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The economic approach to diabetes among older adults

Beatriz Rodriguez Sanchez

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Rodriguez Sanchez, Beatriz

The Economic Approach to Diabetes Among Older Adults

A Focus on European Countries

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A focus on European countries

PhD thesis

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by

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I can still remember the first time I heard someone suggesting me to start a PhD. My first (and very quick) answer was a big no. I just needed a few months to take one step back and to be sure that doing research is what I wanted then and what I want to do now and continue doing in my career life. It was not one single moment or a person what changed my mind, but rather something else that I knew was going to be my side during this whole trip: Stata. Maybe love at first sight, with, of course, ups and downs during these three years of PhD. This great adventure has involved many more characters, and I would like to devote some space here for all of them.

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Finally, this thesis is especially dedicated to my mother; there is a piece of you behind everything I do, and I know you are taking care of me from above, I love you so much.

Beatriz Rodriguez Sanchez
Groningen, December 2017

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND OBJECTIVE

What is diabetes?

According to the Centre for Disease Control and Prevention (CDC), diabetes mellitus (DM) is "the condition in which the body does not properly process food for use as energy. (…) The pancreas, makes a hormone called insulin to help glucose get into the cells of our bodies. When you have diabetes, your body either doesn't make enough insulin or can't use its own insulin as well as it should"[1].

However, it should be noted that there are different types of diabetes mellitus and only in one of them ageing is a risk factor. Type 1 diabetes mellitus (T1DM) is also known as juvenile-onset diabetes, showing symptoms in childhood or early adulthood. It cannot be prevented and its prevalence represents 5 – 10% of all diabetes cases (ADA, 2017; NIDDKD, 2013). On the other hand, type 2 diabetes mellitus (T2DM) is commonly developed during adulthood, could be prevented or delayed with healthy lifestyles and represents 90 – 95% of all DM cases (ADA, 2017; NIDDKD, 2013). Finally, gestational diabetes develops in 2 to 5% of pregnant women and, although gestational diabetes disappears when the baby is born, women who have had gestational diabetes are at greater risk of suffering from T2DM in their adulthood (NIDDKD, 2013).

Given the high prevalence of T2DM among total diabetes cases and the effect of ageing on its prevalence, in this thesis I focus on T2DM. Moreover, around one fourth of the total global burden of disease is due to disorders in older people, being 50% of the burden held by high-income countries (Prince et al., 2015), and diabetes is not an exception (Prince et al., 2015; Murray et al., 2012). Older people represent around half of the people with diabetes and diabetes prevalence reaches one in every four adults aged 65 years old and above (Soriguer et al., 2012). Furthermore, diabetes is one of the largest factors increasing the risk of mortality, morbidity, and disability over the world and its economic burden demands new ways to curb diabetes health care expenditure (De Lagasnerie et al., 2017).

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[1] https://www.cdc.gov/media/presskits/aahd/diabetes.pdf.

Cost of illness (COI) and Burden of disease (BOD) studies

Costs-of-illness (COI) studies are widespread in health economics. Their aim is to provide estimates about the economic burden that any disease might impose on the society (Drummond et al., 2015). COI studies assess the financial burden due to the corresponding condition, including direct and indirect expenditures that result from premature mortality, disability or injury (Jo, 2014; Larg and Moss, 2011). Costs might refer to the hospital costs, which in most countries are one of the most important types of costs (Carey, 2014), but also other cost components including visits to physicians and nurses, drug costs, and visits to the Emergency Room (Oliva et al., 2004). These costs would be called healthcare direct costs, that is, medical expenditures derived from diagnosis, treatment, and rehabilitation. Other direct costs, but non-healthcare related, might also be taken into account, such as transportation or informal care. However, COI studies can also refer to indirect medical costs and indirect non-medical costs, which mainly consist of productivity losses (Neumann et al., 2016). Productivity losses involve both the reduction of work productivity due to the disease and the complete cessation of work due to the disease-specific disability or mortality, supported by the individual, the family, the society as a whole or by the employer.

True knowledge about COI is of help to implement healthcare programs and interventions and eventually allocate health care resources subject to budget constraints to achieve efficiency (Jo, 2014). COI results are useful for several reasons. Firstly, they can serve as an argument to inform policies on a specific disease and its related complications (Larg and Moss, 2011), which should be given a high priority in a policy agenda setting in light of the estimates obtained (Jo, 2014). Secondly, they might be of help to identify target populations who could be subject to specific problems and policies (Drummond et al., 2015). Thirdly, their results could be used to determine the efficacy of any health intervention designed to reduce or eradicate the disease effects (Jo, 2014; Larg and Moss, 2011).

Burden of Disease (BOD) studies focus instead on the burden of a particular disease on the years of life lost (YLL) due to premature death, and the years lost due to disability (YLD). These two categories lead to another measure, Disability-Adjusted Life Years (DALYs), which involves health losses resulting from premature death or disability, probably leading to larger healthcare costs and forgone economic or societal contribution (Jo, 2014). Those studies include analyses on the incidence or prevalence of a specific disease and its impact on longevity, morbidity as well as its effect on health status and quality of life (Jefferson et al., 2000).

In this thesis, I aim to assess the economic and wellbeing-related consequences of diabetes among older adults, looking at both direct medical (total care costs and nursing home costs) and indirect costs (reduction of productive activities and quality of life).

Diabetes and COI / BOD studies

Burden of Diabetes has been ranked as the seventh and eighth cause of YLL and DALYs respectively in Western Societies (Murray and López, 2013) and the 14th cause all over the world in the ranking of causes of DALYs (Murray et al., 2012), accounting for 1.9% of total DALYs and with an increase of more than 60% in 2010 as compared with the data obtained in 1990.

Direct medical costs derived from diabetes represent $116 billion per year (30% of Medicare budget in 2007) for the US government, assessing an average expenditure per capita and per year for an elderly patient between $3,407 for the most-conservative estimate and $9,713 for the least conservative one (Anderson, 2012). The literature has already found that, for the particular case of diabetes in eight European countries (Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom), the direct healthcare costs associated to hospitalization explain around 55% of the total costs, whereas drugs explain 30% (Jönsson, 2002). Other studies such as the United Kingdom Prospective Diabetes Study (UKPDS) (Alva et al., 2015) and the Australian work carried out by Clarke et al. (2008) have also estimated the associated costs of clinical complications in old patients with diabetes focusing only on inpatient hospital admission and primary healthcare services. Both studies show the large impact of diabetes-related complications on healthcare costs, not only in the first year after diagnosis, but also in the following years. Average glucose control has also emerged as a determinant of higher diabetes-related costs, whose management has been found to represent more than one quarter of direct diabetes-related healthcare costs (Köster et al., 2014) and to avoid costs in the short and long run after sustained control (Baxter et al., 2016). Diabetes among older people also increases the risk to be institutionalized. Diabetes has been found to be significantly associated with nursing home placement among the frail elderly and, furthermore, older people with diabetes are 1.8 times more likely to be institutionalized (Matsuzawa et al., 2010). Around 30-35% of institutionalized older people have diabetes (Newton et al., 2013).

Moreover, some researchers have also looked at the impact of diabetes on indirect costs. With respect to productivity losses, diabetes has been found to significantly reduce productivity, (ADA, 2013; Hex et al., 2012; Tunceli et al., 2005), even forcing an early labour-force exit (Rumball-Smith et al., 2014; Herquelot et al., 2011; Norlund et al., 2001) and leading to great economic losses in people with diabetes (Bolin et al., 2009). For example, in Spain, the total cost of productivity loss due to diabetes was projected to be €2.8 billion in 2009 (López-Bastida et al.,

2013) and to account for a total of 154,214 days due to temporary disability generated by diabetes and its complications in 2011 (Vicente-Herrero et al., 2013).

The existing literature has also supported the negative impact that diabetes has on quality of life (Vadyia et al., 2015; Schunck et al., 2012; Papadopoulos et al., 2007; Rubin and Peyrot, 1999), being consistent across health-related quality of life (HRQoL) instruments (Kontodimopoulos et al., 2012; Fu et al., 2011), signalling the relevance of micro and macrovascular diseases (Javanbakht et al., 2012; Redekop et al., 2002). Some authors actually state that the quality of life in people with diabetes worsens due to complications and not due to diabetes itself (Venkataraman et al., 2013).

However, the studies aforementioned lack another component which should be part of the economic analyses in older people: functional status. Functional status is defined as the individual's ability to perform activities of daily life, including self-care and household and physical activities, in order to maintain individual's health and wellbeing (Leidy, 1994). Functional status is one of the most important components in determining the use of health-care systems (Weiss, 2011) and the annual healthcare costs in older populations (Lubitz et al., 2003), which increase in near three folds in people with any limitation in Activities of Daily Living (ADL) compared to those who remain independent. Moreover, diabetes has an increasing negative effect on functional autonomy as people become older (Wong et al., 2013; Kalyani et al., 2010), switching from the traditional focus of living longer without life-threatening complications to extending remaining years lived free from disability (Sinclair et al., 2015).

Why this thesis?

Although it has already been established that the economic burden of diabetes on national healthcare services and public expenditures is quite large (OECD/EU, 2016; Alva et al., 2015; ADA, 2013), as far as I am concerned, there are no relevant and comprehensive studies about the broader economic impact of diabetes among older adults, paying special attention to the role of functional status. The current defiance embraces methodological issues on how to analyse health costs (Wu et al., 2012), or the weight of functional impairment versus comorbidity and complications in the determination of the costs.

The scenario for the next decades shows an increase in the costs associated with the management of people with diabetes due to the ageing of the population and the higher costs per capita among older adults (Waldeyer et al., 2013). Those increasing costs constitute a new challenge for the Health Systems that should implement models of care tailored to the needs of this population (Sinclair et al., 2011).

This thesis aims to contribute to the existing literature by bringing a new and broader insight on the diabetes burden among older populations by not only examining the traditional healthcare resource use and costs associated with diabetes in older people (costs of care for people with diabetes), but also other costs less frequently evaluated, such as nursing home expenditures, and the impact of diabetes on quality of life and productive activities. Additionally, I build on the existing literature by including in the analysis not only the clinical complications that might be suffered at the same time and due to diabetes, but also functional impairment. Diabetes has an increasing negative effect on functional autonomy as people become older (Wong et al., 2013; Kalyani et al., 2010;), having been ranked as the eighth cause of DALYs in Western societies (Murray and López, 2013). Moreover, I use a variety of datasets in this thesis: administrative (Vektis and ZODIAC data in Chapter 2) and survey datasets (the Survey of Health, Ageing and Retirement in Europe, SHARE, in Chapters 3 and 4; and the Toledo Study on Healthy Ageing, TSHA, in Chapter 5), which allow me to explore different sources of information (claims, clinical and self-reported data) on individuals living in different institutional settings.

In the following section, I provide a description of the chapters that are part of my thesis and the specific objectives which I aim to analyse.

1.2 SUMMARY AND MAIN FINDINGS

In Chapter 2, I use Dutch claims data (Vektis) combined with a Dutch GP registry dataset (ZODIAC) to examine the association between average glucose control and care costs incurred by people with diabetes, but not necessarily due to diabetes. I additionally explore the diabetes diagnosis cohort effects and treatment modality. I also distinguish by cost type (total care, General Practitioner (GP), drugs, hospital and specialist, and devices costs). Data has been taken from those two linked datasets, which allows me to use administrative data on all medical treatments reimbursed by Dutch insurance companies within the mandatory insurance package and clinical measurements for a four-year time period window (2008 – 2011).

The results show that average glucose control is significantly associated with higher care costs in people with diabetes, although its impact on costs is mediated by diabetes treatment modality. When I include oral medication and insulin as diabetes treatment variables, a 1% higher HbA1c is significantly associated with an increase in total care costs only if the individual is not being treated with insulin nor with oral medication; no significant effect of HbA1c is reported when the person takes oral medication or uses insulin. However, insulin does report a significant association with higher care costs, regardless of the covariates part of the analysis. Another important finding is that the positive effect of diabetes duration on care costs increases when I

control for year of diabetes onset cohort effects. Actually, without including cohort effects, total costs will increase up to a diabetes duration of 25 years and will decrease afterwards, but, when I include year of onset categories, the threshold at which care costs start decreasing is after 35 years of diabetes duration. McBrien et al. (2012) concluded that healthcare costs in people with diabetes always increase with time since diagnosis after the first five years, as I do, but I do find that the increase in costs will have a decreasing effect after 35 years lived with diabetes, which has not been previously reported in the literature. Lastly, correcting for treatment modality, diabetes duration and year of onset cohorts has led to another innovative result: age is not significantly related to care costs, which has traditionally been linked to increasing care costs (Trogdon and Hylands, 2008; Nichols and Brown, 2002). I not only look at the impact of average glucose control on care costs incurred by people with diabetes, but also at treatment modality, diabetes duration and year of onset effects, which have not been jointly assessed before. Excluding these factors could lead to biased estimates.

Chapter 3 addresses the role of diabetes and a list of clinical and functional complications on the probability of nursing home admission in people older than 50 years old using data from the Survey of Health, Ageing and Retirement in Europe (SHARE). I take data for three different waves: wave 1 (2004), wave 2 (2006-07) and wave 4 (2010); and twelve countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, The Netherlands, Spain, Sweden and Switzerland). Moreover, I aim to analyze whether there are differences across European countries and other subgroups of analysis (by age or gender and by length of stay), in the association between nursing home placement and the main variables of interest. After obtaining these results, the estimates will be used to assess nursing home expenditures attributable to diabetes and its complications in Europe and to explore potential differences between European countries.

My results confirm that diabetes is positive and significantly associated with nursing home placement. Diabetes increases the risk of institutionalization, although its effect decreases when diabetes-related clinical complications are included and especially when functional status is introduced. The effect of diabetes is consequently mediated by clinical and functional complications, reducing the impact of diabetes on the probability of being admitted to a nursing home. Moreover, the effect of functional impairment on the risk of institutionalization is age-dependent, increasing the risk of nursing home placement as people become older. Total average nursing home costs reached $12.66 per capita over all countries, representing the several degrees of functional impairment 78% of the costs attributed to complications.

Although in the overall sample no interaction between diabetes and complications are significant, some differences across countries are indeed reported. In Belgium, France and Greece, diabetes and stroke are significantly related to the risk of institutionalization, whereas diabetes together with functional impairment rises the likelihood of being admitted to a nursing home in Spain. The Netherlands is the top country in nursing home expenditure for people with diabetes, from which more than 25% are due to mild functional impairment. The substantial character of functional status is also confirmed across countries, representing the greatest proportion of costs, especially in Spain, The Netherlands and Germany, usually followed by stroke. Additionally, when institutionalization costs are interpreted as percentages of Gross Domestic Product (GDP) per capita, Spain is the country where costs strictly attributed to diabetes complications show the greatest value as a proportion of GDP per capita, with functional impairment bearing the largest burden. The results contribute to the literature by showing that functional impairment not only helps to explain part of the cost, but it is the main driver of higher nursing home costs. Moreover, it is the first cross-countries analysis looking at the burden of diabetes on nursing home use and costs among older Europeans.

Chapter 4 focuses on the relationship between diabetes and two measures of productive activities, being afraid health limits work for older people still in the working age (50 to 65 years old) and being a formal volunteer for people aged 65 and above who are already retired. For this analysis, I use data from waves 2, 4 and 5, corresponding to the years 2006/07, 2010 and 2013, respectively, and eleven European countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden and Switzerland) from SHARE. Observing the trends among that period could shed more light on how relevant health is with respect to productivity in periods of economic uncertainty. I additionally control for clinical and functional complications, as the effect of diabetes is generally mediated by its comorbidities.

I show that diabetes is associated with productive activities in older adults, both paid and non-paid. Diabetes increases the likelihood of people aged 50 to 65 years old reporting being afraid health limits work, suggesting a positive relationship between diabetes and the fear of health limiting work in people still in the working age. The fear of health limiting work increases during the years after the crisis, 2010 and 2013, compared to the year 2006, even after including clinical complications. This could reflect the increased uncertainty of the employment situation after the economic crisis. Moreover, the probability of being afraid health limits work significantly increases with the interaction between diabetes and year 2010, but no significant effects are found for the interaction with the year 2013. This result might be driven by the combination of the impairing effect of diabetes together with the fact that the economic crisis hit stronger in the

early years of the crisis, leading to a greater fear of health limiting the individual´s performance at work. With respect to volunteering engagement in people older than 65 years old, diabetes reduces the likelihood of doing charity work in comparison to those people without diabetes, as well as the frequency of carrying out such activity. Year 2010 increases the probability of doing charity work in a larger degree than in year 2013. The rationale behind such increase might be greater solidarity or greater need for charity work rather than the individual willingness to be productive. The interactions between having diabetes and years 2010 and 2013 are not significant predictors of volunteering. Moreover, some differences are observed across countries. Only in Denmark, a positive, but not significant, effect is reported in the association with the likelihood of being afraid health limited work, whereas a significant and negative relationship between Italy, Spain, Austria, Sweden and the Czech Republic and volunteering is shown. The results would contribute to the existing literature in several ways. Firstly, by filling the gap on non-paid activities among older people, as much has been written about productivity losses and wages in people with diabetes, but little is known about the relationship with volunteering. Secondly, I additionally control for clinical complications and mobility problems, and not only for diabetes as the main clinical factor. Finally, I have also assessed the influence of uncertain economic periods, which has not been done before, suggesting that there might be an effect of uncertain economic situations on both subjective (fear of health limiting work) and objective (volunteering participation) productivity measures.

In Chapter 5, the aim is to build on the existing literature on Health-Related Quality of Life (HRQoL) and diabetes by analysing the relationship between some factors that could determine the differences in HRQoL among older people with and without diabetes, adding not only the clinical complications, but also the frailty syndrome, which worsens as age increases and leads to higher risk of disability, hospitalization and mortality, as a measure of functional impairment. The analysis is run using data from the first two waves, which correspond to the years 2006 – 2009 (wave 1) and 2011 – 2013 (wave 2) from the Toledo Study on Healthy Ageing (TSHA). Moreover, the association between frailty and the number of comorbidities will be jointly analysed distinguishing by diabetes status to explore the existing differences between those with and without diabetes.

The results confirm that diabetes is associated with lower quality of life in older people, compared to people without diabetes, although its effect decreases when diabetes-related clinical complications are included. But, if the different categories of the frailty syndrome (being pre-frail and frail) are part of the analysis, diabetes is no longer significantly associated with quality of life. Thus, the burden of diabetes on quality of life in older people is mediated by clinical

complications, but more importantly by frailty. When I compare the population with diabetes with those without diabetes, frailty bears the greatest and more negative impact on quality of life in both subsamples. Differences between both groups are significant, with the conditions included in the analysis showing a greater negative effect on the quality of life of people with diabetes than in those without diabetes. The results show that, after frailty, the number of diabetes-related conditions lead to greater reductions in quality of life in people with diabetes, confirming the detrimental effect of single and multiple complications on quality of life. When looking at the joint effect of chronic conditions and frailty, in case of people with diabetes and being frail, having four diabetes-related conditions reduces quality of life the most. Quality of life in people without diabetes is reduced the most when three non-diabetes-related chronic conditions are given jointly to pre-frailty. These figures could provide a valuable contribution to the existing literature since it is the first analysis looking at the burden of diabetes on quality of life in old people analyzing the impact of a list of chronic conditions, additionally comparing people with and without diabetes. It is also pioneer in including the frailty syndrome as one of the factors involved in predicting HRQoL scores, which emerges as the main mediator of the negative burden of diabetes on the outcome.

1.3 POLICY RECOMMENDATIONS

The above results are relevant for public policymakers and other decision makers that provide the society with diabetes prevention and management guidelines, as well as the introduction of new treatments for the disease. I will now consider the policy recommendations that follow from the results that have been obtained.

<u>The key influence of functional status when estimating cost of illness in ageing populations</u>

The main implication driven from this thesis is that the burden of diabetes among older adults is especially mediated by functional status. It is noteworthy that functional status not only helps to explain the associations between diabetes and the different outcomes studied in the thesis (productive activities, nursing home cost and quality of life), but it is the main one. Actually, the results from chapter 3 show that the relationship between functional status and healthcare use is age-dependent, as it is clearly shown in people older than 65, but not so evident in people with ages ranging from 50 to 65 years old. It has already been reported in the literature that functional status is one of the most important components determining the use of health-care systems (Weiss, 2011) and the annual healthcare costs in older people (Lubitz et al., 2003). However, no study has been found including functional status when assessing the economic impact of chronic diseases among older populations, controlling for clinical conditions.

Previous figures about the costs attributable to diabetes among older populations could be overestimating the impact of some other comorbidities that have traditionally been linked to diabetes, such as cerebrovascular diseases, when not controlling for functional status. Policymakers would have had the wrong focus when informing policies and diabetes guidelines, since the main surrogate of increasing costs is functional status. Even though my thesis focuses on one single disease, diabetes, the relevance of functional impairment among older people should be taken into account when measuring and evaluating the healthcare needs in this particular group of the population, as well as its impact on indirect costs.

The scope of diabetes treatment and management among older people

The results from this thesis suggest that the scope of diabetes treatment and management among older individuals should be focused on modifiable factors (diabetes treatment and average glucose control), but especially on the factors that lead to disability, such as functional impairment. Older people with a longer diabetes duration might be in need for different and more costly treatment, such as insulin, and at a higher risk of developing disability, as it has already been reported in the literature (Huang et al., 2011; Stolar, 2010). An in-depth analysis of those factors could lead to the implementation of cost saving policies.

Data collection, availability and suitability

The findings presented from the third, fourth and fifth chapters show that functional status is a relevant variable to be considered when studying older people. However, and as it has been shown in Chapter 2, such information is not frequently available. Hence, I propose to collect more specific data covering the particularities of ageing populations and making them publicly accessible to researchers. Some measure of functional impairment (if not frailty status, limitations in the activities of daily living) should be collected in addition to chronic conditions.

Chapter 2 also highlights the relevance of combining different datasets, as it has been supported that using claims administrative data reduces biases probably found in other data sources (self-reported data) and allowed access to laboratory, clinical and costs registries data. Reliable estimations on care costs per patient would then be provided to policymakers.

Promote a healthy and active ageing

Two measures of indirect costs, quality of life and productive activities, have been assessed in this thesis. My results show that in those aged 65 and above, diabetes reduces the likelihood of performing volunteering work in comparison to those people without diabetes, as well as the frequency of carrying out such activity. In spite of being non-paid productive activities, it might

be one way for older people to feel fruitful (Rumball-Smith et al., 2014; Hank, 2011). Their engagement into those activities report positive outcomes to them and to the society as a whole, so volunteering should be promoted to support a healthy and active ageing.

Chapter 5 shows that diabetes is associated with a reduction in quality of life in people aged 65 years old and above, although its effect is mainly mediated by functional status. Through prevention of chronic diseases, as it is diabetes, and prevention of disability would avoid quality of life losses due to these conditions, leading to a healthy ageing process.

CHAPTER 2

COSTS OF CARE IN PEOPLE WITH DIABETES IN RELATION TO AVERAGE GLUCOSE CONTROL: AN EMPIRICAL APPROACH CONTROLLING FOR YEAR OF ONSET COHORTS[2]

2.1 INTRODUCTION

The number of adults with diabetes has substantially increased (OECD/EU, 2016; NCD Risk Factor Collaboration, 2016), affecting 4.3% and 5% of the men and women adult populations in 1980 and getting to 9% and 7.9%, respectively, in 2014 (NCD Risk Factor Collaboration, 2016). In case of the Netherlands, diabetes prevalence has recently been estimated to be 5.45% (Kleefstra et al., 2016), and 5.13% specifically for type 2 diabetes. The substantial increase in the number of adults suffering from diabetes can largely be attributed to the effects of adverse lifestyle, the population growth and ageing and the joint effects of these factors together (NCD Risk Factor Collaboration, 2016; Wild et al., 2004).

