes, 999=Unknown
13	DM046	Country lived in longest	Country the respondent has lived in for most of their life	Questionnaire	Qualitative	Categorical	Nominal	1 = United Kingdom, 2 = United States, 3=Other, 999=Unknown, 888=Not applicable

14	RwSHLT	Self-report of health	Respondent's self-reported general health status	Questionnaire	Qualitative	Categorical	Ordinal	1 = Excellent, 2 = Very good, 3 = Good, 4 = Fair, 5 = Poor, 999 = Unknown
15	R1DIABE	Diabetes Diagnosis	Whether a doctor has told the respondent they have diabetes or high blood sugar	Questionnaire	Qualitative	Categorical	Nominal	1 = No, 2 = yes, 999=Unknown
16	FAMDIABE	Diabetes in family	Immediate family history of diabetes	Questionnaire	Qualitative	Categorical	Nominal	1 = No, 2 = Yes, 999=Unknown
17	FAMOBES	Obesity in family	Immediate family history of obesity	Questionnaire	Qualitative	Categorical	Nominal	1 = No, 2 = Yes, 999=Unknown
18	FAMCHOL	High cholesterol in family	Immediate family history of high cholesterol	Questionnaire	Qualitative	Categorical	Nominal	1 = No, 2 = Yes, 999=Unknown
19	RwBMI	Body Mass Index (kg/m^2)	Calculated from respondent's self-reported height and weight	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999 = Unknown
20	HBA1C	Glycated haemoglobin test	Results gotten from glycated haemoglobin test	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999= Unknown
21	RwVGACTX_T	Vigorous physical activity per week	Respondent's frequency of vigorous level of energy physical activity in the past 7 days	Questionnaire	Quantitative	Discrete	Interval	Enter value given, 999 = Unknown
22	RwMDACTX_T	Moderate physical	Respondent's frequency of moderate level of	Questionnaire	Quantitative	Discrete	Interval	Enter value given, 999 = Unknown

		activity per week	energy physical activity in the past 7 days					
23	RwLTACTX_T	Light physical activity per week	Respondent's frequency of walking (light) level of energy physical activity in the past 7 days	Questionnaire	Quantitative	Discrete	Interval	Enter value given, 999 = Unknown
24	RwDRINK	Drinks alcohol	Whether respondent drinks alcohol	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
25	RwDRINKD_T	Alcohol consumption frequency	Frequency of alcohol consumption in the last months	Questionnaire	Qualitative	Categorical	Nominal	0 = none in the last 6 months, 1 = less than once a month, 2 = once or twice a month, 3 = once or twice a week, 4 = 3 or 4 days a week, 5 = 5 or 6 days a week, 6 = almost every day, 999=Unknown, 888= Not applicable
26	R1DRINKN_T	Number of drinks/ day when drinks	Number of drinks respondent had when they drank alcohol in the past 6 months	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999 = Unknown, 888=Not applicable
27	R1SMOKEV	Smokes ever	Whether respondent ever smoked daily for at least one year	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown

28	RwSMOKEN	Smokes now	Whether respondent presently smokes at the time of the interview	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
29	R1SMOKEF	Number of cigarettes per day	Indicates how many cigarettes are/ were smoked per day	Questionnaire	Quantitative	Discrete	Interval	Enter value given, 999=Unknown, 888= Not applicable
30	R1JYEARS	Years worked	Total number of self-reported years worked during employment	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999= Unknown
31	R1CORESD	Child residing with respondent	Whether any child resides with the respondent	Questionnaire	Qualitative	Categorical	Nominal	0 = no children co-residing, 1 = 1+ child co-residing, 999=Unknown
32	HH1HHRES	Number of people living in the household	Number of people in the household including the respondent	Questionnaire	Quantitative	Discrete	Interval	Enter value given, 999 = Unknown
33	HHwHHRESP	Household Respondents	Total number of age-eligible respondents in a household	Questionnaire	Quantitative	Discrete	Interval	Enter value given, 999 = Unknown
34	RwCHOLSTE	Previous cholesterol test	Whether respondent has had cholesterol test in the last 2 years	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
35	RwDOCTOR1Y	Doctor visit	Whether respondent has visited the doctor in the past 12 months	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
36	R2DOCTIM1Y	Frequency of doctor visit	Number of times respondents visited doctor	Questionnaire	Qualitative	Categorical	Nominal	0 = no doctor visits, 1 = 1-4 doctor visits, 2 = 5 - 9 doctor visits, 3 = 10-14 doctor visits,

								4 = 15+ doctor visits, 999 = Unknown, 888=Not applicable
37	RwHOMCAR1Y	Home health care utilization	Whether respondent has received any home care in the last 12 months	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
38	RwOUTPT1Y	Outpatient visit	Whether the respondent has visited the hospital as an outpatient in the last 12 months	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
39	RwHIGOV	Government health insurance	Whether respondent is covered by government insurance	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
40	RwHIPRIV	Private health insurance	Whether respondent is covered by private health insurance	Questionnaire	Qualitative	Categorical	Nominal	1 = no, 2 = yes, 999=Unknown
41	HwATOTB	Total wealth in euros	Net value of all respondents and partner's assets including any mortgages	Questionnaire	Quantitative	Continuous	Interval	Enter value given, 999=Unknown
42	HwITOT	Total couple level income in euros	Accumulated value of all couple's income incl. earnings, pension and government transfers	Questionnaire	Quantitative	Continuous	Interval	Enter values given, 999 = Unknown

NA = Not Applicable