The increase in diabetes prevalence will be accompanied by an increase in diabetes-related care costs (OECD/EU, 2016). Diabetes expenditure in 2010 was estimated to represent, on average, 12% among the total world health spending (1,330 US dollars per person with diabetes), with a considerable variation in per capita spending between countries. The average total care cost per Dutch individual with diabetes reached 4,000$ (Zhang et al., 2010). Moreover, those figures were projected to increase by 30/34% by the year 2030.

It has already been stated in the literature that in many countries medical costs in people with diabetes are three times greater than in individuals without diabetes (Clarke et al., 2010), 35 – 40% of the total care costs being due to the management of clinical complications, mainly cardiovascular diseases, and hospitalization costs (Bruno et al., 2008). The risk for developing both micro and macrovascular complications is – amongst others - associated with the degree of long-term glycaemic control (Huang et al., 2011; Stolar, 2010). Hence, one might expect worse

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[2] This chapter uses data from two linked datasets, Vektis and ZODIAC, for the years 2008, 2009, 2010 and 2011. The author would like to thank Chantal van Tilburg and Mirte van Galen for their help with the data.

glycaemic control to also be associated with increased care costs (Degli Esposti et al., 2013; Shetty et al., 2005). A 1% (1 mmol/mol) lower HbA1c level has been found to be associated with a 37% reduction in the prevalence of microvascular complications (Stratton et al., 2000), showing an association between microvascular complications, HbA1c and care costs (Gilmer et al., 2005). These costs might be not too outspoken, since major care costs are driven by macrovascular complications (Herman, 2011), which are not only related to glycaemic control, but also to blood pressure, cholesterol, smoking and other risk factors (Lorber, 2014). Still, impaired glucose tolerance has been found to increase the mortality risk due to cardiovascular diseases (Huang et al., 2011). Hence, an appropriate management of diabetes and glycaemic control might reduce the risk of developing complications and mortality, and thus limit the rise in spending on diabetes care (Shetty et al., 2005). Intensive glycaemic control programs have been found to be very cost-effective in the literature (Liebl et al., 2015; Li et al., 2010; Herman et al., 2005), leading to £258 cost reduction per patient with diabetes in the United Kingdom (Clarke et al., 2001). This was, however, mainly in populations with years of onset in the 1990s and may have changed for recent cohorts that were treated more intensively to begin with.

Most of the available studies measuring the economic impact of glycaemic control place their focus on the long-term savings and lifetime medical costs (Zhuo et al., 2013), but less evidence has been found analysing the short-term burden of glycaemic management on care costs in people with diabetes. Degli Esposti et al. (2013) used data from Italian clinical and administrative registries on 21,586 people with diabetes to analyse the two-year diabetes-related costs according to their glycaemic level. People were classified into five categories according to target HbA1c (HbA1c ≤ 7%) values achieved: excellent (≥80%), good (60%–79%), fair (40%–59%), poor (20%–39%), and very poor (<20%). Authors found that costs for those with good glycaemic control increased mean 2-year total costs by 219.28€ compared to those with excellent HbA1c levels. Similarly, McBrien et al. (2012) concluded that costs for those Canadians with diabetes and with poor glycaemic control increased mean 5-year total costs by 1,623$ compared to those with good HbA1c levels. Higher costs of people with glycaemic levels above target (HbA1c level > 7%) compared to those within target have previously been reported (Menzin et al., 2010; Shetty et al., 2005). These costs were larger when the individual had comorbidities.

Diabetes duration seems to be highly related to increasing healthcare costs due to several reasons. Some researchers have analysed the differences in care costs according to time since diabetes diagnosis, stating that each additional year with diabetes increases annual medical expenditures by $75, when controlling for diabetes complications (Trogdon and Hylands, 2008). However, such increasing trend in medical care costs might be observed only after the first four

years of diagnosis, as some authors have already reported (Nichols and Brown, 2002). Costs were found to be higher during the year immediately after diagnosis. Thereafter, costs followed a U-shaped trajectory, dropping during the first years after diagnosis, and then rising again. First of all, diabetes increases healthcare costs given its associated risk of developing several chronic conditions over time or due to the poor or incomplete control of diabetes-complications (Trogdon and Hylands, 2008). Secondly, glucose levels control might become more difficult over time (Turner et al., 1999), possibly needing multiple treatments in the long-term in order to achieve target glucose levels.

However, as far as I know, no study has been found assessing the impact of glycaemic control on diabetes care costs by diabetes duration cohort. By assessing the diabetes onset cohort effects, I could infer whether there is any pattern by time of diabetes onset in care costs and how the cohort effects impact the associations between diabetes duration and care costs, as well as average glucose control and total costs.

Hence, this study contributes to the existing literature by estimating the impact of average glucose control on total care costs in people with T2DM, not necessarily diabetes-related care costs, i) additionally controlling for diabetes treatment, as drug therapy for glycaemic control represents 18% of the total cost (Liebl et al., 2015) and treatment modality modifies the mean glucose level (Booz&Co, 2011); ii) adding diabetes duration and year of diabetes onset effects, which have not been jointly analysed before, by exploiting the iii) panel feature of the data. For doing so, I will use administrative data from the national Dutch insurance dataset on healthcare use and care costs incurred by people with diabetes and linked data on clinical measurements from ZODIAC dataset, for a four-year time period window, from the year 2008 to the year 2011. I will also include a list of registered clinical diagnoses in the analyses.

In summary, I find that the effects of glucose level on total care costs is mediated by the treatment modality, especially in case of insulin use. Moreover, I show that if I don´t control for year of onset effects, different and inconsistent estimates of the duration effect are obtained.

The chapter is structured as follows. Section 2.2 presents the data that has been used, the variables selected for the analysis and the empirical approach that has been followed. Section 2.3 shows the results from the performed analyses. Section 2.4 discusses the findings, comparing them with the existing literature, suggesting some policy implications and mentioning the limitations of the study.

2.2   DATA AND METHODS

2.2.1 Data

Two datasets have been linked, Vektis and Zodiac databases, for the purpose of the study (Hendriks and Bilo, 2017). Vektis contains reimbursement data on all medical treatments paid for by Dutch insurance companies within the mandatory insurance package, including the costs for compulsory deductibles (Mohnen et al., 2015). Zodiac includes clinical data on subjects who were included in the Zwolle Outpatient Diabetes Project Integrating Available Care (ZODIAC) study, which started in 1998.

Vektis dataset

Vektis, the national insurance dataset on healthcare use, is an information system for healthcare use and costs data in the Netherlands. Individual claims data are available, categorized at various levels of detail. For the current study, claims were aggregated to annual care costs and into categories by expenditure type, such as hospitalization, specialist medical care, drugs, general practitioners, devices and others (obstetrics, maternity, paramedical care, dentistry, hospital transport, mental care and abroad costs). The Vektis database was established according to the Health Insurance Act implemented in 2006 (Ministry of Health, Welfare and Sport, 2012). Further individual information is available (year of birth and gender, socioeconomic status (SES), GP code, year of death) and taken from Vektis data.

ZODIAC dataset

ZODIAC data collection process started in 1998 as a prospective observational study examining the effect of shared care in people with type 2 diabetes mellitus in Zwolle, a city in the north-eastern region of the Netherlands. This shared care initiative became the standard care for the Zwolle region in 2002 and expanded to other regions in the Netherlands in later years, the extent of which has already been described elsewhere (Hendriks et al., 2015). General Practitioners (GPs) provide data on an annual basis to the Diabetes Centre. In 1998, 53 GPs were part of the project; during the years and for the sample included in the analysis, the amount of participating GPs increases from 317 in 2008 to 335 in 2011. ZODIAC contains all the information routinely gathered by GPs, as well as routine laboratory measurements.

Clinical measurements and other sociodemographic information (ethnicity), healthy lifestyle factors and prevalence of selected chronic conditions according to ICPC coding, are used from the ZODIAC dataset in this analysis. These will be described in the following section. Table 2.A1 in the Appendix provides a detailed description of the variables used in the analysis.

For the current study, data of all patients participating from year 2008 to 2011 in the Zodiac data were linked to the Vektis dataset to identify the healthcare costs of those patients. Linkage on patient level between data from the ZODIAC cohort and from Vektis was performed using the unique citizen service number or unique Insurance number. The privacy of all patients was assured by using a trusted third party (ZorgTTP) to combine the data and, subsequently, encrypt the personal identity number, thus creating a database with detailed information, which could not be traced to a known individual.

After linkage between both datasets, 211,484 observations were merged. Selecting only the individuals with complete follow-up over the period 2008 – 2011, no missing value in any of the variables which are part of the analysis and still alive in 2011, further reduced the sample to 22,612 observations[3], grouped in 5,653 individuals.

2.2.2 Variables description

<u>Dependent variable: care costs</u>

Total care costs incurred by people with diabetes, but not necessarily related to diabetes, are taken for the years 2008, 2009, 2010 and 2011. Those costs have been inflated or deflated, as appropriate, to 2010 euros, using the Consumer Price Index (CPI) found in Statistics Netherlands[4]. Costs that have not been included are uninsured care (i.e. informal care), as well as care from any additional insurance (extra number of treatments not covered by the insurance policy).

Table 2.1 shows the distribution of total care costs incurred by people with diabetes and the different costs components. On average, the most important cost components are hospital and specialist costs and drugs costs. The number of zeros in the cost items is very small, even in hospital costs, with one exception: devices costs. More than half of the individuals report no devices costs. The distribution of all cost items is right-skewed, all of them having their mean above the median (p50), with some differences in the skewness across costs components. Hospital and specialist costs are more skewed than GP costs. The mean of the former is higher than the costs claimed by more than 75% (p75) of the sample, whereas in the latter, the mean cost of the overall sample is above the mean cost for the 50% of the sample, but below the 75%. This provides statistical reasons to formulate the models in terms of the logarithmic variable

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[3] From the 211,484 initial observations, 42,770 were dropped as duplicates, leading to 168,714 remaining observations. From these, 80,544 were further removed as they had missing data in any of the variables used in the analysis, leaving 88,170 observations. Then, additional 11,973 and 53,585 observations were dropped due to being extreme values and non being present in the four years of analysis, respectively. This would then lead to the final sample of 22,612 observations.

[4] Inflate the 2008 costs to 2009 costs by multiplying them times 1.012 and then the 2009 costs to 2010 costs by multiplying by 1.013. 2011 costs were deflated to 2010 prices by multiplying the 2010 cost data times 0.9775.

instead of its original form, so the data distribution approximately follows a normal distribution. Regression models with the natural logarithm form also have an attractive economic interpretation as they will measure the relative increase in spending due to changes in the explanatory variables. Economists are often more interested in such relative effects than in absolute effects. Then, since the logarithmic transformation may also reduce heteroscedasticity (Heij et al*.,* 2004), I use the natural logarithm of total care costs generated by people with type 2 diabetes mellitus as the main dependent variable.

Table 2.1 shows that there is still some right-skewness in the logarithm (the mean of the logarithm of total care costs, 7.83, is slightly above the median, 7.70), but far less dramatic than with the original form.

Secondary outcomes are the different types of care costs that are included in the dataset, such as GP, hospitalization, drugs and devices cost, for which I also use their log-transformed costs as the outcome.

<u>Independent variables</u>

I use information on a set of sociodemographic characteristics (age, gender, ethnicity and socioeconomic status (SES)), diabetes duration, type of medication for diabetes (oral medication or insulin), a lifestyle factor (smoking status), laboratory and clinical measurements (average glucose control, measured by HbA1c in %) and indications of chronic conditions.

One of the main independent variables of interest in the present analysis is average glucose control, measured by HbA1c. It is a continuous variable expressed as a percentage of mmol/mol, with 5.7% as the maximum value indicating good HbA1c level in a person without diabetes and 6.5% in case of having diabetes, according to the American Diabetes Association (ADA, 2017). Average glucose control will be adjusted by type of medication reimbursed for treating diabetes, which consists of two dichotomous variables, 1) oral medication and 2) insulin, which take value 1 if the individual is either on diet or using oral medication or if the individual is using insulin, respectively, and 0 otherwise. The reason to include the interaction between average glucose control and treatment is that HbA1c is the representation of the efforts the individual and the healthcare professionals make to reach adequate metabolic control and the underlying disease severity. Its outcome is dependent on patient behavior (lifestyle aspects), Body Mass Index (BMI), treatment and treatment intensification.

Diabetes duration cohorts are also generated using the age at diagnosis variable, which was registered by GPs in the dataset. I will include the time since diabetes diagnosis, as well as the square of diabetes duration to control for its potential decreasing marginal effect.

Table 2.1: Distribution of costs, n = 22,612

	Mean (SD)	Number of zeros	P1	P5	P10	P25	P50	P75	P90	P95	P99
Total care costs (in 2010€)	4,361.32 (7,173.35)	0	470.17	677.96	816.82	1,248.36	2,214.55	4,396.38	9,536.25	15,308.57	34,558.11
Logarithm of total care costs	7.83 (0.96)	0	6.15	6.52	6.71	7.13	7.70	8.39	9.16	9.64	10.45
GP costs (in 2010€)	219.61 (130.01)	0	72.01	91.38	105.02	135.44	186.12	262.9	373.19	465.97	703.92
Logarithm of GP costs	5.26 (0.49)	0	4.28	4.52	4.65	4.91	5.23	5.57	5.92	6.14	6.56
Drugs costs (in 2010€)	1,008.33 (2,280.29)	33	53.01	121.25	181.15	345.23	686.24	1,214.63	1,964.17	2,577.1	4,642.47
Logarithm of drugs costs	6.45 (0.95)	0	4.06	4.81	5.21	5.85	6.53	7.10	7.58	7.85	8.44
Hospitalization costs (in 2010€)	2,259.23 (5,758.75)	198	3.21	36	49.4	139.54	485.87	1,647.02	5,747.85	10,990.69	27,742.84
Logarithm of hospitalization costs	6.23 (1.78)	0	2.01	3.70	3.98	4.97	6.21	7.42	8.66	9.31	10.23
Devices costs (in 2010€)	264.67 (698.54)	11,894	0	0	0	0	0	234.92	752.31	1,271	3,341.89
Other costs (in 2010€)	532.01 (1,974.05)	1,086	0	0	54	192.5	353.83	385	789.56	1,485	4,061.08

Moreover, dummy variables for three-year of diagnosis cohorts are generated to study cohort effects by diagnosis of diabetes. Year of diagnosis cohorts could help to explain potential variations in diabetes care costs over time among those individuals with shared year of onset.

In Figure 2.1, I plot the mean of the logarithm of total care costs in the years 2008, 2009, 2010 and 2011 for each three-year of diabetes onset cohort, represented by each coloured line. Assuming that there are no calendar year effects, the vertical difference between cohort lines measures the year of diabetes diagnosis cohort effect, whereas the difference along the same line exactly measures the diabetes duration effect within a cohort with same year of diabetes diagnosis. If the first observation of every cohort is connected, the 2008 cross-sectional relationship between care costs and diabetes duration would be obtained. However, it should be noticed that it is not possible to disentangle diabetes duration from cohort effects. When the cross-sectional feature is considered, the increase in the costs is smaller than when moving along the line of every cohort. The figure is consequently suggestive of existing year of onset cohort effects. By ignoring year of diabetes onset effects, the costs- diabetes duration gradient would be underestimated.

Figure 2.1: Mean logarithm of total care costs by diabetes duration and cohort
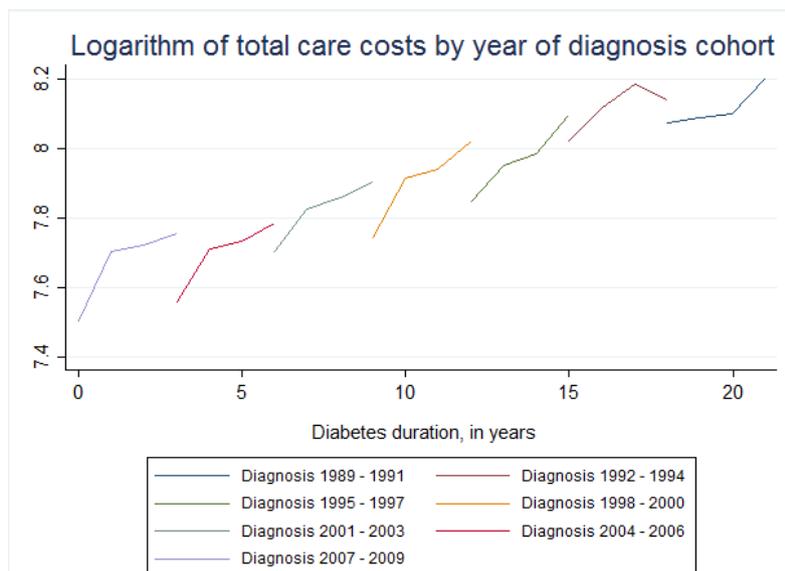
The logarithm of total care costs seems to have strongly increased across cohorts up to the individuals being diagnosed of diabetes between 1989 and 1991. A jump between three-year of onset cohorts for same diabetes duration is observed. The graph indicates that the biggest cohort time effect is between the cohort newly diagnosed (diabetes diagnosis between years 2007 to 2009) and the diabetes onset cohort between 2004 to 2006. The costs in those who are diagnosed

in years 2007 – 2009 and with a diabetes duration of four years are higher than in those who have been diagnosed between 2004 and 2006 at the same diabetes duration.

The figure suggests that the diabetes duration-time effect is also large. In particular, the newly-diagnosed individuals and those who have been diagnosed of diabetes between 1998 and 2000 and between the years 1995 to 1997 are suspected to have experienced a sizable increase in the logarithm of total care costs as the number of years lived with diabetes increases.

Such differences between year of onset cohorts can also be observed in hospital, drugs (although the year of onset effects are rather small, almost negligible for drugs costs, and the increase seems to be rather linear) and devices costs (Figure 2.A1, Appendix).

Figure 2.2 shows a similar picture for HBA1c against duration by year of onset cohort. Average glucose control increases with diabetes duration, indicating a poorer control of the disease as the number of years lived with the disease is higher. However, the figure does not really suggest so clear year of onset effects. Vertical differences in average glucose control by year of diabetes diagnosis cohort might also reflect the different need for treatment intensification with its associated changes in average glucose control when diabetes duration increases.

Figure 2.2: Average glucose control by year at onset cohorts
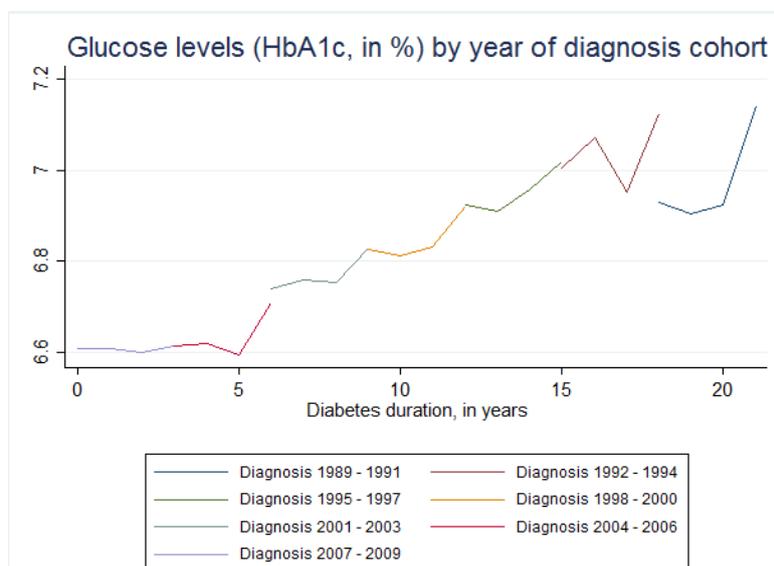
Chronic conditions are also corrected for in the analysis by means of what are called Elixhauser comorbidities. Elixhauser comorbidities allow researchers to classify comorbidities according to the International Classification of Diseases (ICD) diagnosis codes (Elixhauser et al., 1998). Such categorization has been widely used to assess hospital resource use and mortality (Menendez et al., 2014; Shaw et al., 2012). The information on chronic conditions was taken from the ZODIAC dataset, which did not contain the ICD diagnosis codes but the International

Classification of Primary Care (ICPC) codes. The ICPC codes have already been found to be able to be linked and, consequently, correspond to ICD codes (Jae-Yong et al., 2016). The list of Elixhauser comorbidities included in the current study are: cancer, congestive heart failure, acute myocardial infarction, peripheral vascular disease, uncomplicated hypertension, complicated hypertension, alcohol abuse, paralysis, stroke, any other cerebrovascular accident, dementia, chronic pulmonary disease, retinopathy, neuropathy, hypothyroidism, renal failure, liver disease, peptic ulcer, rheumatoid arthritis, weight loss, obesity, anaemia, psychosis and depression. The corresponding ICPC codes for each of the conditions have been listed in Table 2.A1, in the Appendix.

Elixhauser comorbidities will be divided into diabetes non-related and diabetes-related conditions. Diabetes non-related conditions refer to cancer, alcohol abuse, paralysis, chronic pulmonary disease, hypothyroidism, liver disease, peptic ulcer, rheumatoid arthritis, anaemia, psychosis and depression. Congestive heart failure, acute myocardial infarction, peripheral vascular disease, uncomplicated hypertension, complicated hypertension, stroke, any other cerebrovascular accident, dementia, retinopathy, neuropathy, renal failure, weight loss, obesity are considered the diabetes-related comorbidities.

Vektis dataset also contains the identification number of the GP that has treated every patient. Dummies for every GP will be added to the analysis as there might be a GP treatment effect, being some patients treated more efficiently depending on the GP that they go to.

Additionally, as lifestyle factors to be part of the analysis, I will include a dichotomous variable for those who are currently smoking.

I also include sociodemographic factors such as age and age-squared to additionally control for its potential decreasing marginal effect. For socioeconomic status, the Vektis standard categories were applied. SES has been created by Vektis according to postcode characteristics, following a normal distribution. Then, three quintiles have been generated: 1 denoting people in low socioeconomic status, 2 if medium and 3 in case of high SES. Dummy variables for gender and non-Caucasian ethnicity are also included.

2.2.3 Sample characteristics

Descriptive analyses showing the sample characteristics and by HbA1c[5] are made. Continuous variables are presented as the mean ± the standard deviation and dichotomous variables as percentages. Univariate analyses will be performed to compare the means between groups using

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[5] According to the American Diabetes Association guidelines (2017), HbA1c levels are at target level if they are equal or below 6.5%. Hence, three categories of HbA1c levels are set according to HbA1c levels: i) HbA1c ≤ 6.5%; ii) 6.5% < HbA1c ≤ 7.5%; and iii) HbA1c > 7.5%, which indicates uncontrolled diabetes.

the Pearson χ^2 test. Characteristics of the whole study population and by average glucose control group are shown in Table 2.2.

The mean total care cost incurred by people with diabetes in the whole sample is €4,361, with hospitalization and drugs costs as the main cost components (€2,260 and €1,008, respectively). 52% of the sample are women, the mean age is 68.38 years old and 0.2% are non-Caucasian. 15% are current smokers. The mean diabetes duration is 7.69 years and the average glucose control is, on average, 6.77%. 85% of the sample take oral medication as their diabetes treatment, whereas 15% use insulin. With respect to health conditions, the most prevalent conditions are uncomplicated hypertension, stroke and acute myocardial infarction, whose prevalence are 10.7%, 9% and 1.4%, respectively.

Table 2.2 suggests that there are some differences across average glucose control categories. Care costs are higher for those with HbA1c above 7.5% (€4,913) and HbA1c ≤ 6.5% (€4,394), compared to the subjects with HbA1c between 6.5% and 7.5% (€4,160). Hospitalization and drugs costs are also the largest costs components across average glucose control categories, although some variances are also observed: hospitalization costs are €2,130 in those with HbA1c between 6.5 and 7.5%, whereas these increase to €2,303 and €2,538 if average glucose control is below or equal to 6.5% and above 7.5%, respectively. With respect to drugs costs, they are greater for people with average glucose control up to 6.5% (€1,010) and HbA1c above 7.5% (€1,178), compared to individuals with HbA1c between 6.5 and 7.5% (€955). Moreover, people with higher average glucose control seem to be more likely to use insulin than people within lower average glucose control (39% if HbA1c > 7.5 vs 19% if 6.5 < HbA1c ≤ 7.5 vs 7% if HbA1c ≤ 6.5). Time since diabetes diagnosis is longer with higher average glucose control (9.60 years if HbA1c > 7.5% vs 8.02 if 6.5 < HbA1c ≤ 7.5% vs 6.79 if HbA1c ≤ 6.5%). Health status does not seem to significantly differ between average glucose control groups, with some exceptions. Uncomplicated hypertension rates drop from 11% in both lower average glucose control categories to 9.3% in those individuals with HbA1c above 7.5%. On the contrary, retinopathy and stroke prevalence rates increase with average glucose control. In particular, the stroke prevalence is 8.2 in people with HbA1c ≤ 6.5% and 10% in individuals with HbA1c > 7.5%.

Table 2.2: Summary statistics for the whole sample and by average glucose control

Variables	Whole sample (N = 22,612)	HbA1c ≤ 6.5% (N = 9,845)	6.5% < HbA1c ≤ 7.5%[2] (N = 9,779)	HbA1c > 7.5%[2] (N = 2,988)	Comparison of means
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	p-value
Total care costs (in 2010€)	4,361.32 ± 7,173.35	4,393.47 ± 7,737.18	4,160.31 ± 6,517.51	4,913.28 ± 7,262.05	0.001***
Logarithm of total care costs	7.83 ± 0.96	7.79 ± 0.98	7.81 ± 0.93	7.98 ± 0.95	0.000***
Types of costs					
GP cost (in 2010€)	219.61 ± 130.01	216.20 ± 126.24	219.32 ± 126.90	231.78 ± 150.05	0.000***
Drugs cost (in 2010€)	1,008.33 ± 2,280.29	1,010.09 ± 3,147.87	954.61 ± 1,202.50	1,178.31 ± 1,390.12	0.043**
Hospitalization cost (in 2010€)	2,259.23 ± 5,758.75	2,303.38 ± 5,878.40	2,129.51 ± 5,450.95	2,538.32 ± 6,304.91	0.057*
Devices cost (in 2010€)	264.67 ± 698.54	218.44 ± 710.30	279.29 ± 691.02	369.16 ± 670.23	0.000***
Other cost (in 2010€)	532.01 ± 1,974.05	565.75 ± 2,172.21	503.86 ± 1,928.19	513.00 ± 1,330.72	0.104
Female	0.52	0.51	0.53	0.53	0.053*
Age (in years)	68.38 ± 10.27	68.18 ± 10.11	68.49 ± 10.25	68.71 ± 10.85	0.081*
Non-Caucasian ethnicity	0.002	0.001	0.003	0.003	0.177
Socioeconomic Status (SES)					0.088*
Low	0.33	0.36	0.32	0.33	
Medium	0.34	0.35	0.36	0.38	
High	0.32	0.29	0.31	0.29	
Current smoker	0.15	0.16	0.14	0.14	0.014**
HbA1c (in %, mmol/mol)	6.77 ± 0.79	6.12 ± 0.33	6.99 ± 0.28	8.19 ± 0.68	-
Diabetes duration (in years)	7.69 ± 5.31	6.79 ± 4.65	8.02 ± 5.38	9.60 ± 6.39	0.000***

Table 2.2: (continued)

Variables	Whole sample (N = 22,612)	HbA1c ≤ 6.5% (N = 9,845)	6.5% < HbA1c ≤ 7.5%[2] (N = 9,779)	HbA1c > 7.5%[2] (N = 2,988)	Comparison of means
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	p-value
Type of medication					
No medication	0.11	0.14	0.10	0.06	0.003***
Oral medication	0.85	0.84	0.85	0.86	0.015**
Insulin	0.16	0.07	0.19	0.39	0.000***
Elixhauser comorbidities					
Cancer	0.009	0.009	0.009	0.010	0.512
Congestive heart failure	0.009	0.008	0.010	0.011	0.060*
Acute myocardial infarction	0.014	0.013	0.014	0.014	0.624
Peripheral vascular disease	0.007	0.008	0.008	0.006	0.429
Hypertension, uncomplicated	0.107	0.109	0.110	0.093	0.033**
Hypertension, complicated	0.013	0.012	0.013	0.013	0.669
Alcohol abuse	0.001	0.002	0.001	0.002	0.811
Paralysis	0.00004	0.0001	0.000	0.000	0.317
Stroke	0.09	0.082	0.092	0.10	0.041**
Any other cerebrovascular accident	0.01	0.011	0.009	0.009	0.225
Dementia	0.002	0.001	0.002	0.002	0.649
Chronic pulmonary disease	0.002	0.002	0.002	0.002	0.814
Retinopathy	0.005	0.003	0.006	0.007	0.005***
Neuropathy	0.004	0.004	0.004	0.004	0.512

Table 2.2: (continued)

Variables	Whole sample (N = 22,612)	HbA1c ≤ 6.5% (N = 9,845)	6.5% < HbA1c ≤ 7.5%² (N = 9,779)	HbA1c > 7.5%² (N = 2,988)	Comparison of means
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	p-value
Hypothyroidism	0.004	0.003	0.004	0.003	0.803
Renal failure	0.01	0.014	0.014	0.015	0.817
Liver disease	0.0004	0.0004	0.0005	0.000	0.412
Peptic ulcer	0.0004	0.0005	0.0003	0.000	0.117
Rheumatoid arthritis	0.002	0.001	0.002	0.003	0.159
Weight loss	0.00004	0.0001	0.000	0.000	0.317
Obesity	0.007	0.005	0.007	0.009	0.022**
Anaemia	0.004	0.005	0.003	0.007	0.627
Psychosis	0.0004	0.0005	0.0004	0.0003	0.544
Depression	0.008	0.008	0.008	0.009	0.665

*** $p<0.01$; ** $p<0.05$; * $p < 0.1$. Standard errors were clustered at the individual level.

2.2.4 Statistical analyses

Random-effects linear regression models will be applied to the data to take into account individual variation between the four years included in the analysis, allowing time-invariant factors to be associated with the outcome. Variation across individuals is assumed to be random and uncorrelated with the independent variables (Heij et al., 2004).

The baseline model with random-effects is as follows:

$$\log(totalcarecost_{it}) = \beta'_1 SE_{it} + \beta_2 HbA1c_{it} + \beta_3 smoker_{it} + c_i + u_{it} \quad (1)$$

where $\log(totalcarecost_{it})$ is a continuous variable that represents the logarithm form of the total care costs claimed by individual *i* with type 2 diabetes mellitus in year *t*; SE_{it} is a vector of explanatory variables referring to age and its quadratic form, gender, ethnicity and socioeconomic status categories; $HbA1c_{it}$ denotes a continuous variable referring to average glucose control measured in HbA1c, in %; $smoker_{it}$ refers to the fact of being a current smoker. c_i represents the random effects term, where the conditional mean of the random-effects is independent of the independent variables. u_{it} denotes the idiosyncratic error term.

In a second regression model, dummy variables for each treatment modality (oral medication and insulin) and the interactions between HbA1c categories and treatment are included.

As I am also interested in evaluating the impact of time since diabetes diagnosis, the diabetes duration and its square will be added in a third regression model. A fourth model will also include the dummies for the three-year of diabetes onset cohorts. GP dummies will be added in a subsequent model to control for any potential GP efficiency treatment. If the GP dummies are jointly significant, I could infer that some GPs might treat patients more efficiently than others.

The full model with random-effects has the following form:

$$\log(totalcarecost_{it})$$
$$= \beta'_1 SE_{it} + \beta_2 HbA1c_{it} + \beta_3 smoker_{it}$$
$$+ \beta'_4 treatment_{it} + \beta_2 \beta'_4 (HbA1c_{it} * treatment_{it}) + \beta_5 diabetesdur_{it}$$
$$+ \beta_6 diabetesdur_{it}^2 + \beta'_7 yearofdiagnosis_{it} + \beta'_8 GP_{it} + c_i + u_{it} \quad (2)$$

where $treatment_{it}$ is a vector of treatment variables referring to both dichotomous variables oral medication and insulin; $HbA1c_{it} * treatment_{it}$ denotes the interaction term between average glucose control and treatment modality; $diabetesdur_{it}$ and $diabetesdur_{it}^2$ represent the diabetes duration and diabetes duration squared, respectively. $yearofdiagnosis_{it}$ denotes a vector of three-year of diagnosis cohort dummy variables and GP_{it} the vector of GP identification code dummies.

All the statistical analyses have been performed using STATA 14.0 software (Stata Corporation, College Station, TX).

<u>Sensitivity analyses[6]</u>

To test for the robustness of the results, in the above regression models, clinical complications have been excluded. Diabetes non-related comorbidities will be included in a sixth regression model and diabetes-related conditions in a seventh model.

<u>By cost component</u>

Model 5, which is assumed to be the full model, is estimated to assess the relationship between the independent variables and the different costs components (GP costs, hospital and specialists, and drugs costs). However, in case of devices costs, a new regression model will be applied, given the substantial proportion of zeros, which represent around 50% of the whole sample (Table 2.1). Two-part models combine a model for the binary response variable, which would take value 1 if the individual claims more than zero devices costs and 0 if no devices costs, and a model for the outcome variable that is conditioned on the binary response (Farewell et al., 2017), conditional on having claimed devices costs.

The first stage defines a dichotomous variable R indicating the regime into which observations of the dependent variable y falls (Frondel and Vance, 2011):

$$R = 1, if \ y^* = x_1^T \tau + \ \epsilon_1 > 0 \ \ and \ R = 0 \ , if \ y^* \leq 0 \ \ (3)$$

y* is a latent variable, vector x_1 denotes its determinants, τ is a vector of associated parameters, and ϵ_1 is an error term with a standard normal distribution. R = 1 indicates that y > 0, whereas R = 0 is equivalent to y = 0.

After estimating τ using Probit estimation techniques the second stage involves a Generalized Linear Model (GLM) witk gamma distribution and log link regression of the parameters β that affect the expected value E[y | y > 0] conditional on y > 0, i. e. , R = 1:

$$E[y \ | R = 1, x_2] = E[y|y > 0, x_2] = x_2^T \beta + E(\epsilon_2 \ |Y > 0, X_2) \ \ (4)$$

where x_2 includes the determinants of the dependent variable y, and ϵ_2 is another error term. The expected value of the dependent variable y then consists of two parts, with the first part resulting from the first stage (3), $P(y > 0) = \ \boldsymbol{\Phi}(x_1^T \tau)$, and the second part being the conditional expectation E[y | y > 0] from the second stage (4).

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[6] I have also performed the same regressions including Mundlak terms (Mundlak, 1978) to relax the assumption that observed time-varying variables are uncorrelated with the unobserved variables by adding individual-means of independent variables that do vary over time within individuals. However, the Mundlak terms included are not significant, and the coefficients are quite similar to the ones obtained in the Random-effects linear regression models. Hence, results with Mundlak terms are not reported here and will be made available upon request.

2.3 RESULTS

2.3.1 Regression results

Table 2.3 shows the results obtained from the random-effects linear regression model applied to the overall sample. Model 1 includes socioeconomic characteristics (gender, age, ethnicity, socioeconomic status), being a current smoker, and average glucose control. Model 2 adds to Model 1 the dummy variables for treatment modalities and the interactions between HbA1c and type of medication (oral medication or insulin). Model 3 adds to Model 2 diabetes duration and its quadratic form. Model 4 additionally includes to Model 3 the year of diabetes onset groups. Model 5 adds to Model 4 dummies for the General Practitioners (GPs).

The first regression model (Column 1, Table 2.3) shows that a higher 1% HbA1c is significantly associated with an increase in total care costs by 2.2.% (p<0.01). Moreover, being a woman is related to higher total care costs, which increase by 5.7 percentage points (p<0.01), compared to males; as well as increasing age, with an additional year of age being associated with an increase in total care costs by 1.74% (p<0.1). Compared to people with high socioeconomic status, having low SES is related to greater total costs by 5.94% (p<0.05). Being a current smoker is associated with higher care costs by 5.21% (p<0.1).

However, when the diabetes treatment dummies and the interactions between diabetes treatment and average glucose control are introduced (Column 2, Table 2.3), there seems to be a significant association between treatment and average glucose control and care costs, decreasing the significance of HbA1c alone. Furthermore, age is no longer significantly related to total costs.

A higher 1% HbA1c is significantly associated with an increase in total care costs by 3.42% if the individual is not being treated with insulin nor with oral medication. If the person takes oral medication, a higher 1% HbA1c is associated with an increase in total care costs of 1.25 percentage points (coefficient of HbA1c level alone = 0.0342 + coefficient of the interaction HbA1c # Oral medication = - 0.0217). However, the effect of HbA1c in people being treated with oral medication on total care costs is not significant (t-statistic = 1.29, p-value > 0.1). If the person uses insulin, a higher 1% HbA1c is related to a decrease in total care costs of 1.56 percentage points (coefficient of HbA1c level alone = 0.0342 + coefficient of the interaction HbA1c # Insulin = - 0.0498). Still, the effect of a higher HbA1c is neither significantly associated with total costs (t-statistic = -0.67, p-value > 0.1). As diabetes treatment, taking oral medication is related to higher care costs, which increase by 8.23% (coefficient of oral medication alone = 0.104 + coefficient of the interaction HbA1c # Oral medication = - 0.0217) with every additional unit of HbA1c, but the effect is not significant (t-statistic = 0.73, p-value > 0.1). Being treated with insulin is significantly associated with an increase in costs of 60.81 percentage points

(coefficient of insulin alone = 0.658 + coefficient of the interaction HbA1c # Insulin = - 0.0498) for every 1% higher HbA1c rise (t-statistic = 4.85, p-value < 0.01).

Being a female is associated with an increase in total care costs by 4.85 percentage points (p<0.05), compared to males. Having low socioeconomic status is associated with a 6.51% (p<0.01) higher care costs, in comparison with subjects with high SES. Being a current smoker is related to an increase in total costs by 5.09% (p<0.1).

In a third regression model with the diabetes duration and its square introduced in the analysis (Column 3, Table 2.3), HbA1c level is no longer significant individually. Age and age squared are not significant either.

If the person takes oral medication, a higher 1% HbA1c is associated with an increase in total care costs of 0.25 percentage points, but not significant either (t-statistic = 0.26, p-value > 0.1). A higher 1% HbA1c and using inulin is not significantly related to total care costs of 2.32% (t-statistic = -1.00, p-value > 0.1). Looking at the effect of diabetes treatment, taking oral medication is not significantly related (t-statistic = 0.43, p-value > 0.1) to higher care costs. Being treated with insulin is significantly associated with an increase in total costs of 49.57 percentage points for every 1% increase in HbA1c (t-statistic = 3.97, p-value < 0.01).

Each additional year of time since diabetes diagnosis is associated with higher care costs, which are augmented by 3.68% (p<0.01), although the negative sign of the square of diabetes duration shows that such effect will be decreasing at some point. Being a woman is associated with an increase in care costs by 5.35 percentage points (p<0.01). Being in low SES is related to a rise in care costs by 6.27% (p<0.01), compared to high SES.

When the set of three-year dummies for year at diabetes diagnosis are introduced (Column 4, Table 2.3), the same pattern as in Model 3 is followed. Average glucose control individually is not significantly associated with care costs. Age and age squared are not significant either.

If the person takes oral medication as diabetes treatment, a higher 1% HbA1c is associated with an increase in total care costs of 0.13%, but the effect is not significant (t-statistic = 0.14, p-value > 0.1). A higher HbA1c by 1% and using inulin is not significantly related to total care costs of 2.52 percentage points (t-statistic = -1.09, p-value > 0.1). With respect to diabetes treatment, taking oral medication is not significantly related (t-statistic = 0.57, p-value > 0.1) to higher care costs. Being treated with insulin is significantly associated with an increase in costs of 52.46 percentage points by a 1% higher HbA1c (t-statistic = 4.22, p-value < 0.01).

Each additional year of time since diabetes diagnosis is related to an increase of care costs by 6.28% (p<0.01), although the negative sign of the square of diabetes duration shows that such effect will be decreasing at some point.

Actually, looking at Figure 2.3 and taking into account the difference in the coefficients of diabetes duration and its quadratic form between Model 3 and Model 4, the time point at which care costs start decreasing is posterior when the three-year dummies for year at diabetes diagnosis are part of the regression model. In case of Model 3, the beginning of decreasing costs would be after 25 years of diabetes duration. In Model 4, it would be after around 35 years since diabetes diagnosis. The figure would be suggestive of a "happy survivor" effect. If a person with diabetes has stayed stable after 25 – 35 years since disease diagnosis, the likelihood of developing complications is lower, reducing costs of total care.

Figure 2.3: Diabetes duration and care costs
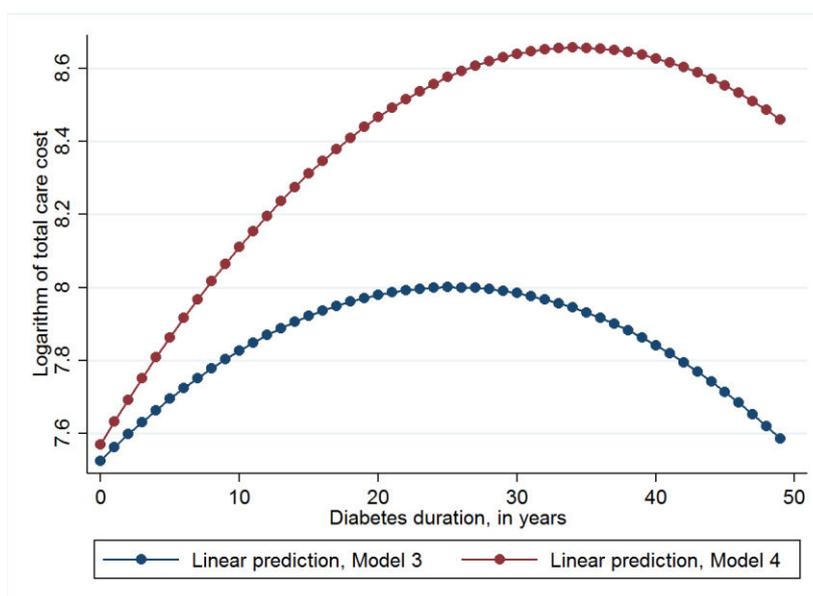
Women are associated with higher care costs, which increase by 5.65% (p<0.01), compared to males. Being in low SES is also related to a rise in care costs by 6.71% (p<0.01), compared to high SES. Moreover, dummies for year at onset cohorts are significantly related to care costs, both individually and jointly, as suggested by Figure 2.1. Compared to individuals who have been newly diagnosed of diabetes (during the years 2007 – 2009), those whose diabetes onset has occurred between 2004 to 2006 are associated with a decrease in care costs by 15.7% (p<0.01) to 70.6% (p<0.01) in case of having been diagnosed before the year 1989.

Such trend is maintained in the fifth regression model (Column 5, Table 2.3), in which dichotomous variables for each GP identification number were included. GP dummies are jointly significant (p<0.01), suggesting a GP treatment effect. Age and age squared are not significant either. HbA1c individually is not significantly associated with care costs. If the effect of HbA1c is analysed dependent on diabetes treatment, if the person takes oral medication, the effect of average glucose control is not significant (t-statistic = 0.49, p-value > 0.1). A higher 1% HbA1c

and using inulin is not significantly related to total care costs either (t-statistic = -1.24, p-value > 0.1).

Looking at the effect of diabetes treatment, taking oral medication is not significantly related (t-statistic = 0.30, p-value > 0.1) to higher care costs. Being treated with insulin is significantly associated with an increase in costs of 54.49% for every 1% higher HbA1c (t-statistic = 4.36, p-value < 0.01).

Every additional year of time since diabetes diagnosis is related to an increase of care costs of 6.28% (p<0.01), although such effect will be decreasing at some point, according to the negative sign of the square of diabetes duration. Being in low SES associated with higher total costs, which grow by 5.80% (p<0.1), compared to high SES individuals. Being a female is also related to higher care costs by 5.07% (p<0.05), compared to men. Dummies for year at onset cohorts are significantly related to care costs too. Those whose diabetes onset has occurred between 2004 to 2006, care costs decrease by 12.8% (p<0.01) to 58.2% (p<0.01) in case of having been diagnosed before the year 1989, compared to the newly-diagnosed people.

Sensitivity analysis

Table 2.A2, in Appendix, reports the results from Models 6 and 7, which include non-diabetes related and diabetes-related comorbidities, respectively.

In case of the regression model with the non-diabetes related Elixhauser comorbidities (Column 1, Table 2.A2, Appendix), the coefficients of gender (associated with increasing care costs by 5% (p<0.05)), being treated with insulin (significantly associated with increasing total costs by 56.05% (t-statistic = 4.45, p-value < 0.01) if HbA1c is higher by 1%), diabetes duration (associated with increasing care costs by 6.60% (p<0.01) and negative coefficient of diabetes duration squared), low SES (associated with increasing total costs by 5.83% (p<0.1)) and year of onset categories (associated with decreasing care costs by 13.9% (p<0.01) if diagnosis was between 2004 to 2006 and by 66.5% (p<0.01) in case of having been diagnosed before the year 1989) remain as significant determinants of higher care costs. Age and age squared are not significant either. HbA1c, regardless of diabetes treatment, is not significantly associated with care costs. Taking oral medication is not significantly related to total costs either.

Within the list of comorbidities, suffering from cancer, anaemia and depression is associated with increasing total care costs the most, by 62.9% (p<0.01), 18% (p<0.01) and 15.1% (p<0.05), respectively. On the other hand, rheumatoid arthritis is related to lower care costs, decreasing by 39.6 percentage points (p<0.01).

Table 2.3: Results from the random-effects linear regression model on the logarithm of total care costs

VARIABLES	Coeff. Model 1	Coeff. Model 2	Coeff. Model 3	Coeff. Model 4	Coeff. Model 5
Female	0.0572***	0.0485**	0.0535***	0.0565***	0.0507**
	(0.0202)	(0.0197)	(0.0198)	(0.0197)	(0.0198)
Age	0.0174*	0.0149	0.00811	0.0111	0.0130
	(0.00996)	(0.00976)	(0.00971)	(0.00969)	(0.00988)
Age²	2.66e-05	4.01e-05	6.55e-05	3.84e-05	2.50e-05
	(7.27e-05)	(7.12e-05)	(7.08e-05)	(7.06e-05)	(7.20e-05)
Non-Caucasian ethnicity	0.0453	0.0548	-0.00197	0.00914	-0.0427
	(0.198)	(0.204)	(0.207)	(0.199)	(0.173)
Socioeconomic Status (SES) categories					
Low SES	0.0594**	0.0651***	0.0627***	0.0671***	0.0580*
	(0.0246)	(0.0241)	(0.0241)	(0.0241)	(0.0337)
Medium SES	0.0248	0.0213	0.0181	0.0228	0.0341
	(0.0245)	(0.0238)	(0.0237)	(0.0236)	(0.0352)
Current smoker	0.0521*	0.0509*	0.0432	0.0365	0.0305
	(0.0291)	(0.0285)	(0.0286)	(0.0285)	(0.0287)
HbA1c, in % (mmol/mol)	0.0222***	0.0342*	0.0169	0.0154	0.0145
	(0.00835)	(0.0191)	(0.0190)	(0.0190)	(0.0193)
Type of medication					
Oral medication		0.104	0.0631	0.0781	0.0441
		(0.132)	(0.131)	(0.131)	(0.133)
Insulin		0.658***	0.536***	0.565***	0.589***
		(0.145)	(0.144)	(0.144)	(0.144)
Glycaemic level # type of medication					
HbA1c # Oral medication		-0.0217	-0.0145	-0.0141	-0.00961
		(0.0194)	(0.0193)	(0.0193)	(0.0196)
HbA1c # Insulin		-0.0498**	-0.0402**	-0.0406**	-0.0436**
		(0.0197)	(0.0196)	(0.0195)	(0.0196)
Diabetes duration			0.0368***	0.0628***	0.0605***
			(0.00367)	(0.00569)	(0.00597)
Diabetes duration²			-0.000732***	-0.000911***	-0.000923***
			(0.000113)	(0.000158)	(0.000162)
Year of onset categories					
Before 1989				-0.706***	-0.582***
				(0.123)	(0.126)
Year 1989 – 1991				-0.575***	-0.485***
				(0.0902)	(0.0927)
Year 1992 – 1994				-0.429***	-0.383***
				(0.0785)	(0.0815)
Year 1995 – 1997				-0.449***	-0.385***
				(0.0650)	(0.0673)
Year 1998 – 2000				-0.335***	-0.291***
				(0.0538)	(0.0556)
Year 2001 – 2003				-0.221***	-0.193***
				(0.0456)	(0.0469)
Year 2004 – 2006				-0.157***	-0.128***
				(0.0401)	(0.0408)
Constant	6.291***	6.308***	6.553***	6.529***	6.335***
	(0.344)	(0.358)	(0.356)	(0.356)	(0.400)
N (Observations)	22,612	22,612	22,612	22,612	22,612
N (Individuals)	5,653	5,653	5,653	5,653	5,653
General Practitioner FE	NO	NO	NO	NO	YES

Table 3.3: (continued)

VARIABLES		Coeff. Model 1	Coeff. Model 2	Coeff. Model 3	Coeff. Model 4	Coeff. Model 5
R-squared						
	Within	0.0159	0.004	0.012	0.015	0.023
	Between	0.0626	0.112	0.111	0.116	0.174
	Overall	0.0434	0.073	0.076	0.080	0.120
σ_u		0.668	0.640	0.639	0.639	0.630
σ_e		0.651	0.651	0.650	0.650	0.650
ϱ		0.513	0.491	0.491	0.491	0.485
Age and age2 jointly significant (χ2)		470.00***	464.21***	64.35*	394.23	24.18
Diabetes duration and diabetes duration2 jointly significant (χ2)		-	-	128.16***	141.89***	144.56***
Joint significance of new variables (χ^2)			220.11***	128.16***	57.22***	5.1^{e6}***

Clustered standard errors at the individual level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Reference categories: men, Caucasian ethnicity, high SES, no current smokers, no medication, year of diabetes onset 2007 - 2009.

Model 1 includes socioeconomic characteristics (gender, age, ethnicity, socioeconomic status), being a current smoker, glycaemic level. Model 2 adds to Model 1 the interaction between glycaemic level and type of medication (oral medication or insulin). Model 3 adds to Model 2 diabetes duration and its quadratic form. Model 4 additionally includes to Model 3 the year of diabetes onset groups. Model 5 adds to Model 4 dummies for the General Practitioners (GPs).

In the last regression model where diabetes-related complications are included (Column 2, Table 2.A2, Appendix), age and age squared are not significant. HbA1c, regardless of diabetes treatment, is not significantly associated with care costs. Taking oral medication is not significantly related to total costs either.

Being treated with insulin is significantly associated with higher care costs by 51.79 percentage points for every 1% higher HbA1c (t-statistic = 4.15, p-value < 0.01). Each additional year of time since diabetes diagnosis is associated with increasing care costs, by 7.58%, although the negative sign of the square of diabetes duration shows that such effect will be decreasing at some point. In those whose diabetes onset has occurred between 2004 to 2006, care costs decrease by 15.4% (p<0.01) and by 81.8 (p<0.01) percentage points in case of having been diagnosed before the year 1989, compared to the newly-diagnosed people.

With respect to the chronic conditions newly considered, suffering from weight loss, peripheral vascular disease and congestive heart failure are associated with the greatest increases in care costs, by 56.3 (p<0.01), 35.5 (p<0.01) and 35.4 (p<0.01), percentage points, respectively.

Being a female is associated with higher care costs, which rise by 6.39 percentage points (p<0.01), compared to men. Being in low SES is related to total costs by 5.60% (p<0.1), compared to high SES.

<u>By cost component</u>

Table 2.4 shows the results obtained from the random-effects linear regression model applied to the overall sample by cost type: GP costs, drugs costs, hospital and specialist costs; and the results from the two-part model on devices costs.

GP costs

The first column in Table 2.4 shows that a higher 1% HbA1c is significantly associated with an increase in GP costs by 3.48% if the individual is not being treated with insulin nor with oral medication. If the person takes oral medication, a higher 1% HbA1c is significantly associated with an increase in GP costs of 0.90 (t-statistic = 1.88, p-value < 0.1) percentage points. If the person uses insulin, a higher 1% HbA1c is related to an increase in GP costs of 1.20 percentage points. With respect to the diabetes treatments, taking oral medication is significantly related to higher GP costs, which increase by 10.12% (t-statistic = 1.66, p-value < 0.1) with every additional unit of HbA1c. Being treated with insulin is significantly associated with an increase in GP costs of 20.63 percentage points for every 1% higher HbA1c (t-statistic = 3.10, p-value < 0.01).

Each additional year of time since diabetes diagnosis reduces GP costs by 12% (p<0.01), although the positive sign of the square of diabetes duration shows that such effect will be increasing at some point of diabetes duration[7].

Compared to individuals who have been newly diagnosed of diabetes (during the years 2007 – 2009), those whose diabetes onset has occurred between 2004 to 2006, GP costs are higher by 24.8% (p<0.01) to 178.6% (p<0.01) in case of having been diagnosed before the year 1989.

Being female is related to an increase in GP costs, by 9.37 percentage points (p<0.01), compared to men. An additional year of age is associated with 3.17% (p<0.01) GP costs reduction. However, the positive sign of the square of age shows that costs will be increasing after some age threshold.

Moreover, GP dummies are jointly significant (p<0.01), also suggesting a GP treatment effect on GP costs.

Drugs costs

The second column in Table 2.4 shows that a higher 1% HbA1c is associated with higher drugs costs, by 5.40% (p<0.01) if the individual is not being treated with insulin nor with oral medication. If the person takes oral medication, a higher 1% HbA1c is significantly associated with an increase in drugs costs of 2.43% (t-statistic = 3.57, p-value < 0.01). If the person uses

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[7] It has already been found in the literature that the incremental costs in the first years after diabetes diagnosis decrease (Nichols et al., 2000) and then start increasing again. We only have four years of data, so we do not know at which point of the curve the individual is.

insulin, a higher 1% HbA1c is related to an increase in drugs costs of 3.15 percentage points (t-statistic = 2.06, p-value < 0.05). With respect to the diabetes treatments, taking oral medication is significantly related to higher drugs costs, which increase by 17.06 percentage points (t-statistic = 2.13, p-value < 0.05) with every additional unit of HbA1c. Being treated with insulin is significantly associated with an increase in drugs costs of 27.76% for every 1% higher HbA1c (t-statistic = 3.06, p-value < 0.01).

Being female is also related to an increase in drugs costs by 10.7% (p<0.01), compared to males, as well as increasing age, with an additional year of age increasing drugs costs by 2.24% (p<0.1). Compared to high SES, being in low socioeconomic status is associated with higher drugs costs by 11.7% (p<0.01) and by 9.22% (p<0.05) if the individual has medium SES. Being a current smoker is also positively associated with drugs costs, increasing costs by 8.57% (p<0.01).

Each additional year of time since diabetes diagnosis is related to higher drugs costs by 2.66% (p<0.01), although the negative sign of the square of diabetes duration shows that such effect will be increasing at some point of diabetes duration.

Compared to individuals who have been newly diagnosed of diabetes (during the years 2007 – 2009), those whose diabetes onset has occurred between 2001 to 2003 have higher drugs costs by 13.1% (p<0.01) to 58.4% (p<0.01) in case of having been diagnosed before the year 1989.

Moreover, GP dummies are jointly significant (p<0.01), being suggestive of a GP treatment effect on drugs costs.

Hospital and specialist costs

In case of hospital and specialist costs (third column, Table 2.4), HbA1c is not significantly related to hospital and specialist costs, regardless of whether the person receives no treatment (p > 0.1), oral medication (t-statistic = 0.47, p-value > 0.1), or insulin (t-statistic = -1.45, p-value > 0.1). Oral medication is not significantly associated with hospital costs (t-statistic = 0.27, p-value > 0.1). Being treated with insulin is significantly associated with an increase in hospital and specialist costs of 81.29% (t-statistic = 3.22, p-value < 0.01) for every 1% higher HbA1c.

An additional year of age is related to higher hospital and specialist costs by 5.62% (p<0.01), although the negative sign of age-squared shows that hospital and specialist costs will start decreasing after some age point.

Diabetes duration, gender, socioeconomic status, being a current smoker and year of onset categories are not significant predictors of hospital and specialist costs.

GP dummies are jointly significant (p<0.01), pointing to a significant GP treatment effect on hospital and specialist costs.

Devices costs

The fourth and fifth column in Table 2.4 show the results from the probit and the GLM, respectively, on devices costs.

Column four (first part two-part model: Probit results) shows that increasing HbA1c, both types of diabetes treatment (oral medication and insulin), diabetes duration and diabetes duration squared, being a female, socioeconomic status (both low and medium) are positive and significantly associated with the probability of incurring in devices costs. Moreover, age, having non-Caucasian ethnicity and some of the three-year onset categories (diabetes diagnosis before 1989, years 1992 – 1994, years 1998 – 2000, years 2001 – 2003, years 2004 – 2006, compared to the newly-diagnosed cases) significantly reduce the probability of having devices costs.

The fifth column (second part two-part model: GLM results) reports that HbA1c is not significantly related to devices costs, regardless of whether the person receives no treatment ($p > 0.1$), oral medication (t-statistic = -1.62, p-value > 0.1), or insulin (t-statistic = -0.89, p-value > 0.1). Oral medication is not significantly associated with devices costs (t-statistic = 0.94, p-value > 0.1). Being treated with insulin is significantly associated with an increase in devices costs of 62.55% (t-statistic = 2.92, p-value < 0.01) for every one additional unit of HbA1c.

Compared to high SES, being in low socioeconomic status is related to higher devices costs by 23.5% (p<0.01) and by 15.1% (p<0.05) in case of medium SES.

Diabetes duration, gender, being a current smoker and year of onset categories are not significant determinants of higher devices costs.

Moreover, GP dummies are jointly significant (p<0.01), suggesting a GP treatment effect on devices costs.

Table 2.4: Results from the random-effects linear regression model on the different costs components

VARIABLES	Coeff. Model 5 logarithm GP costs	Coeff. Model 5 logarithm drugs costs	Coeff. Model 5 logarithm hospital costs	Coeff. Model 5 devices costs (1st part two-part model: probit)	Coeff. Model 5 devices costs (2nd part two-part model: GLM with log-link)
Female	0.0937***	0.107***	0.00115	0.342***	-0.0318
	(0.00925)	(0.0227)	(0.0347)	(0.0283)	(0.0423)
Age	-0.0317***	0.0224*	0.0562***	-0.0685***	-0.00973
	(0.00455)	(0.0115)	(0.0165)	(0.0142)	(0.0216)
Age²	0.000324***	-5.66e-05	-0.000221*	0.000698***	0.000186
	(3.37e-05)	(8.41e-05)	(0.000122)	(0.000105)	(0.000154)
Non-Caucasian ethnicity	-0.0592	-0.131	0.0618	-0.524**	-0.537
	(0.0849)	(0.207)	(0.341)	(0.239)	(0.526)
Socioeconomic Status (SES) categories					
Low SES	0.00911	0.117***	0.00482	0.117**	0.235***
	(0.0161)	(0.0415)	(0.0604)	(0.0517)	(0.0681)
Medium SES	-0.00183	0.0922**	-0.0248	0.148***	0.151**
	(0.0166)	(0.0413)	(0.0614)	(0.0529)	(0.0637)
Current smoker	0.0213	0.0857***	-0.0479	-0.0273	-0.0529
	(0.0137)	(0.0325)	(0.0497)	(0.0402)	(0.0652)
HbA1c, in % (mmol/mol)	0.0348***	0.0540***	0.0219	0.252***	0.0173
	(0.0103)	(0.0143)	(0.0399)	(0.0397)	(0.0374)
Type of medication					
Oral medication	0.127*	0.200**	0.0765	0.896***	0.274
	(0.0712)	(0.0936)	(0.277)	(0.274)	(0.263)
Insulin	0.229***	0.300***	0.904***	2.805***	0.675***
	(0.0769)	(0.104)	(0.292)	(0.362)	(0.248)
Average glucose control # type of medication					
HbA1c # Oral medication	-0.0257**	-0.0296**	-0.0128	-0.153***	-0.0608*
	(0.0106)	(0.0137)	(0.0407)	(0.0408)	(0.0366)
HbA1c # Insulin	-0.0228**	-0.0224	-0.0914**	-0.142***	-0.0495
	(0.0105)	(0.0137)	(0.0402)	(0.0496)	(0.0342)
Diabetes duration	-0.120***	0.0266***	-0.0118	0.0622***	0.00361
	(0.00310)	(0.00509)	(0.0119)	(0.0111)	(0.0149)
Diabetes duration²	0.00168***	-0.000723***	0.000330	-0.000682**	2.30e-05
	(0.000105)	(0.000166)	(0.000349)	(0.000335)	(0.000289)
Year of onset categories					
Before 1989	1.786***	0.584***	0.120	-0.771***	-0.0447
	(0.0659)	(0.121)	(0.240)	(0.219)	(0.243)
Year 1989 – 1991	1.497***	0.408***	0.178	-0.239	-0.305
	(0.0481)	(0.0865)	(0.182)	(0.173)	(0.205)
Year 1992 – 1994	1.299***	0.303***	0.245	-0.288**	-0.189
	(0.0409)	(0.0798)	(0.155)	(0.140)	(0.183)
Year 1995 – 1997	1.058***	0.238***	0.0927	-0.176	-0.191
	(0.0321)	(0.0633)	(0.127)	(0.113)	(0.163)
Year 1998 – 2000	0.823***	0.198***	0.0449	-0.178**	-0.0568
	(0.0262)	(0.0554)	(0.104)	(0.0898)	(0.140)
Year 2001 – 2003	0.557***	0.131***	0.0284	-0.152**	-0.0149
	(0.0218)	(0.0504)	(0.0843)	(0.0712)	(0.117)
Year 2004 – 2006	0.248***	0.0483	-0.108	-0.0936*	-0.134
	(0.0181)	(0.0470)	(0.0696)	(0.0563)	(0.0984)
Constant	5.947***	4.160***	3.367***	-1.002*	5.991***
	(0.185)	(0.429)	(0.663)	(0.595)	(0.846)

Table 2.4: (continued)

VARIABLES		Coeff. Model 5 logarithm GP costs	Coeff. Model 5 logarithm drugs costs	Coeff. Model 5 logarithm hospital costs	Coeff. Model 5 devices costs (1st part two-part model: probit)	Coeff. Model 5 devices costs (2nd part two-part model: GLM with log-link)
N (Observations)		22,612	22,579	22,414	22,612	10,718
N (Individuals)		5,653	5,653	5,653	5,653	3,862
General Practitioner FE		YES	YES	YES	YES	YES
R-squared						
	Within	0.128	0.020	0.007	-	-
	Between	0.247	0.181	0.138	-	-
	Overall	0.193	0.158	0.077	-	-
σ_u		0.271	0.771	1.036	-	-
σ_e		0.344	0.403	1.381	-	-
ϱ		0.382	0.786	0.360	-	-
Log-pseudolikelihood		-	-	-	-11,933.96	-77,331.85
AIC		-	-	-	-	14.486
BIC		-	-	-	-	-80,685.66
Joint significance of GP dummies		1.6^{e05}***	3.5^{e05}***	4.3^{e05}***	1.9^{e06}***	1.9^{e06}***

Clustered standard errors at the individual level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Reference categories: men, Caucasian ethnicity, high SES, no current smokers, no medication, year of diabetes onset 2007 - 2009.

Model 5 includes socioeconomic characteristics (gender, age, ethnicity, socioeconomic status), being a current smoker, glycaemic level, the interaction between glycaemic level and type of medication (oral medication or insulin), diabetes duration and its quadratic form, the year of diabetes onset groups and the dummies for the General Practitioners (GPs).

2.4 DISCUSSION

In this study, I aim to estimate the impact of average glucose control on total care costs incurred by people with type 2 diabetes mellitus, but not exclusively diabetes-related costs, in adult people, additionally controlling for year of onset cohort effects. I have used claims data for around 5,600 Dutch people with type 2 diabetes with complete data for years 2008 to 2011 available. Diabetes claims data have been used for years to evaluate clinical care provided by health systems (Khan et al., 2009). The availability of very specific and detailed clinical information has improved the ability to have more precise diabetes registries that capture more accurately cohorts of people with diabetes (Brown et al., 2000). The current dataset combines both types of data and hence provides enriched claims data.

The results show that care costs incurred by people with diabetes differ depending on the average glucose control. 4-year mean total care costs increase by €520 between people with HbA1c below 6.5% and people with HbA1c above 7.5%. Differences in care costs related to the degree of average glucose control in people with diabetes have already been reported in the literature (Bron et al., 2015; Degli Esposti et al., 2013; McBrien et al., 2012; Shetty et al., 2005). Degli Esposti et al. concluded that mean 2-year costs in Italian people with diabetes and without poor glucose management are higher by €219 to €565, compared to those individuals with diabetes with good glycaemic levels.

Looking at the regression results, I have found that a higher 1% HbA1c is associated with higher total care costs by 2.2%. The incremental increase in care costs as glucose control worsens has also been shown in the literature. Degli Esposti et al. found that good glycaemic control increased 2-year care costs by 219.28€; by 264.65€ if fair and by 513.18€ if poor, compared to excellent control. Moreover, McBrien et al. stated that 5-year healthcare costs in the US increased by 1,623$ if HbA1c levels were between 8 to 9% and by 5,565$ if HbA1c > 9%. Although the conclusion about increasing costs due to higher average glucose control is supported by the findings presented here, the interpretation of the results cannot be comparable. The authors used the absolute value of total care costs, whereas I use the natural logarithm of total care costs. Hence, their interpretation is made in absolute terms and mine is made in percentages.

I have found that the impact of average glucose control on care costs is mediated by the treatment modality; in my case, by whether individuals with T2DM take oral medication or use insulin. When diabetes treatmens are included in the analysis, a higher 1% HbA1c is significantly associated with an increase in total care costs by 3.42% if the individual is not being treated with insulin nor with oral medication. The effect of oral medication or insulin use on average glucose control impact is, however, not significant. Nevertheless, insulin use is significantly related to

higher total care costs, which will increase by 49.57 to 60.81 percentage points, depending on the covariates included, for every 1% higher HbA1c. One must consider that, in primary care in The Netherlands, mean HbA1c in people on oral medication is 6.8%, and on insulin is 7.4% (Booz&Co, 2011). Therefore, treatment intensity is one of the factors needed to be considered in this analysis. Moreover, it has already been found in the literature that care costs are higher when using insulin (Hendriks and Bilo, 2017; Brandle et al., 2003), but the increase in healthcare costs is also dependent on the type of insulin and the regime (Borah et al., 2009; van den Berghe et al., 2006), which is not available in the data.

With respect to the effect of diabetes duration, I have found that an additional year of diabetes duration is associated with higher care costs by 3.68%, reaching 6.28% when year of onset categories are included. This result would highlight the relevance of correcting for year of onset cohort effects, as not doing so would lead to biased diabetes duration estimates. Moreover, findings suggest that there is a strong association between diabetes duration and total costs, as Figure 2.1 has put forward too. I also observe that the diabetes duration point at which care costs start decreasing is found to be ten years later when year of onset categories are part of the analysis. McBrien et al. (2012) also looked at the impact of diabetes duration on healthcare spending, defining two categories, between one and five years since diabetes onset and greater than five years. Their results showed a more significant and greater effect of time since diagnosis over five years, increasing costs by $4,861, compared to an increase of $663 if diabetes duration was one to five years. They show that care costs in people with diabetes increase with time since diagnosis, as I do, but I do find that the increase in costs will have a decreasing effect at some point (particularly, after 25 to 35 years after diabetes diagnosis when year of onset effects are included). Trogdon and Hylands (2008) did find that annual medical expenditures increase at a decreasing rate as the time with diabetes increases, which would be confirmed by my results, but they do not report after how many years lived with diabetes the costs would be decreasing.

The introduction of diabetes treatment, diabetes duration and year of onset cohorts has led to another remarkable result. I find that the effect of age is not significantly related to care costs, contradicting the results found by Trogdon and Hylands (2008). The authors did include age and age squared together with diabetes duration and diabetes duration squared, as I do in this analysis. However, in their case, age was significantly associated with increasing care costs, having age squared a negative sign, regardless of the covariates included in the regression model (diabetes duration, diabetes duration squared and even some comorbidities). Hence, my results would denote that it is diabetes duration and the complications associated with the progression of the disease rather than age what explain the rise in total care costs.

These results also suggest that diabetes complications, both non-related and diabetes-related, have a different impact on the effect of average glucose control and treatment and diabetes duration on total costs. The findings are suggestive of a mediation effect of diabetes-related complications on average glucose control and insulin use. In fact, being treated with insulin is significantly associated with an increase in total care costs, by 56.06 and 51.8 percentage points for every one additional unit of HbA1c, when non-related and diabetes-related complications are, respectively, part of the analysis. On the other hand, when chronic conditions are introduced, the effect of diabetes duration increases, compared to previous regression models, which would contradict previous findings (Trogdon and Hylands, 2008). In the current analysis, one additional year lived with diabetes increases total costs by 6.60% when non-diabetes related comorbidities are considered and by 7.58 percentage points if diabetes-related complications enter into the regression model. In Trogdon and Hylands (2008), before and after adjusting for comorbidities, the effect of one additional year since diabetes diagnosis decreased by half, from 2.4% to 1.1%.

Moreover, I have found that the influence of average glucose control, diabetes treatment modality, and diabetes duration is maintained across costs components, with some minor exceptions. The greatest impact of HbA1c is observed on drugs (Hendriks and Bilo, 2017) and GP costs, whereas the greatest impact of insulin treatment is placed on devices and hospital and specialist costs (Brandle et al., 2003).

Some limitations should also be mentioned. Firstly, the analyses were performed based on the population from the North of The Netherlands, being especially representative of the specific population. Although the generalizability of the results to other areas in the country might be limited, I expect that the relative differences in costs would be maintained in other regions of The Netherlands. Secondly, it would have been good to have a longer period of data and a greater number of complete cases to observe the same individuals for more time. Only having four-year data might not be enough to fully disentangle the diabetes duration effect from the year of diagnosis effect. The reimbursement and claims data allows to assess the association between care costs and diabetes, but I might not be able to completely fill in the gap in the literature and the clinical feature. Moreover, using ICPC codes to correct for comorbidities might be under-reporting the prevalence and, thus, the relevance of the association between comorbidities and care costs in people with diabetes. For example, the obesity prevalence in the data is 0.7%, whereas estimates from the World Health Organization for 2008 showed that obesity prevalence among Dutch adults was 18.8% (WHO, 2013). In fact, the lack of information on actual prevalence might be the reason behind the minor change on the coefficients and significance of the other covariates.

These findings lead to several contributions to the existing literature. Firstly, I not only look at the impact of average glucose control on care costs incurred by people with diabetes, but I also correct for treatment modality and for diabetes duration and year of onset effects. The inclusion of all these factors together has not been previously done. Excluding these factors could lead to an overestimation of the burden of other variables. Treatment modality has been proved to be definitely associated with the outcome, higher care costs, and average glucose control, but it does not necessarily mean that improving HbA1c is related to total costs. This could have implications for the pharmaceutical industry when developing different treatments for older people with diabetes as, instead of placing the focus largely on the management of the chronic conditions, the scope could change to average glucose control and treatment modality, which can be modified and improved. Actually, the effect of diabetes duration and year at onset cohort also points to the relevance of diabetes treatment, as people with a longer diabetes duration might be in need for different and more costly treatment. Secondly, controlling for comorbidities allows to quantify the corrected impact of HbA1c and time since diagnosis on care costs, showing that the greatest variation on the effect of HbA1c, diabetes treatment and diabetes duration is shown when diabetes-related complications are part of the analysis. These two main contributions are of great relevance for policymakers when implementing diabetes management guidelines and programs. The results suggest that if a good management of average glucose control could be implemented for a whole population, the impact of diabetes duration, which is not modifiable, and the risk of developing associated complications could be reduced. Finally, another strength of the data is that using claims data reduces biases which can be derived from other data sources, such as self-reported data. The available data allowed me to have access to laboratory, clinical and costs registries data. I actually show that it might be important not to rely only on reimbursement data, but also on clinical data to get consistent results. I then provide researchers and policymakers with reliable estimations on reimbursed care costs per patient.

APPENDIX CHAPTER 2

Figure 2.A1: Mean logarithm of care costs component (GP, hospital and specialist, drugs and devices costs) by diabetes duration and cohort
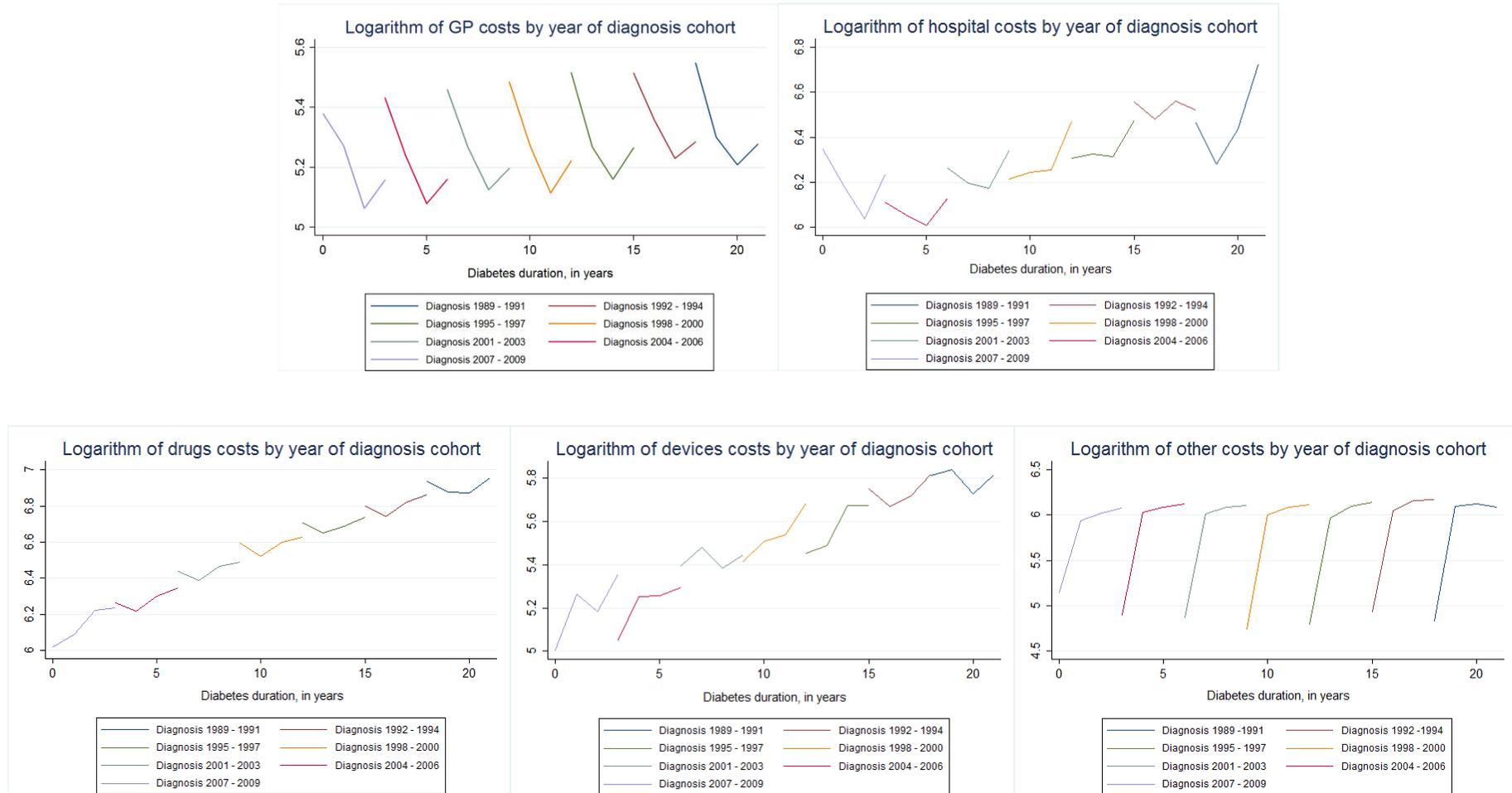
Table 2.A1: Description of variables included in the analysis

Variables	Dataset of origin	Coding	Observations
Total care costs (in 2010€)	VEKTIS dataset	Total care costs incurred by people with diabetes and reimbursed by the insurance	Time-variant. Costs were inflated or deflated, as appropriate, according to the Consumer Price Index (CPI) obtained from Statistics Netherlands.
GP cost (in 2010€)	VEKTIS dataset	Total costs incurred by people with diabetes when visiting their General Practitioner (GP) and reimbursed by the insurance	Time-variant. Costs were inflated or deflated, as appropriate, according to the CPI obtained from Statistics Netherlands.
Drugs cost (in 2010€)	VEKTIS dataset	Total drugs costs incurred by people with diabetes and reimbursed by the insurance	Time-variant. Costs were inflated or deflated, as appropriate, according to the CPI obtained from Statistics Netherlands.
Hospital cost (in 2010€)	VEKTIS dataset	Total hospitalization and specialist visits costs incurred by people with diabetes and reimbursed by the insurance	Time-variant. Costs were inflated or deflated, as appropriate, according to the CPI obtained from Statistics Netherlands.
Devices cost (in 2010€)	VEKTIS dataset	Total costs incurred by people with diabetes covering devices and other tools reimbursed by the insurance	Time-variant. Costs were inflated or deflated, as appropriate, according to the CPI obtained from Statistics Netherlands.
Other cost (in 2010€)	VEKTIS dataset	Total other costs (obstetrics, maternity, paramedical care, dentistry, hospital transport, mental care and abroad costs) incurred by people with diabetes and reimbursed by the insurance	Time-variant. Costs were inflated or deflated, as appropriate, according to the CPI obtained from Statistics Netherlands.
Female	VEKTIS dataset	1: individual is a woman; 0: if man	Time-invariant.
Age (in years)	VEKTIS dataset	Age of the individual in each calendar year, in years	Time variant. Self-generated by subtracting the year of birth from the calendar year

Table 2.A1: (continued)

Variables	Dataset of origin	Coding	Observations
Non-Caucasian ethnicity	ZODIAC dataset	1: the individual ethnicity is non-Caucasian (Afro-Caribbean / Black or Asian-Indian); 0: if Caucasian ethnicity	Time-invariant
Socioeconomic Status (SES)	VEKTIS dataset	1: the individual SES is low; 2: the individual SES is medium; 3: if high	Time-variant. Socioeconomic status by postcode and self-divided into three quintiles
Current smoker	ZODIAC dataset	1: individual is currently smoking; 0: otherwise	Time invariant
Average glucose control	ZODIAC dataset	HbA1c, in % (mmol/mol)	Time-variant. Upper and lower bounds were applied[8]
Diabetes duration	ZODIAC dataset	Time since diabetes diagnosis in each calendar year, in years	Time-invariant. Self-generated by subtracting the age at diagnosis diagnosis from current age
Year of diagnosis	ZODIAC dataset		Time-invariant. Self-generated by subtracting the diabetes duration from the calendar year
Type of medication			
Oral medication	ZODIAC dataset	1: individual has been told to take oral medication as diabetes treatment; 0: otherwise	Time-variant. A low proportion of the sample undergoes both diabetes treatments (oral medication and insulin)
Insulin	ZODIAC dataset	1: individual has been told to use insulin as diabetes treatment; 0: otherwise	Time-variant. A low proportion of the sample undergoes both diabetes treatments (oral medication and insulin)
General Practitioner (GP) code	VEKTIS dataset	GP identification number	Time-variant

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[8] Extreme values were deleted according to the KCK DS Extreme Values report from 2016.

Table 2.A1: (continued)

Variables	Dataset of origin	Coding	Observations
Elixhauser comorbidities			
Cancer	ZODIAC dataset	1: the individual has ever been diagnosed of cancer; 0: otherwise	Time-variant. Corresponding ICPC codes: A79, B72, B72.01, B72.02, B74, B75, D74, D75, D76, D77, D77.01, D77.02, D77.03, D77.04, D78, D78.01, F74, F74.01, F74.02, H75, H75.01, H75.02, I71, I71.01, I71.02, K71, K71.02, K72, K72.01, K72.02, L88, L88.01, L88.02, N74, N75, N76, R83.02, R84, R85, R86, S77, S77.01, S77.02, S77.03, S78, S79, S79.01, S80, S80.01, S81, T71, T72, T73, U75, U76, U77, U78, U79, X75, X76, X76.01, X77, X77.01, X77.02, X78, X78.01, X79, X80, X81, Y71.01, Y77, Y78, Y78.01, Y78.02, Y78.03, Y79
Congestive heart failure	ZODIAC dataset	1: the individual has ever been diagnosed of congestive heart failure; 0: otherwise	Time-variant. Corresponding ICPC codes: K77, K77.01, K77.02
Acute myocardial infarction	ZODIAC dataset	1: the individual has ever suffered an acute myocardial infarction; 0: otherwise	Time-variant. Corresponding ICPC codes: K75, K76.02
Peripheral vascular disease	ZODIAC dataset	1: the individual has ever been diagnosed of peripheral vascular disease; 0: otherwise	Time-variant. Correspondent ICPC codes: K92, K92.01, K92.02, K92.03, K92.04
Hypertension, uncomplicated	ZODIAC dataset	1: the individual has ever been diagnosed of uncomplicated hypertension; 0: otherwise	Time-variant. Corresponding ICPC codes: K86
Hypertension, complicated	ZODIAC dataset	1: the individual has ever been diagnosed of complicated hypertension; 0: otherwise	Time-variant. Corresponding ICPC codes: K87

Table 2.A1: (continued)

Variables	Dataset of origin	Coding	Observations
Alcohol abuse	ZODIAC dataset	1: the individual has ever been diagnosed of alcohol abuse; 0: otherwise	Time-variant. Corresponding ICPC codes: P15, P15.01, P15.02, P15.03, P15.05, P15.06, P16
Paralysis	ZODIAC dataset	1: the individual has ever been diagnosed of paralysis; 0: otherwise	Time-variant. Corresponding ICPC codes: N18
Stroke	ZODIAC dataset	1: the individual has ever suffered an stroke	Time-variant. Corresponding ICPC codes: K90.03
Any other cerebrovascular accident	ZODIAC dataset	1: the individual has ever suffered any other cerebrovascular accident; 0: otherwise	Time-variant. Corresponding ICPC codes: K90, K90.01, K90.02
Dementia	ZODIAC dataset	1: the individual has ever been diagnosed of dementia; 0: otherwise	Time-variant. Corresponding ICPC codes: P70, P70.01, P70.02
Chronic pulmonary disease	ZODIAC dataset	1: the individual has ever been diagnosed of chronic pulmonary disease; 0: otherwise	Time-variant. Corresponding ICPC codes: R91, R91.01, R91.02, R95
Retinopathy	ZODIAC dataset	1: the individual has ever been diagnosed of retinopathy; 0: otherwise	Time-variant. Corresponding ICPC codes: F83, F83.01, F83.02
Neuropathy	ZODIAC dataset	1: the individual has ever been diagnosed of neuropathy; 0: otherwise	Time-variant. Corresponding ICPC codes: N94.02
Hypothyroidism	ZODIAC dataset	1: the individual has ever been diagnosed of hypothyroidism; 0: otherwise	Time-variant. Corresponding ICPC codes: T86
Renal failure	ZODIAC dataset	1: the individual has ever been diagnosed of renal failure; 0: otherwise	Time-variant. Corresponding ICPC codes: U99.01, T88
Liver disease	ZODIAC dataset	1: the individual has ever been diagnosed of liver disease; 0: otherwise	Time-variant. Corresponding ICPC codes: D72, D72.01, D72.02, D72.03, D96, D97, D97.04, D97.05

Table 2.A1: (continued)

Variables	Dataset of origin	Coding	Observations
Peptic ulcer	ZODIAC dataset	1: the individual has ever been diagnosed of peptic ulcer; 0: otherwise	Time-variant. Corresponding ICPC codes: D85, D86, D86.01
Rheumatoid arthritis	ZODIAC dataset	1: the individual has ever been diagnosed of rheumatoid arthritis; 0: otherwise	Time-variant. Corresponding ICPC codes: K71.01, K71.01, K71.02, L88, L88.01, L88.02
Weight loss	ZODIAC dataset	1: the individual has ever suffered weight loss; 0: otherwise	Time-variant. Corresponding ICPC codes: T06, T06.01, T08
Obesity	ZODIAC dataset	1: the individual has ever been diagnosed of obesity; 0: otherwise	Time-variant. Corresponding ICPC codes: T82
Anaemia	ZODIAC dataset	1: the individual has ever been diagnosed of anaemia; 0: otherwise	Time-variant. Corresponding ICPC codes: B78, B78.01, B78.02, B78.03, B79, B80, B81, B81.01, B81.02, B82
Psychosis	ZODIAC dataset	1: the individual has ever been diagnosed of psychosis; 0: otherwise	Time-variant. Corresponding ICPC codes: P71, P72, P73, P73.02
Depression	ZODIAC dataset	1: the individual has ever been diagnosed of depression; 0: otherwise	Time-variant. Corresponding ICPC codes: P74, P74.01, P74.02, P75, P76, P76.01

Table 2.A2: Results from the random-effects linear regression model on the logarithm of total care costs. Sensitivity analysis

VARIABLES	Coeff. Model 6	Coeff. Model 7
Female	0.0500**	0.0639***
	(0.0197)	(0.0194)
Age	0.0117	0.0108
	(0.00982)	(0.00973)
Age²	3.37e-05	2.87e-05
	(7.16e-05)	(7.10e-05)
Non-Caucasian ethnicity	-0.0377	-0.0381
	(0.174)	(0.173)
Socioeconomic Status (SES) categories		
Low SES	0.0583*	0.0560*
	(0.0335)	(0.0329)
Medium SES	0.0339	0.0301
	(0.0349)	(0.0341)
Current smoker	0.0303	0.0209
	(0.0285)	(0.0280)
HbA1c, in % (mmol/mol)	0.0153	0.0130
	(0.0193)	(0.0192)
Type of medication		
Oral medication	0.0516	0.0555
	(0.133)	(0.133)
Insulin	0.606***	0.556***
	(0.146)	(0.144)
Glycaemic level # type of medication		
HbA1c # Oral medication	-0.0108	-0.0114
	(0.0196)	(0.0195)
HbA1c # Insulin	-0.0454**	-0.0380*
	(0.0198)	(0.0196)
Diabetes duration	0.0660***	0.0758***
	(0.00602)	(0.00650)
Diabetes duration²	-0.000996***	-0.00114***
	(0.000162)	(0.000165)
Year of onset categories		
Before 1989	-0.665***	-0.818***
	(0.126)	(0.129)
Year 1989 – 1991	-0.556***	-0.679***
	(0.0930)	(0.0972)
Year 1992 – 1994	-0.444***	-0.560***
	(0.0817)	(0.0861)
Year 1995 – 1997	-0.434***	-0.518***
	(0.0674)	(0.0698)
Year 1998 – 2000	-0.328***	-0.390***
	(0.0557)	(0.0576)
Year 2001 – 2003	-0.217***	-0.262***
	(0.0469)	(0.0478)
Year 2004 – 2006	-0.139***	-0.154***
	(0.0405)	(0.0402)
Diabetes non-related comorbidities		
Cancer	0.629***	0.638***
	(0.0830)	(0.0841)
Alcohol abuse	0.300*	0.301*
	(0.161)	(0.159)
Paralysis	0.0170	0.0650
	(0.0444)	(0.0481)

Table 2.A2: (continued)

VARIABLES	Coeff. Model 6	Coeff. Model 7
Chronic pulmonary disease	0.177	0.144
	(0.135)	(0.139)
Hypothyroidism	0.0948	0.0604
	(0.0848)	(0.0857)
Liver disease	0.105	0.0356
	(0.346)	(0.336)
Peptic ulcer	0.0195	-0.108
	(0.183)	(0.240)
Rheumatoid arthritis	-0.396***	-0.379***
	(0.141)	(0.142)
Anaemia	0.180***	0.149**
	(0.0687)	(0.0684)
Psychosis	0.393*	0.433**
	(0.216)	(0.213)
Depression	0.151**	0.144**
	(0.0624)	(0.0614)
Diabetes-related comorbidities		
Congestive heart failure		0.354***
		(0.0656)
Acute myocardial infarction		0.349***
		(0.0644)
Peripheral vascular disease		0.355***
		(0.0757)
Hypertension, uncomplicated		-0.0290*
		(0.0173)
Hypertension, complicated		0.0363
		(0.0503)
Stroke		0.250***
		(0.0322)
Any other cerebrovascular accident		0.322***
		(0.0619)
Dementia		0.159
		(0.143)
Retinopathy		0.0272
		(0.0672)
Neuropathy		0.125
		(0.0813)
Renal failure		0.0671
		(0.0480)
Weight loss		0.563***
		(0.0295)
Obesity		0.0765
		(0.0678)
Constant	6.367***	6.382***
	(0.398)	(0.396)
N (Observations)	22,612	22,612
N (Individuals)	5,653	5,653
General Practitioner FE	YES	YES
R-squared		
Within	0.027	0.035
Between	0.187	0.217
Overall	0.130	0.151
σ_u	0.613	0.587
σ_e	0.648	0.645

Table 2.A2: (continued)

VARIABLES	Coeff. Model 6	Coeff. Model 7
ϱ	0.472	0.453
Joint significance of new variables (χ^2)	83.87***	578.97***

Clustered standard errors at the individual level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Reference categories: men, Caucasian ethnicity, high SES, no current smokers, no medication, year of diabetes onset 2007 - 2009.

Model 6 adds to Model 5 the diabetes non-related Elixhauser comorbidities. Model 7 additionally includes the diabetes-related Elixhauser comorbidities.

DIABETES-ASSOCIATED FACTORS AS PREDICTORS OF NURSING HOME ADMISSION AND COSTS IN THE ELDERLY ACROSS EUROPE[9]

3.1 INTRODUCTION

The number of patients with diabetes has rapidly increased globally, being projected to near doubling the figures of the turn of the century (2.8%) and reaching around 380 million people by 2025 all over the world and 4.8% of the whole population in the year 2030 (O'Shea et al., 2013). Older adults will lead this increase (Sloan et al., 2008), representing around 50% of the people with diabetes and with a prevalence of diabetes around 25% (Soriguer et al., 2012; Sloan et al.,

2008). In fact, the ageing of the population, together with greater levels of obesity, will make diabetes becoming a pandemic (O'Shea et al., 2013).

Traditionally, the social impact of diabetes has been linked to the use of health and social resources, as well as healthcare and non-healthcare costs. It has been proved that medical costs for patients with diabetes are up to three times higher than costs for patients without the disease (Clarke et al., 2010). Furthermore, a recent report from the American Diabetes Association (ADA, 2013) reported that due to the increase in diabetes prevalence, their estimations about use of healthcare resources as well as costs had increased almost one third in comparison with their previous analysis from 2007, increasing from $135 billion to $176 billion. Another study from the US concluded that direct costs derived from diabetes represent $174 billion per year for the government, assessing an average expenditure per capita and per year for an elderly patient between $3,407 for the most-conservative estimate and $9,713 for the least conservative one (Anderson, 2012).

Regarding the components of the costs, associated costs typically include visits to physicians (GP and specialists) and nurses, drug costs, visits to the Emergency Room and hospitalization (Oliva et al., 2004). However, two other components usually neglected should be added into the calculation of costs of diabetes in the elderly: those related to impaired functional status and those associated with institutionalization. Functional status is one of the most important components in determining the use of health-care systems (Weiss, 2011) and the annual healthcare costs in older people (Lubitz et al., 2003), which increase in near three fold the costs in people with any limitation in Activities of Daily Living (ADL) compared with those who remain independent and by nine times in institutionalized patients.

Diabetes among older people increases in a significant manner both risks: to be dependent and to be institutionalized. Some evidence from the US reported that diabetes is a determinant of nursing home placement among the frail elderly and, moreover, old people with diabetes are 1.8 times more likely to be institutionalized (Matsuzawa et al., 2010). Around 30-35% of institutionalized older people have diabetes, a condition associated to a higher resource utilization (Newton et al., 2013). With all these figures in mind, the scenario for the next decades shows an increase in the costs associated to the management of people with diabetes due to the ageing of the population and the higher costs per capita with advancing age (Waldeyer et al., 2013). Those increasing costs constitute a new challenge for the Health Systems, who should refine broadly implemented procedures with non-proved benefits for the patients and costly for the Health System, and, at the same time, implement models of care tailored to the needs of this population (Sinclair et al., 2015; Sinclair et al., 2011).

Diabetes relevance might vary between countries: in low and middle income countries, diabetes is becoming more important due to the diet and lifestyle factors in younger populations (Hanson et al., 2012; Hu, 2011); whereas in high-income countries, diabetes is becoming a pandemic in the elderly, as previously mentioned, due to the population ageing and the increasing prevalence of diabetes in this group age (O'Shea et al., 2013). Bearing in mind the effect of an increasing prevalence of diabetes among the elderly on a positive shift in the demand for health and social care and, consequently, in its costs, it seems relevant to estimate the burden of diabetes on both long-term care use and expenditure in developed countries, such as European countries. However, not many studies analyzing the drain of diabetes in old ages in Europe are currently available. There are reports about quality of care for people with diabetes mellitus (Gorter et al., 2010; Sinclair, 2007), but not too much has been published about the determinants of nursing home admission and cost drivers within the European diabetic population. The UKPDS study, which is being carried out in the United Kingdom, showed that diabetes and its associated complications had a great impact on healthcare expenditures not only in the year of the event, but also in succeeding years (Alva et al., 2014). Another study carried out in the Netherlands showed differences in costs when people with diabetes received different kinds of care (van der Heijden et al., 2014).

The main aim of this chapter is to estimate the role of diabetes and a list of clinical and functional complications leading to institutionalization of people older than 50 years old using observational data and to what extent the association between nursing home placement and the main variables of interest differ across Europe. A recent review on ageing in the European Union (Rechel et al., 2013) claimed the great need of coordination and organization of long-term services across Europe, where long-term care policies seem to differ substantially between countries. It is well-known that there are cultural differences between North and South Europe in terms of health and social care use, which prompts my approach. Actually, Southern European countries are considered to be "strong-family-ties countries", where looking after an old and very old relative at home is more likely than being transferred to a nursing home, while their Northern counterparts are regarded as "weak-family-ties countries", where, in comparison, the odds of being transferred to a nursing home are higher (Reher, 1998). After obtaining these results, I will use them to estimate nursing home expenditures attributable to diabetes and its complications in Europe. Public expenditures are likely to significantly increase in Europe from $1-2\%$ to $2-3\%$ of the GDP between 2007 and 2060 (Rechel et al., 2013). Cross-countries differences associated with long-term care are also found regarding public expenditures. For instance, in 2000, public

expenditures on long-term care as a percentage of GDP was reported to range from 2.74 in Sweden to 0.16 in Spain (OECD, 2005).

So, investigating more broadly the factors that increase the risk of being institutionalized as well as the impact of diabetes and the problems associated with the disease on nursing home costs would help policy makers to a better allocation of the scarce resources and to inform effective policy interventions to avoid the excessive use of healthcare resources related to nursing home entry of people with diabetes and, consequently, reduce its associated costs.

The chapter proceeds as follows. First, the data that have been used to run the analyses are presented. Second of all, the empirical methods used for both the estimation of the determinants of institutionalization and the costs associated with diabetes and its clinical and functional complications in this study will be described. Third, the results are presented. Finally, the chapter concludes with a discussion of the implications of my results for governments and policymakers.

3.2 DATA AND METHODS

3.2.1 Data and sample

Data for this study have been obtained from the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a longitudinal study which includes information about health, socioeconomic status and family networks of a representative sample of the community-dwelling individuals consisting of 86,290 individuals aged fifty and over from nineteen European countries (Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, The Netherlands, Poland, Portugal, Slovenia Spain, Sweden and Switzerland) and Israel. I limited my study to twelve of those countries, namely Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, The Netherlands, Spain, Sweden and Switzerland[10]. I have pooled data from three different waves: wave 1 (2004), wave 2 (2006-07) and wave 4 (2010)[11]. SHARE contains individual level information on general characteristics (age, gender, country, marital status, education, etc.), health status (self-perceived health, diagnoses), functional impairment (number of limitations in ADLs) and health care use (being admitted into a nursing home (NH), being admitted to hospital, etc.). Persons in a nursing home are included when one of their family members is in the sample.

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[10] Estonia, Hungary, Ireland, Israel, Poland, Portugal and Slovenia have not been included due to their small size of sample.

[11] Wave 3 has been excluded due to a change in the questionnaire (the SHARELIFE questionnaire), which registered information on individuals' childhood health and, hence, the information provided in wave 3 was not useful for the analysis. However, I have used Wave 3 data to drop the observations already reporting to suffer diabetes in their childhood.

Data regarding total expenditure for NHs per country have been taken from the Organization for Economic Co-operation and Development (OECD) Data and Statistics databases for the survey years (2004, 2006, 2007 and 2010). OECD Data and Statistics offers users information about a wide range of variables (general statistics, demography and population data, education and training, environment, health, labour and productivity, etc.) across OECD countries. I have collected information about healthcare expenditure and financing by provider, selecting data from services of long-term nursing care in nursing and residential care facilities. Institutionalization costs are not available for Italy, Sweden and Greece, so their analyses is just focused on finding out the predictors leading to nursing home admission.

Finally, in order to make the results across countries more comparable, information on Gross Domestic Product (GDP), adjusted by Power Purchasing Parity (PPP) index for every country and year included in this study has been taken from the World Bank.

3.2.2 Methodological framework

By combining a logit model based on SHARE data which gives the probability of being in a nursing home for given diabetes and other characteristics, with information from the OECD database on country specific expenditure, the costs of nursing home attributable to diabetes are calculated as follows.

Taking the coefficients estimated in the logit model, the etiological fraction for each of the clinical and functional complications associated with diabetes is calculated. This approach has been previously used in the reports published by the American Diabetes Association (ADA, 2013; ADA, 2003). The main difference between those and the present study is that the former estimated an etiological fraction for each medical condition regardless of the healthcare resource, whereas I appraise a specific etiological fraction for every medical condition and for a specific healthcare resource (nursing home use in this analysis), which allows for more accurate interpretation. By doing so, I am able to estimate the excess of healthcare resource use by people with diabetes that would be avoided if an individual did not have diabetes. The etiological fraction is the excessive proportion of healthcare resource use due to a medical condition that affects individual's health state, including cognitive and functional impairment, which could be attributable to diabetes according to the diabetes status and the probability of having diabetes (ADA, 2013; ADA, 2003). The formula to calculate the etiological fraction is as follows,

$$EF_d = \frac{[P_d \ x \ (RR_d - 1)]}{[P_d \ x \ (RR_d - 1) + 1]} \qquad (1)$$

where EF_d is the etiological fraction of healthcare resource use, nursing home use in my study, for each condition d (diabetes, diabetes non-related complications and diabetes-related

complications) which is attributable to diabetes; P_d represents disease specific prevalence; and RR_d denotes the adjusted relative risk of condition d for those diabetic people against people without diabetes. Adjusted relative risks are calculated according to Norton et al. (2014); Norton, et al., (2013); and Kleinman and Norton (2009). They show that previous estimations on how to convert odds ratio to relative risk measures are biased or overestimate the interpretation of odds ratio. Moreover, they show how to compute adjusted relative risks in Stata for logit models, as it is the case in the present analysis (Norton et al., 2014).

Several reasons motivated the use of etiological fractions for the calculation of costs. Firstly, etiological fractions let the researcher make more clear judgements about causality. Secondly, they allow to consider the "external validity" of the results, since etiological fractions force researches, first of all, to examine the relevance of their results and, then, to think about the impact of their results in society as a whole (Steenland and Amstrong, 2006).

Finally, costs in this study are divided into two subcategories (ADA, 2013; ADA, 2003): those costs incurred by people with diabetes and the costs that can be attributed to diabetes, which are those extra costs that governments have to face strictly due to diabetes and its complications (both clinical and functional complications).

The former costs can be estimated using the following formula,

$$C_{Dj}^{NH} = EF_D \; x \; C_j^{NH} \tag{2}$$

where C_{Dj}^{NH} denotes the total nursing home costs generated by people with diabetes, EF_D is the etiological fraction for diabetes based on Model 1 and C^{NH} represents the total expenditure on nursing home care for the overall sample and by country j[12].

In order to evaluate the costs directly attributed to diabetes, the following formula is used running the analysis only for the subsample with diabetes[13]:

$$C_{dj}^{NH} = EF_d \; x \; C_{Dj}^{NH} \tag{3}$$

where C_{dj}^{NH} denotes the total nursing home costs attributed to condition d, EF_d is the etiological fraction for condition d and C_D^{NH} represents the total expenditure on nursing home care incurred by people with diabetes for the overall sample and by country j[8].

Disease specific prevalence within the sample and by country is provided in Table 3.A1 in the Appendix.

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[12] No data was available for nursing home expenditures in Sweden, Italy and Greece in OECD Database, so I couldn't estimate nursing home expenditures attributed to diabetes in these countries.

[13] The regressions for the diabetic population could not be run for Denmark, neither for Switzerland due to data failures. These two countries were dropped from the costs analysis in addition to the European nations that were dropped due to the lack of available information on nursing home expenditures.

3.2.3 Statistical analyses

First of all, univariate analyses are performed between the dependent variable and each of the independent variables. Only the variables that are significant in the univariate analysis are afterwards included in the multivariate regressions.

Then, modelling the probability of a positive outcome with a linear probability model (LPM) is known to be problematic (non-sensical predictions, functional form misspecification and heteroskedasticity are a few of the econometric issues of the LPM). Actually, LPM are also run in case they are feasible, but its application to this analysis has been rejected since there are too many negative probabilities predicted (more than 20%). Instead, non-linear models for binary responses such as logistic regressions with random effects are estimated (Rabe-Hesketh and Skrondal, 2008; Jones, 2005; Heij et al., 2004). In order to make sure my regression model choice is the most appropriate, the average marginal effects from the LPM and the logit model have been compared. LPM marginal effects strongly differ from the ones derived from the logistic regression, supporting my decision. Furthermore, fixed-effects logit models are also run but the number of observations dramatically dropped (from 90,589 observations to 479 observations), so only random-effects regressions are finally used for the purpose of this study.

In logit models, estimated coefficients capture the effects on the log-odds-ratio (see e.g. Heij et al., 2004). Let $\Lambda(t) = e^t/(1 + e^t)$ be the logistic function with values stretching between zero and one, and let

$$Pr[NHP_{ict} = 1 \,|x_{it}] = \Lambda\,(x_{it}'\beta) \qquad (4)$$

where i represents the individual, c country, and t year. NHP_{ict} is a dummy variable indicating that respondent i lived in country c and either permanently or temporarily in a nursing home in year t. $x_{it} = (\text{SE}_{it},\ \text{diabetes}_{it},\ \text{HI}_{it}, \text{country dummies}, \text{time dummies})'$ is a vector of explanatory variables. SE_{it}, diabetes_{it}, HI_{it} denote the set of socioeconomic variables, having diabetes and chronic conditions, respectively. In other words I can rewrite model (4) as:

$$Pr[NHP_{ict} = 1 \,|x_{it}] = \Lambda(\,\beta_0 + \,\beta_1 SE_{it} + \,\beta_2 diabetes_{it} + \,\beta_3 HI_{it} + \,\gamma_c + \,\zeta_t) \quad (5)$$

where γ_c and ζ_t denote country and time dummy coefficients, respectively. I estimate the parameters of equation (5) using a panel dataset (SHARE). In order to take into account within individual autocorrelation, I always compute clustered standard errors at the individual level.

In the above logistic regression model, some diseases such as cerebrovascular conditions as well as functional impairment have not been included due to their relationship with diabetes, the main disease of interest in my analysis. If these complications had been counted in, the gross effect of diabetes would not be measured. However, in order to evaluate the net impact of diabetes in institutionalization and, consequently, its costs, these variables are incorporated into

the vector of independent variables in a second (clinical complications) and a third (functional complications) regression model. In the latter model, informal care is also added to test whether receiving informal care at home is an alternative of nursing home care and, hence, reduces the odds of being institutionalized or, on the other hand, whether it is a determinant of nursing home placement. This third regression model also controls for smoking as a potential confounding variable.

I then perform several sensitivity analyses. Firstly, in order to measure the effect of complications related with diabetes on the outcome, interactions between diabetes and health conditions, health behaviours and informal care reception are included in the vector of explanatory variables (model 4).

Second, since more disaggregation of the data allows for more accurate projections of the overall effect and cost of diabetes, the sample has been stratified into gender (males and females) and age groups (50-65, 66-80 and older than 80 years) and models 1, 3 and 4 are re-estimated for these five subgroups.

Third, since the survey question about nursing home use differentiates between temporary and permanent use, the first, third and fourth regression models are also run for the different types of length of stay.

Finally, since one of the aims of this analysis is to study across countries differences, regression models 1, 3 and 4 detailed in this section are run by country, excluding the country dummies term.

All the statistical analyses have been performed using STATA 14.0 software (Stata Corporation, College Station, TX).

3.2.4 Variables description

Table 3.A2, Appendix, presents all variables included in the analyses.

Nursing home in SHARE is defined as *institutions sheltering older persons who need assistance in activities of daily living, in an environment where they can receive nursing care, for short or long stays.* Thus, the dependent variable takes value 1 if the respondent has been in a nursing home overnight in the last twelve months, either temporarily or permanently, and 0 otherwise.

Figure 3.1 shows the idea that motivates the criteria for the inclusion of clinical and functional complications in the regression model. Diabetes effect on nursing home admission is expected to be mediated by both clinical and functional complications, which might be at the same time caused by other diseases and other factors.

<u>Figure 3.1: Flow chart of diabetes and clinical and functional complications leading to nursing home placement</u>
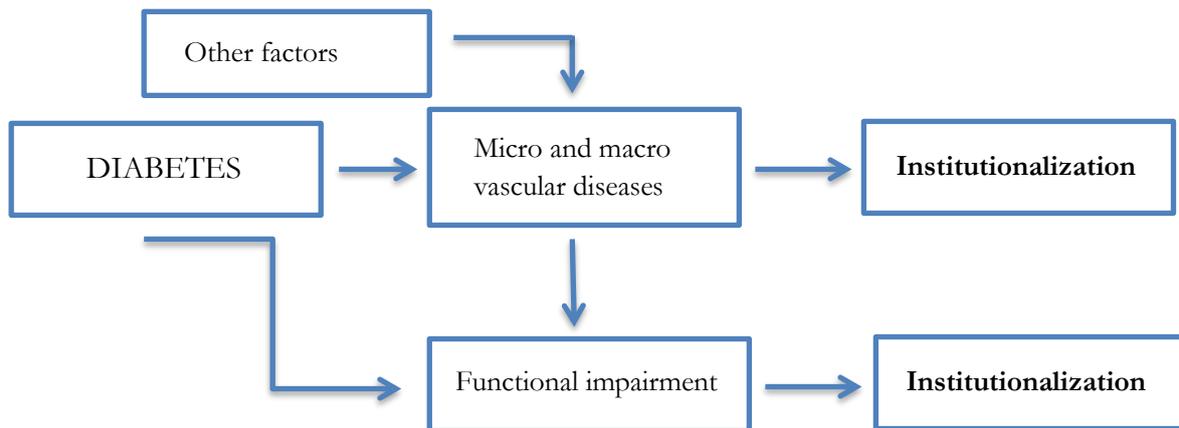
Moreover, a literature review has been made on the association between nursing home admission and health, as well as on institutionalization and diabetes to justify the inclusion of the variables. Results showed that sociodemographic factors such as age (Drame et al., 2012; Luppa et al., 2010; Gaugler et al., 2009; Luppa et al., 2008; Gaugler et al., 2007; Andel et al., 2007; Russell et al., 2005; Yaffe et al., 2002; Agüero-Torres et al., 2001; Smith et al., 2001; Smith et al., 2000; Jagger et al., 2000), gender (Gaugler et al., 2009; Habermann et al., 2009; Luppa et al., 2008; Gaugler et al., 2007; Russell et al., 2005; Agüero-Torres et al., 2001; Smith et al., 2001), marital status (Drame et al., 2012; Luppa et al., 2010; Gaugler et al., 2009; Habermann et al., 2009; Luck et al., 2008; Luppa et al., 2008; Gaugler et al., 2007; Andel et al., 2007; Russell et al., 2005; Yaffe et al., 2002; Smith et al., 2001; Smith et al., 2000; Severson et al., 1994), education (Luppa et al., 2008; Smith et al., 2000; Severson et al., 1994), and number of children (Drame et al., 2012; Gaugler et al., 2007) are associated with the risk of institutionalization, either with a negative or a positive sign. Other factors such as employment status (Luppa et al., 2010; Banaszak-Holl et al., 2004) and income (Gaugler et al., 2009; Colerick and George, 1986) are also included in some of the studies. Previous researches have also analysed the influence of chronic conditions (Luppa et al., 2010; van Rensbergen and Nawrot, 2010; Gaugler et al., 2009; Gaugler et al., 2007; Nihtila et al., 2007; Russell et al., 2005; Banaszak-Holl et al., 2004), functional (Drame et al., 2012; Luppa et al., 2010; Gaugler et al., 2009; Habermann et al., 2009; Luppa et al., 2008; Gaugler et al., 2007; Coehlo et al., 2007; Yaffe et al., 2002; Agüero-Torres et al., 2001; Smith et al., 2001; Hebert et al., 2001; Smith et al., 2000; Severson et al., 1994; O'Donnell et al., 1992; Steele et al., 1990) and cognitive impairment (Drame et al., 2012; Luppa et al., 2010; Gaugler et al., 2009; Habermann et al., 2009; Luppa et al., 2008; Gaugler et al., 2007; Russell et al., 2005; Yaffe et al., 2002; Smith et al., 2001; Severson et al., 1994; O'Donnell et al., 1992; Steele et al., 1990) on the risk of being transferred into a nursing home.

Bearing in mind my motivation and the literature search results, the main independent variables of interest are diabetes, as well as the complications that might be related to it. SHARE includes self-reported information about doctor's diagnosis on individuals' chronic conditions and self-reported limitations in ADL. In this analysis, I use six dichotomous indicators of chronic medical conditions, being heart attack, stroke, chronic lung disease, cancer, ulcer and being cognitively impaired, in addition to diabetes. Each diagnosis (model 2) as well as their interaction with diabetes (model 4) are part of the regression model.

Furthermore, SHARE contains responses to the Katz Activities of Daily Living Index. This index, usually referred to as the Katz ADL evaluates functional status as a measurement of the person's ability to carry out six activities of daily living independently (Abizanda et al., 2014)). These are bathing, dressing, toileting, transferring, continence and feeding. Regarding the number of limitations, functional impairment is divided into four categories: i) no impairment if individuals report no limitation in any ADL; ii) mild functional impairment when respondents declare being limited in one or two ADL; iii) moderate functional impairment if participants describe being limited in three to five of these activities; and iv) severe functional impairment when the person reports having difficulties in all ADLs. The last three involved the disability group, whereas the former is used as the reference group. Dummy variables for the different severity levels of functional impairment are included (model 3), as well as their interaction with diabetes (model 4).

Besides, in models 3 and 4, informal care is considered as a social support variable that might be a confounder in my analysis. Only smoking habits are also included in the third and fourth regression as health behaviours due to their expected large confounding effect. Smokers will die earlier and run a smaller risk of being institutionalized.

Finally, I also include in all four regression models other variables that might be related to the risk of being transferred to a nursing home. These are age, gender, level of education, marital and employment status, household income, household size, number of children and grandchildren and distance of these children to the respondent's household.

Dummy variables for each country are included in all these regressions, as well as for each wave.

3.3 RESULTS

3.3.1 Sample characteristics

Table 3.1 shows the descriptive statistics for the overall sample divided according to the outcome: whether respondents have been discharged to a nursing home or not. Furthermore, the table shows a comparison of means test in order to find out which are the significant variables that lead to institutionalization within this sample.

The results suggest that there are socioeconomic and health factors differences across both populations. Those who are admitted to nursing homes are older, more likely to be women, and retired and with lower income. In contrast, being married and high school education or higher, larger household size, a greater number of children and living with these children are more common in people who have not been institutionalized.

Regarding the health factors, worse health status is observed in those respondents who have answered yes to the nursing home use question. The same trend is observed for the diseases by their own as well as for the functional impairment categories. Particularly, the prevalence of diabetes between those discharged to a nursing home and those who are not varies in seven percentage points, from 18.49% in the former group to 11.49% in the latter.

The percentage of people receiving informal care is higher in the nursing home population. Finally, current smokers and those who have ever smoked seem to be less prone to be institutionalized.

Table 3.1: Summary statistics

Variables	Admitted to nursing home (N = 441)			No nursing home (N = 63386)			Comparison of means
	Mean (SD)	Min	Max	Mean (SD)	Min	Max	p-value
Age	75.18 (11.91)	50.1	100.1	65.08 (10.33)	50	104.3	0.000 ***
Female (%)	62.32	0	1	56.03	0	1	0.012 **
High or middle education (%)	38.64	0	1	52.33	0	1	0.000 ***
Married (%)	50.58	0	1	75.42	0	1	0.000 ***
Low household income (%)	36.53	0	1	33.33	0	1	0.077 *
High household income (%)	30.67	0	1	33.35	0	1	0.121
Retired (%)	69.06	0	1	52.01	0	1	0.000 ***
Homemaker (%)	10.43	0	1	11.65	0	1	0.99
Household size	1.73 (0.93)	1	7	2.23 (1.03)	1	14	0.000 ***
Number of children	2.07 (1.58)	0	11	2.23 (1.46)	0	17	0.095 *
Number of grandchildren	3.73 (3.49)	0	20	2.87 (3.26)	0	25	0.000 ***
Children in household (%)	23.96	0	1	37.91	0	1	0.000 ***
Children in less than 5 km (%)	23.20	0	1	22.08	0	1	0.11
Diabetes (%)	18.49	0	1	11.49	0	1	0.000 ***
Heart attack (%)	24.15	0	1	12.94	0	1	0.000 ***
Stroke (%)	19.44	0	1	3.85	0	1	0.000 ***
Chronic lung disease (%)	8.70	0	1	5.66	0	1	0.002 ***
Cancer (%)	7.97	0	1	4.91	0	1	0.012 ***
Ulcer (%)	6.04	0	1	5.52	0	1	0.780
Cognitive impairment (%)	18.63	0	1	6.61	0	1	0.000 ***
Mild functional impairment (%)	29.38	0	1	8.84	0	1	0.000 ***
Moderate functional impairment (%)	12.71	0	1	1.17	0	1	0.000 ***
Severe functional impairment (%)	11.75	0	1	0.63	0	1	0.000 ***
Current smoker (%)	12.68	0	1	19.16	0	1	0.000 ***
Ever smoked (%)	39.69	0	1	46.50	0	1	0.003 ***
Informal care (%)	43.82	0	1	17.74	0	1	0000 ***
Austria (%)	6.94	0	1	6.38	0	1	0.558
Germany (%)	6.10	0	1	5.69	0	1	0.964
Sweden (%)	9.69	0	1	6.14	0	1	0.219
The Netherlands (%)	9.33	0	1	6.65	0	1	0.044 **
Spain (%)	5.14	0	1	6.53	0	1	0.059 *
Italy (%)	6.22	0	1	7.30	0	1	0.935
France (%)	8.73	0	1	9.38	0	1	0.586
Denmark (%)	6.82	0	1	5.20	0	1	0.300
Greece (%)	7.89	0	1	4.91	0	1	0.000 ***
Switzerland (%)	3.59	0	1	4.95	0	1	0.098 *
Belgium (%)	11.60	0	1	9.72	0	1	0.079 *
Czech Republic (%)	7.18	0	1	7.09	0	1	0.790
Wave 1 (%)	35.41	0	1	24.49	0	1	0.000 ***
Wave 2 (%)	26.79	0	1	29.16	0	1	0.080 *
Wave 4 (%)	37.80	0	1	46.35	0	1	0.003 ***

***: $p < 0.01$; **: $p < 0.05$; *: $p < 0.10$; Source: authors of this chapter using data from SHARE. Means of dichotomous variables are expressed as percentages

3.3.2 Diabetes and its complications as determinants of nursing home use

Table 2 shows the results for the overall sample from the three regression models. Model 1 (Column 1, Table 3.2) shows that having diabetes significantly increases the risk of being transferred to a nursing home (OR 1.55). Diabetes ranks second in size for its odds of being institutionalized after cognitive impairment and followed by cancer and chronic lung disease. Being married (OR 0.53), lower household income[14] (OR 0.81), being retired (OR 0.80) and an increasing number of grandchildren (OR 0.96) are the set of socioeconomic factors that are significantly protective against the outcome. On the other hand, increasing age (OR 1.07) significantly increases the risk of nursing home transit.

When clinical (Model 2, Table 3.2) and functional complications (Model 3, Table 3.2) are included, diabetes is still a significant variable, but its coefficient decreases (OR 1.45 in Model 2 and OR 1.24 in Model 3). In the former model, stroke (OR 3.50) shows the highest probability within the chronic diseases leading to institutionalization. Nevertheless, in Model 3, the complication that mostly increases the odds of nursing home placement are the several levels of functional impairment, with severe functional impairment having the highest odds ratio (OR 12.53). The latter model also shows that receiving informal care (OR 1.38) is significant and positively associated with the dependent variable. Regarding the socioeconomic variables, the same pattern for most of them as in model 1 and 2 holds in model 3, with the exception of being retired, which is no longer a significant determinant.

Marginal effects of the regressors on the probability of nursing home use are displayed in Table 3.A3 in Appendix.

3.3.2.1 Sensitivity analysis

Table 3.2 also shows the results from the interactions model (Model 4, Table 3.2). As shown in the table, none of the interactions between the disease of interest and clinical and functional complications are statistically significant. Moreover, diabetes is still positively associated with institutionalization, but it is no longer significant either, probably due to lack of power.

Marginal effects are displayed in Table 3.A3 in Appendix.

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[14] Not enough information was available to interpret the negative association between household income and nursing home admission. It might be due to the fact that, given their low income, those individuals cannot afford the institutionalization fees. However, it was not possible to identify whether the admission was in a public or a private instititution.

Table 3.2: Results from the logit regressions regarding nursing home admission for the overall sample

VARIABLES	Odds ratio Model 1	Odds ratio Model 2	Odds ratio Model 3	Odds ratio Model 4
Diabetes	1.55***	1.45***	1.24*	1.10
	(1.22-1.97)	(1.14-1.85)	(0.98-1.62)	(0.66-1.83)
Diabetes & Chronic lung disease				0.76
				(0.34-1.69)
Diabetes & Cancer				0.72
				(0.30-1.70)
Diabetes & Ulcer				0.96
				(0.44-2.10)
Diabetes & Cognitive impairment				0.67
				(0.34-1.32)
Diabetes & Heart attack				1.05
				(0.62-1.77)
Diabetes & Stroke				1.04
				(0.55-1.98)
Diabetes & Mild functional impairment				1.00
				(0.54-1.86)
Diabetes & Moderate functional impairment				1.10
				(0.46-2.61)
Diabetes & Severe functional impairment				1.82
				(0.68-4.87)
Diabetes & Ever smoked				1.50
				(0.89-2.51)
Diabetes & Informal care				0.95
				(0.56-1.60)
Age	1.07***	1.07**	1.04***	1.04***
	(1.06-1.09)	(1.05-1.08)	(1.03-1.06)	(1.03-1.05)
Female	0.96	0.98	0.92	0.93
	(0.78-1.18)	(0.80-1.21)	(0.74-1.16)	(0.74-1.16)
High or middle education	0.88	0.89	0.97	0.96
	(0.70-1.10)	(0.71-1.11)	(0.77-1.23)	(0.76-1.22)
Married	0.53***	0.53***	0.58***	0.57***
	(0.42-0.66)	(0.42-0.66)	(0.46-0.74)	(0.45-0.73)
Low household income	0.81*	0.80*	0.81*	0.81*
	(0.63-1.04)	(0.62-1.03)	(0.65-1.08)	(0.62-1.04)
Retired	0.80*	0.80*	0.92	0.92
	(0.64-1.02)	(0.63-1.01)	(0.70-1.14)	(0.72-1.17)
Household size	0.98	0.97	0.93	0.93
	(0.84-1.15)	(0.83-1.14)	(0.77-1.09)	(0.78-1.11)
Number of children	1.01	1.01	1.00	0.99
	(0.91-1.12)	(0.91-1.12)	(0.90-1.11)	(0.90-1.10)
Number of grandchildren	0.96*	0.96*	0.96*	0.96*
	(0.92-1.01)	(0.92-1.00)	(0.92-1.00)	(0.92-1.00)
Children in household	0.81	0.81	0.77*	0.77*
	(0.62-1.05)	(0.62-1.05)	(0.58-1.01)	(0.59-1.01)
Chronic lung disease	1.26	1.19	0.96	1.02
	(0.90-1.77)	(0.85-1.67)	(0.68-1.37)	(0.68-1.52)
Cancer	1.42**	1.34*	1.27	1.35
	(1.01-2.00)	(0.95-1.89)	(0.92-1.84)	(0.92-1.99)
Cognitive impairment	2.65***	2.48***	2.00***	2.16***
	(2.07-3.37)	(1.94-3.16)	(1.60-2.68)	(1.63-2.86)
Heart attack		1.14	0.98	0.96
		(0.90-1.44)	(0.77-1.25)	(0.73-1.28)

Table 3.2: (continued)

VARIABLES	Odds ratio Model 1	Odds ratio Model 2	Odds ratio Model 3	Odds ratio Model 4
Stroke		3.50***	2.08***	2.05***
		(2.72-4.49)	(1.61-2.80)	(1.48-2.82)
Mild functional impairment			3.27***	3.28***
			(2.60-4.19)	(2.53-4.25)
Moderate functional impairment			8.48***	8.41***
			(6.02-13.09)	(5.42-13.04)
Severe functional impairment			12.53***	10.59***
			(8.03-19.98)	(6.27-17.91)
Current smoker			0.88	0.89
			(0.63-1.22)	(0.64-1.23)
Ever smoked			1.04	0.96
			(0.81-1.31)	(0.74-1.25)
Informal care			1.38***	1.40***
			(1.09-1.68)	(1.10-1.77)
Observations	90,589	90,589	90,589	90,589
Log pseudolikelihood	-2609.98	-2571.28	-2456.44	-2453.33
Prob > chi2 interactions				0.8301
Country effects	YES	YES	YES	YES
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment) and country dummies. Model 2 adds to the previous model diabetes-related clinical complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care. Model 4 adds the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Each of the interactions measures the effect of jointly having diabetes and any of the above variables compared with not having any of them.

When the sample is divided into age groups (Table 3.A4, Appendix), diabetes is a determinant factor of higher risk of nursing home admission in later ages, from 65 years old and older. Furthermore, diabetes coefficients are greater in the case people's age is over 80 years old (OR 1.839 in Model 1, 5th Column, Table 3.A4) than in those whose age ranges between 66 and 80 years old (OR 1.713 in Model 1, 3rd Column, Table 3.A4) when clinical and functional complications are omitted. However, when these are included in the regression, diabetes remains as a significant predictor only in the oldest subsample (OR 1.454 in Model 3, 6th Column, Table 3.A4). For the population whose age ranges between 50 to 65 years old, diseases such as functional and cognitive impairment, stroke and cancer are the ones that lead to institutionalization (2nd Column, Table 3.A4). Furthermore, informal care is only significant for the oldest cohort. Such variable significantly increases the probability of being institutionalized in those people older than 80 years old (OR 1.710 in Model 3, 6th Column, Table 3.A4). Finally, when interaction terms are part of the regression, none of the interactions neither diabetes appear to be significant predictors of nursing home placement in the population aged 66 and older (Table 3.A5, Appendix). But, if one looks at the youngest age group, diabetes together with cancer (OR 2.472, 1st Column, Table 3.A5, Appendix) significantly increases the probability of being in a nursing home. Conversely, if an individual suffers from diabetes and heart attack, his/her likelihood of being institutionalized is significantly reduced, maybe due to the lower severity of such conditions in this group age.

Tables 3.A6 and 3.A7 in Appendix show the results from the regression models for females and males, and the regressions including interactions for both genders, respectively. Diabetes stands as a significant predictor of nursing home admission for males across the regression models without interactions, although its OR decreases from 1.994 (3rd Column, Table 3.A6) in the baseline model to 1.556 (4th Column, Table 3.A6) when both clinical and functional complications are included in the regression. Conversely, for women, diabetes never emerges as a determinant factor of the measured outcome. For females, the different degrees of functional impairment severity, stroke and cognitive impairment are the most determinant health factors of institutionalization (2nd Column, Table 3.A6). Informal care is never significant neither smoking habits for women. Equally, severity levels of functional impairment are highly significant for males (4th Column, Table 3.A6), being the impact of severe functional impairment greater than for females, but moderate and mild report lower odds ratios for men. Informal care (OR 1.897) does appear to be significant and positively associated with increasing odds of nursing home placement (4th Column, Table 3.A6). As a final point, jointly having diabetes and stroke are interaction terms (Table 3.A7, Appendix) commonly significant for both genders, but with

contrary interpretations: women with diabetes and stroke are more prone to be institutionalized (OR 2.415, 1st Column, Table 3.A7), whereas men who suffer from both diseases are less likely to be placed in a nursing home (OR 0.362, 2nd Column, Table 3.A7) compared to those without any of both. Also, severe (OR 5.784) functional impairment interaction with diabetes does significantly predict higher odds of being admitted into a nursing home for males. Diabetes is not significant for any of the genders (Table 3.A7, Appendix) when interactions are part of the analysis.

Length of stay results are shown in Table 3.A8, Appendix, for permanent and temporary use of nursing homes, respectively, and in Table 3.A9, Appendix, with the results from the regression with interactions. Diabetes is a significant factor of nursing home transit when the respondent stays either permanent or temporarily (OR 1.435 in Model 1 for permanent stay, 1st Column, Table 3.A8; OR 1.819 in Model 1 for temporary stay, 3rd Column, Table 3.A8) as long as diabetes-related complications and functional impairment indicators are not included in the regression. When they are introduced, diabetes is no longer significant. Cognitive impairment, heart attack, stroke and functional impairment are statistically significant and always positively associated with the outcome, regardless of the length of stay (2nd and 4th Columns, Table 3.A8). However, heart attack is statistically significant in both subsamples, but with opposite interpretation between length of stays. Moreover, informal care follows the same trend as heart attack, but it is only significant for temporary admissions. Eventually, no interaction term is reported to be significant, irrespective of the length of stay (Table 3.A9, Appendix). Diabetes is not a determinant of nursing home placement anymore in Model 4.

Finally, results by country without interaction terms are shown in Table 3.3. When looking at models 1 and 3, diabetes is only significant in three countries: Sweden, The Netherlands and Spain. In Sweden and in the Netherlands, diabetes is significantly associated with an increasing probability of being institutionalized only in Model 1. Conversely, in the case of Spain, diabetes is a determinant of nursing home regardless of the covariates that are included. Actually, within the Spanish population, when related clinical and functional complications are part of the regression model, diabetes coefficient reduces from OR 3.496 (Model 1) to OR 3.184 (Model 3). Results regarding other diseases and complications vary quite a lot across countries, although some agreement seems to be reached about greater severity of functional impairment, cognitive impairment and, in a shorter majority, about heart attack and stroke.

Results from the regression models with interactions are shown in Table 3.A10, in the Appendix[15]. Spain, France, Denmark, Greece, Belgium and Czech Republic report significant results for some of the interactions. Diabetes together with stroke is the most common interactions highly increasing the likelihood of being institutionalized in France, Greece and Belgium.

Increasing age is always a factor leading to institutionalization, apart from Belgium and Czech Republic, where age is not a significant variable. Being a woman only significantly increases the risk of nursing home placement in the Netherlands. High household income only appears as a protective factor against institutionalization in Sweden. In the rest of the countries, income is not a significant predictor. Other socioeconomic factors generally follow the same pattern as the overall sample.

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[15] Only four countries (Sweden, The Netherlands, Italy and Switzerland) do not allow for the calculation of the model with interactions (Model 4) due to their sample size.

Table 3.3: Logit regression models from the sensitivity analysis: Countries

VARIABLES	Odds ratio Model 1 Austria	Odds ratio Model 3 Austria	Odds ratio Model 1 Germany	Odds ratio Model 3 Germany
Diabetes	1.675	1.189	1.626	1.297
	(0.837)	(0.704)	(0.784)	(0.716)
Age	1.082***	1.039*	1.107***	1.069**
	(0.0191)	(0.0214)	(0.0274)	(0.0331)
Female	0.520*	0.545	1.237	1.333
	(0.192)	(0.216)	(0.637)	(0.666)
High or middle education	0.672	0.743	0.933	0.877
	(0.179)	(0.211)	(0.227)	(0.252)
Married	1.938**	1.987**	1.043	0.955
	(0.503)	(0.594)	(0.259)	(0.272)
Retired	0.507	0.541	0.572	0.447
	(0.217)	(0.247)	(0.271)	(0.229)
Household size	1.137	1.056	0.594	0.575
	(0.366)	(0.421)	(0.222)	(0.227)
Number of children	0.826	0.795	0.779	0.650*
	(0.204)	(0.209)	(0.137)	(0.167)
Number of grandchildren	0.906	0.926	1.084	1.084
	(0.0809)	(0.0857)	(0.0911)	(0.115)
Children in household	0.640	0.617	1.086	0.858
	(0.344)	(0.324)	(0.542)	(0.494)
Chronic lung disease	0.507	0.341	3.588***	3.528**
	(0.522)	(0.400)	(1.747)	(2.000)
Cancer	2.593	1.941	2.166	2.058
	(1.642)	(1.314)	(1.247)	(1.057)
Cognitive impairment	2.696*	3.487**	2.518**	1.681
	(1.513)	(1.882)	(1.130)	(0.726)
Heart attack		2.276*		1.156
		(1.087)		(0.537)
Stroke		2.278		3.041**
		(1.276)		(1.715)
Mild functional impairment		1.980		3.214**
		(1.033)		(1.649)
Moderate functional impairment		1.554		42.35***
		(1.886)		(23.35)
Severe functional impairment		31.79***		5.201
		(24.35)		(6.091)
Current smoker		0.195		3.229*
		(0.205)		(2.192)
Ever smoked		1.318		0.486
		(0.575)		(0.249)
Informal care		1.126		2.209**
		(0.539)		(0.884)
Observations	5,924	5,924	5,102	5,102
Log pseudolikelihood	-160.20	-145.34	-138.01	-112.91
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.
Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-related clinical complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care.

Table 3.3: (continued)

VARIABLES	OR Model 1 Sweden	OR Model 3 Sweden	OR Model 1 Netherlands	OR Model 3 Netherlands
Diabetes	2.645**	1.441	2.188**	1.785
	(1.077)	(0.493)	(0.860)	(0.916)
Age	1.127***	1.053*	1.106***	1.073***
	(0.0276)	(0.0301)	(0.0197)	(0.0228)
Female	0.822	0.665	2.101*	2.509*
	(0.302)	(0.299)	(0.894)	(1.392)
High or middle education	0.997	0.850	0.472***	0.521**
	(0.296)	(0.292)	(0.112)	(0.132)
Married	0.629	0.520	0.768	0.890
	(0.219)	(0.240)	(0.298)	(0.344)
Low household income	0.808	0.721	1.058	1.109
	(0.381)	(0.456)	(0.483)	(0.564)
High household income	0.141*	0.0721***	1.121	0.988
	(0.153)	(0.0559)	(0.622)	(0.650)
Retired	0.739	1.255	0.690	0.719
	(0.552)	(1.181)	(0.247)	(0.322)
Household size	0.254**	0.129**	0.186**	0.230**
	(0.177)	(0.124)	(0.141)	(0.148)
Number of children	1.044	1.050	1.126	1.060
	(0.188)	(0.225)	(0.122)	(0.124)
Number of grandchildren	0.918	0.883	0.947	1.025
	(0.0673)	(0.0800)	(0.0442)	(0.0547)
Children in household	-	-	3.322**	4.028**
			(1.562)	(2.350)
Chronic lung disease	2.952**	2.587	0.947	0.524
	(1.570)	(1.786)	(0.512)	(0.436)
Cancer	0.769	0.494	0.401	0.448
	(0.497)	(0.459)	(0.422)	(0.486)
Cognitive impairment	2.846**	2.646*	3.066***	1.374
	(1.169)	(1.410)	(1.164)	(0.698)
Heart attack		1.186		1.046
		(0.508)		(0.464)
Stroke		7.697***		0.864
		(3.753)		(0.522)
Mild functional impairment		4.839***		8.534***
		(2.591)		(3.581)
Moderate functional impairment		52.51***		52.46***
		(33.23)		(37.45)
Severe functional impairment		174.0***		143.1***
		(119.1)		(113.7)
Current smoker		0.871		0.342
		(0.839)		(0.246)
Ever smoked		1.056		2.501*
		(0.565)		(1.239)
Informal care		1.624		0.791
		(0.749)		(0.321)
Observations	4,863	4,863	5,913	5,913
Log pseudolikelihood	-171.80	-115.03	-185.72	-153.65
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.
Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-related clinical

complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care.

Table 3.3: (continued)

VARIABLES	OR Model 1 Spain	OR Model 3 Spain	OR Model 1 Italy	OR Model 3 Italy
Diabetes	3.496**	3.184**	1.564	1.434
	(1.734)	(1.664)	(0.659)	(0.565)
Age	1.048*	1.039	1.027	1.016
	(0.0292)	(0.0360)	(0.0219)	(0.0217)
Female	0.467	0.726	0.609	0.547
	(0.334)	(0.546)	(0.213)	(0.210)
High or middle education	1.195	1.207	1.207	1.238
	(0.343)	(0.352)	(0.317)	(0.327)
Married	0.953	0.966	0.818	0.788
	(0.218)	(0.246)	(0.211)	(0.208)
Retired	0.214*	0.187*	1.009	1.101
	(0.186)	(0.179)	(0.362)	(0.409)
Household size	0.580**	0.544**	0.907	0.867
	(0.160)	(0.162)	(0.207)	(0.206)
Number of children	0.712	0.731	1.040	1.046
	(0.257)	(0.253)	(0.217)	(0.223)
Number of grandchildren	1.084	1.067	0.990	0.983
	(0.180)	(0.178)	(0.0742)	(0.0752)
Children in household	1.950	1.846	1.187	1.174
	(0.980)	(0.905)	(0.500)	(0.501)
Chronic lung disease	0.647	0.463	1.451	1.362
	(0.656)	(0.359)	(0.814)	(0.766)
Cancer	1.023	1.006	1.310	1.141
	(1.099)	(0.823)	(0.975)	(0.808)
Cognitive impairment	2.567*	1.831	1.506	1.307
	(1.348)	(1.176)	(1.120)	(1.030)
Heart attack		0.820		0.609
		(0.497)		(0.385)
Stroke		2.559		0.823
		(2.104)		(0.887)
Mild functional impairment		2.001		2.235
		(1.378)		(1.188)
Moderate functional impairment		4.651		3.177
		(5.084)		(4.213)
Severe functional impairment		7.027*		10.41**
		(7.364)		(11.19)
Current smoker		0.804		1.510
		(0.651)		(0.816)
Ever smoked		2.885		0.781
		(1.915)		(0.367)
Informal care		0.852		0.762
		(0.653)		(0.436)
Observations	5,867	5,867	6,860	6,860
Log pseudolikelihood	-125.41	-119.98	-207.18	-203.34
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.
Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-related clinical complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care.

Table 3.3: (continued)

VARIABLES	OR Model 1 France	OR Model 3 France	OR Model 1 Denmark	OR Model 3 Denmark
Diabetes	1.263	1.207	1.009	1.089
	(0.551)	(0.557)	(0.671)	(0.974)
Age	1.044***	1.012	1.125***	1.039
	(0.0164)	(0.0190)	(0.0262)	(0.0298)
Female	1.022	0.990	0.408**	0.345
	(0.334)	(0.416)	(0.162)	(0.253)
High or middle education	1.104	1.196	0.631	1.072
	(0.183)	(0.211)	(0.195)	(0.400)
Married	0.994	0.996	1.984	2.127
	(0.197)	(0.210)	(1.457)	(1.860)
Low household income	-	-	0.918	1.201
			(0.454)	(0.763)
High household income	0.740	0.753	2.286	1.250
	(0.320)	(0.327)	(1.872)	(1.054)
Retired	3.686***	4.565***	0.477	0.664
	(1.658)	(2.064)	(0.373)	(0.619)
Household size	0.974	0.972	0.151	0.107
	(0.210)	(0.229)	(0.217)	(0.188)
Number of children	0.965	0.958	1.219	1.053
	(0.138)	(0.147)	(0.181)	(0.290)
Number of grandchildren	0.989	0.989	0.958	1.107
	(0.0583)	(0.0608)	(0.0657)	(0.104)
Children in household	1.738	1.648	-	-
	(0.820)	(0.818)		
Chronic lung disease	1.806	1.553	0.297	0.223
	(0.891)	(0.836)	(0.332)	(0.226)
Cancer	1.632	1.534	1.296	0.877
	(0.810)	(0.767)	(0.848)	(0.723)
Cognitive impairment	2.263**	2.452**	5.483***	6.142***
	(0.877)	(0.963)	(2.378)	(3.382)
Heart attack		1.033		1.877
		(0.462)		(1.083)
Stroke		2.675*		5.142**
		(1.358)		(3.688)
Mild functional impairment		2.382*		12.97***
		(1.117)		(7.258)
Moderate functional impairment		2.121		498.2***
		(2.536)		(575.8)
Severe functional impairment		11.83**		19.32*
		(13.34)		(32.36)
Current smoker		0.189		0.250*
		(0.198)		(0.200)
Ever smoked		1.093		0.687
		(0.438)		(0.472)
Informal care		1.577		1.922
		(0.590)		(0.903)
Observations	8,313	8,313	4,083	4,083
Log pseudolikelihood	-244.54	-233.53	-122.19	-79.55
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.
Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-

related clinical complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care.

Table 3.3: (continued)

VARIABLES	OR Model 1 Greece	OR Model 3 Greece	OR Model 1 Switzerland	OR Model 3 Switzerland
Diabetes	1.094	1.123	1.931	2.957
	(0.478)	(0.500)	(1.870)	(2.310)
Age	1.030	1.021	1.047	1.008
	(0.0230)	(0.0224)	(0.0470)	(0.0398)
Female	1.256	0.915	1.053	0.969
	(0.418)	(0.279)	(0.810)	(0.821)
High or middle education	1.336	1.337	0.581	1.025
	(0.298)	(0.301)	(0.342)	(0.624)
Married	1.389**	1.410**	0.393*	0.237**
	(0.211)	(0.214)	(0.207)	(0.138)
Low household income	-	-	0.491	0.361
			(0.425)	(0.229)
High household income	-	-	1.122	0.823
			(0.842)	(0.582)
Retired	0.917	0.924	3.425	4.197*
	(0.343)	(0.350)	(2.777)	(3.658)
Household size	1.502**	1.573***	0.118**	0.0482***
	(0.238)	(0.275)	(0.102)	(0.0511)
Number of children	0.930	0.856	1.011	1.153
	(0.176)	(0.166)	(0.220)	(0.275)
Number of grandchildren	0.979	0.994	0.860	0.847
	(0.0780)	(0.0837)	(0.0862)	(0.0985)
Children in household	0.341***	0.333***	1.180	0.686
	(0.110)	(0.112)	(0.941)	(0.619)
Chronic lung disease	0.443	0.466	2.002	1.278
	(0.462)	(0.503)	(2.435)	(1.676)
Cancer	3.068*	3.173*	2.452	2.346
	(2.054)	(2.119)	(2.293)	(2.211)
Cognitive impairment	1.341	1.363	2.451	2.940
	(0.851)	(0.867)	(2.248)	(2.447)
Heart attack		0.249*		0.601
		(0.206)		(0.704)
Stroke		1.218		1.161
		(0.877)		(1.221)
Mild functional impairment		1.786		12.76***
		(0.835)		(8.782)
Moderate functional impairment		2.520		82.69***
		(2.678)		(103.9)
Severe functional impairment		-		-
Current smoker		0.841		2.055
		(0.408)		(1.990)
Ever smoked		0.519*		0.799
		(0.206)		(0.559)
Informal care		1.160		6.988**
		(0.488)		(5.432)
Observations	5,167	5,147	4,385	4,383
Log pseudolikelihood	-271.81	-265.50	-74.53	-60.09
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-related clinical complications: heart

attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care.

Table 3.3: (continued)

VARIABLES	OR Model 1 Belgium	OR Model 3 Belgium	OR Model 1 Czech Republic	OR Model 3 Czech Republic
Diabetes	1.291	0.866	1.108	0.885
	(0.500)	(0.352)	(0.472)	(0.362)
Age	1.108***	1.089***	1.020	0.991
	(0.0170)	(0.0165)	(0.0254)	(0.0242)
Female	1.191	1.273	0.508*	0.517*
	(0.375)	(0.494)	(0.184)	(0.187)
High or middle education	1.131	1.202	0.853	0.899
	(0.194)	(0.211)	(0.243)	(0.262)
Married	1.417*	1.406*	1.310	1.333
	(0.269)	(0.282)	(0.244)	(0.261)
Low household income	0.761	0.784	-	-
	(0.258)	(0.254)		
Mid household income	-	-	0.651	0.604
			(0.293)	(0.270)
High household income	0.546	0.560	-	-
	(0.250)	(0.264)		
Retired	0.868	0.980	1.134	1.156
	(0.283)	(0.314)	(0.582)	(0.595)
Household size	0.953	0.958	1.009	0.982
	(0.289)	(0.310)	(0.213)	(0.243)
Number of children	1.256**	1.200	0.986	0.974
	(0.144)	(0.137)	(0.205)	(0.215)
Number of grandchildren	0.893**	0.899**	1.036	1.035
	(0.0445)	(0.0455)	(0.0875)	(0.0811)
Children in household	0.715	0.692	0.691	0.630
	(0.323)	(0.327)	(0.281)	(0.275)
Chronic lung disease	1.336	1.177	1.619	1.216
	(0.653)	(0.588)	(0.916)	(0.657)
Cancer	1.277	1.002	1.341	1.124
	(0.604)	(0.481)	(0.797)	(0.770)
Cognitive impairment	2.032*	2.010*	4.877***	3.339***
	(0.779)	(0.769)	(2.015)	(1.472)
Heart attack		1.041		1.436
		(0.393)		(0.527)
Stroke		2.021		2.266*
		(0.867)		(1.032)
Mild functional impairment		2.502***		2.585**
		(0.748)		(1.019)
Moderate functional impairment		1.546		5.490**
		(1.135)		(4.419)
Severe functional impairment		30.39***		18.73***
		(20.68)		(15.13)
Current smoker		1.066		0.638
		(0.485)		(0.321)
Ever smoked		1.390		1.373
		(0.507)		(0.499)
Informal care		1.453		1.444
		(0.455)		(0.513)
Observations	8,947	8,947	6,721	6,721
Log pseudolikelihood	-285.39	-270.50	-225.39	-211.49
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-related clinical complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care.

3.3.3 The cost of diabetes and its complications

The methods to estimate the costs have already been discussed in section 3.2. Table 3.4 shows the results for the Adjusted Relative Risks and the Etiological Fractions. Table 3.4 shows that without estimating the adjusted relative risks, my estimation could be overestimating the impact of diabetes and its non-related and related clinical and functional complications if I had used the Odds Ratio directly from the regressions output.

Results of nursing home costs are shown in Figure 3.2. Information about total nursing home costs per capita per country and year can be found in Table 3.A11 in the Appendix. Monetary values are in current international US dollars and adjusted by Purchasing Power Parity (PPP) index. Gross Domestic Product (GDP) per capita per country and year, which has been used to calculate the expenditures per capita as a percentage of country GDP, is shown in Table 3.A12, Appendix.

Figure 3.2 shows that total average costs per capita incurred by people with diabetes within the SHARE sample and along the years of the three waves reach $12.66, with one third of them attributed to its complications. The complications associated with diabetes that generate the greatest burden to cross-countries nursing home expenditures are functional impairment ($3.17 in total) and stroke ($0.45). Functinal impairment represent 78% of the total costs attributed to diabetes complications in overall countries.

Costs incurred by people with diabetes by country level range from $61.34 per capita in the Netherlands to $0.35 in Czech Republic. Figure 3.2 also reports nursing home expenditures per capita attributed to diabetes by country as a percentage of country Gross Domestic Product (GDP), adjusted by Power Purchasing Parity (PPP) index. When interpreting nursing home costs attributed to diabetes as percentages of GDP, Spain is again the country which reports the highest figures. Within Spanish' results, the main drivers of increasing costs are the several levels of severity of functional impairment (0.058% and 0.038% of the GDP in Spain for moderate and severe functional impairment, respectively), and heart attack (0.017% of Spanish GDP).

Across countries, the main drivers of costs attributed to diabetes vary in some way, as Figure 3.2 shows. Severity of functional impairment seems to be the main determinant of increasing nursing home costs attributed to diabetes, especially when the severity of functional impairment is mild. After functional impairment, stroke is the complication with a higher burden on institutionalization costs, especially in France, Belgium and Czech Republic.

Table 3.4: Odds Ratio (OR), Adjusted Relative Risks (RR) and Etiological Fractions (EF) for diabetes and diabetes non-related and related clinical and functional complications

VARIABLES	OR[a] Model 1	RR[b] Model 1	EF[c] Model 1	OR[a] Model 3	RR[b] Model 3	EF[c] Model 3	OR[a] Model 1 Austria	RR[b] Model 1 Austria	EF[c] Model 1 Austria	OR[a] Model 1 Austria	RR[b] Model 1 Austria	EF[c] Model 1 Austria
Diabetes	1.55	1.54	0.06	-	-	-	1.68	1.653	0.065	-	-	-
Chronic lung disease	1.26	1.26		0.88	0.89	-0.006	0.51	0.513		-	-	-
Cancer	1.42	1.41		1.04	1.04	0.002	2.59	2.516		5.77	3.25	0.097
Cognitive impairment	2.65	2.60		1.38	1.34	0.022	2.70	2.621		19.19	5.94	0.225
Heart attack				1.05	1.04	0.005				86.55	23.96	0.717
Stroke				2.23	2.08	0.036				0.22	0.35	-0.029
Mild functional impairment				3.69	3.12	0.144				2.15	1.77	0.061
Moderate functional impairment				8.82	6.52	0.046				-	-	-
Severe functional impairment				25.81	15.18	0.060				-	-	-

VARIABLES	OR[a] Model 1 Germany	RR[b] Model 1 Germany	EF[c] Model 1 Germany	OR[a] Model 3 Germany	RR[b] Model 3 Germany	EF[c] Model 3 Germany	OR[a] Model 1 Netherlands	RR[b] Model 1 Netherlands	EF[c] Model 1 Netherlands	OR[a] Model 1 Netherlands	RR[b] Model 1 Netherlands	EF[c] Model 1 Netherlands
Diabetes	1.63	1.585	0.067	-	-	-	2.19	2.04	0.085	-	-	-
Chronic lung disease	3.59	3.366		7.68	4.39	0.16	0.95	0.95		0.03	0.21	-0.053
Cancer	2.17	2.073		2.30	1.92	0.050	0.40	0.43		-	-	-
Cognitive impairment	2.52	2.410		-	-	-	3.067	2.76		0.79	0.88	-0.007
Heart attack				0.22	0.32	-0.089				1.78	1.37	0.038
Stroke				0.22	0.32	-0.026				0.01	0.10	-0.034
Mild functional impairment				6.06	3.78	0.174				8.85	3.82	0.132
Moderate functional impairment				150.67	28.41	0.208				96.85	8.49	0.037
Severe functional impairment				-	-	-				-	-	-

Table 3.4: (continued)

VARIABLES	OR [a] Model 1 Spain	RR [b] Model 1 Spain	EF [c] Model 1 Spain	OR [a] Model 3 Spain	RR [b] Model 3 Spain	EF [c] Model 3 Spain	OR [a] Model 1 France	RR [b] Model 1 France	EF [c] Model 1 France	OR [a] Model 1 France	RR [b] Model 1 France	EF [c] Model 1 France
Diabetes	3.50	3.40	0.28	-	-	-	1.26	1.26	0.0253	-	-	-
Chronic lung disease	0.65	0.65		-	-	-	1.81	1.78		-	-	-
Cancer	1.02	1.02		-	-	-	1.63	1.62		-	-	-
Cognitive impairment	2.57	2.52		-	-	-	2.26	2.23		0.62	0.75	-0.023
Heart attack				0.03	0.09	-0.117				0.07	0.18	-0.116
Stroke				-	-	-				248.59	12.70	0.253
Mild functional impairment				0.57	0.63	-0.035				9.26	3.22	0.176
Moderate functional impairment				1,308.07	35.69	0.392				-	-	-
Severe functional impairment				467.39	23.75	0.257				-	-	-

VARIABLES	OR [a] Model 1 Belgium	RR [b] Model 1 Belgium	EF [c] Model 1 Belgium	OR [a] Model 3 Belgium	RR [b] Model 3 Belgium	EF [c] Model 3 Belgium	OR [a] Model 1 Czech Republic	RR [b] Model 1 Czech Republic	EF [c] Model 1 Czech Republic	OR [a] Model 1 Czech Republic	RR [b] Model 1 Czech Republic	EF [c] Model 1 Czech Republic
Diabetes	1.29	1.28	0.025	-	-	-	1.11	1.11	0.017	-	-	-
Chronic lung disease	1.34	1.32		3.64	1.74	0.0391	1.62	1.61		1.58	3.80	0.14
Cancer	1.28	1.27		4.21	1.84	0.0448	1.34	1.34		-	-	-
Cognitive impairment	2.03	1.98		10.78	2.62	0.1084	4.88	4.74		1.07	2.36	0.062
Heart attack				0.05	040	-0.0799				0.36	1.35	0.05
Stroke				41785.38	24.28	0.4330				0.93	2.26	0.057
Mild functional impairment				12.31	2.75	0.1627				1.29	2.72	0.114
Moderate functional impairment				2774.87	9.43	0.0720				-	-	-
Severe functional impairment				11227.4	12.29	0.0253				4.01	24.23	0.057

OR: Odds Ratio; RR: Relative Risk; EF: Etiological Fraction

[a] Odds ratio obtained from logit regressions controlling for age, gender, education, marital status, household income, employment status, household size, number of children and grandchildren, whether any children lives in respondent's household, smoking status and informal care. [b] Adjusted relative risks estimated after running logit regressions using the Stata command *adjrr* (Norton et al., 2013). [c] Etiological fractions estimated using formula (1).

Figure 3.2: Components of costs per capita and per year attributed to diabetes complications. Costs per capita incurred by people with diabetes in brackets adjusted by PPP, current international $, followed by % of nursing home costs over GDP per capita

Whole sample
Total NH costs: $211.15; incurred by people with diabetes: $12.66
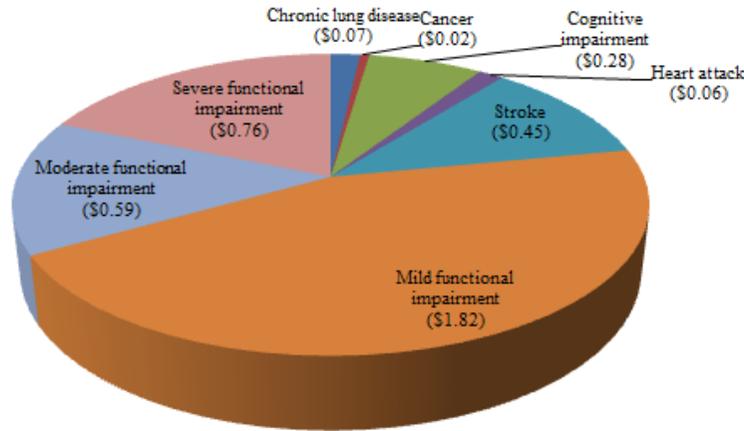
Austria
Total NH costs: $249.68; incurred by people with diabetes: $16.23
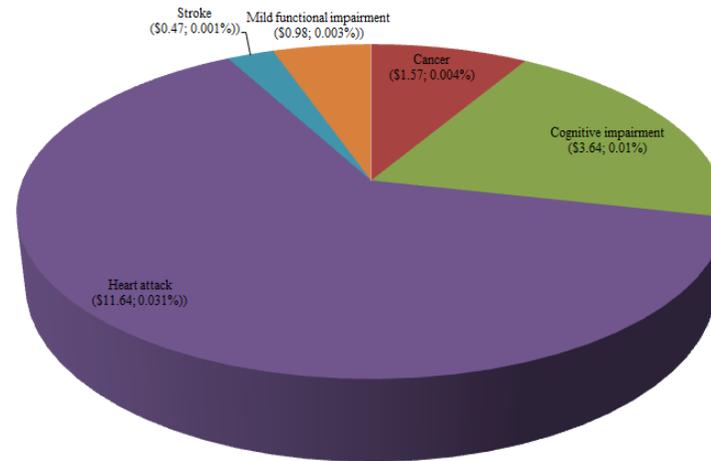
Germany
Total NH costs: $266.13; incurred by people with diabetes: $18.72
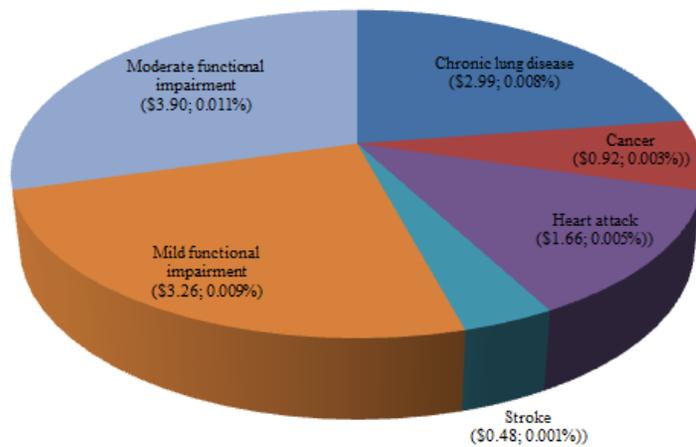
The Netherlands
Total NH costs: $715.93; incurred by people with diabetes: $61.34
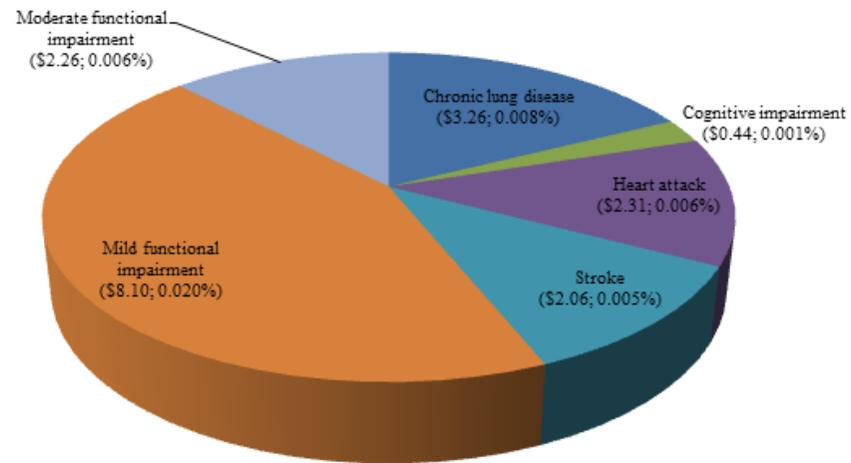
Figure 3.2: (continued)
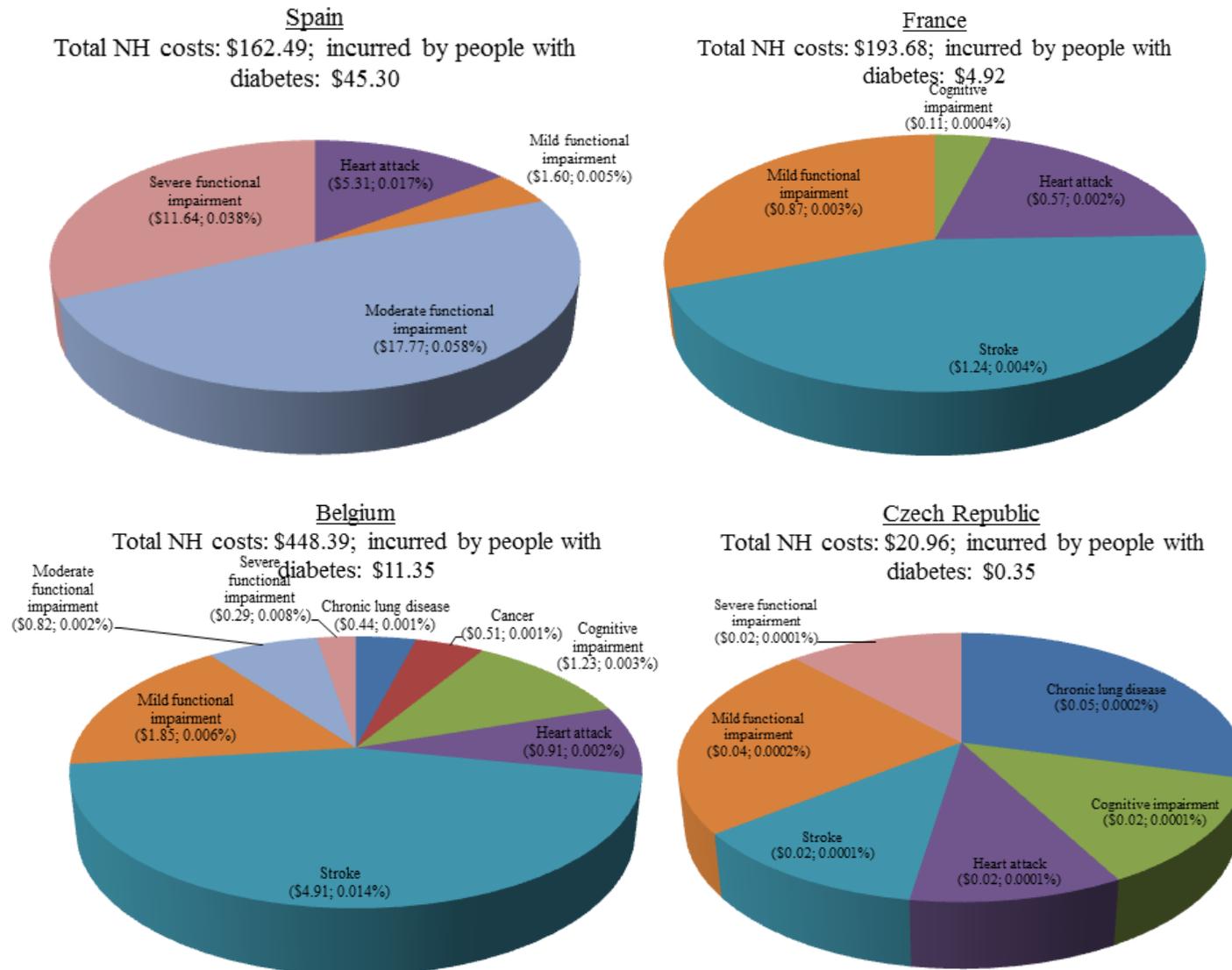
Costs attributed to diabetes complications are estimated using formula (3), multiplying the EF corresponding for each disease (Table 3, Model 3) times the costs incurred by people with diabetes. So, for example, for the whole sample, the costs attributed to mild functional impairment are calculated as follows: 0.1437 x $12.66 = $1.82.

3.3. DISCUSSION

This analysis assesses the main drivers of nursing home entry among a representative sample of the European people older than 50 years old, focusing on one disease and its related complications: diabetes. Furthermore, taking the values obtained from the logistic regressions, estimates about expenditures on diabetic institutionalized people are calculated.

It has been found in the literature that diabetes among older people increases in a significant manner the risk to be institutionalized. One study developed in the US shows that diabetes is a determinant of nursing home placement among the frail elderly, increasing the risk of nursing home placement of old adults by 1.8 (Matsuzawa et al., 2010). My results confirm that diabetes is a predictor of nursing home placement. Diabetes increases the risk of institutionalization in the overall sample by 1.552 OR when compared with people without diabetes, being ranked second in size of its odds. However, when clinical and functional complications are included in the regression, diabetes is still significant, but its coefficient decreases till OR 1.240, showing that the variables remaining in the model explain part of the effect of diabetes as a risk factor for admission in a nursing home. Remarkably, the major factor explaining this association is functional impairment. Hence, it could be concluded that the effect of diabetes is mediated by the clinical and functional complications included in the regression, reducing its impact on healthcare resources use.

Newton et al. (2013) also reported that around 30-35% of institutionalized older people have diabetes, a condition associated to a higher resource utilization. In my data, the rates of diabetes among institutionalized adults are lower, affecting around 20% of the overall sample who are in a nursing home and reaching 22% when people are 75 and older.

It might be expected that some diseases when linked with diabetes, such as stroke or functional impairment, increase the odds of being placed into a nursing home, as some previous studies have already showed (Abizanda et al., 2014; Rechel et al., 2013; Russell et al., 2005; Banaszak-Holl et al., 2004). However, my results from the overall sample contradict this assumption since none of the interactions between diabetes and clinical and functional complications are statistically significant. Still, in some countries, such as Belgium, France and Greece, diabetes and stroke do significantly increase the risk of institutionalization, whereas diabetes linked to functional impairment rises the likelihood of being admitted to a nursing home in Spain.

Overall, total nursing home costs per capita due to diabetes reach $12.66 within the whole sample and the time period analyzed in this study. Moreover, when costs attributed to diabetes complications are calculated, the greatest burden of the disease is due to the different categories

of functional impairment ($3.17 per capita in total), whose effect is quite larger than the next complication with the highest costs, stroke, which accounts for $0.45 per capita.

Diabetes remains in the adjusted model as a determinant of nursing home admission only in three countries: Sweden, The Netherlands and Spain, suggesting that other factors added to the ones included in my adjusted models may contribute to explain the relationship between diabetes and admission to nursing home. The latter country reports the highest increasing risk of institutionalization, even when complications are part of the regression model.

The Netherlands is the top country in nursing home expenditure for people with diabetes, whose expenses on nursing home care are about $61.34 per capita, from which around one third are due to mild functional impairment. The substantial character of functional status is confirmed across countries analysis, as it bares the greatest proportion of costs, usually followed by stroke. This result is driven mainly by one single factor: the relevance of functional status inside the complications caused by diabetes, which has been consistently ascertained in this analysis. Additionally, when comparing the results across countries as percentages of GDP per capita, Spain is the country where costs strictly attributed to diabetes complications show the greatest value[16].

The methods used to estimate nursing home costs attributable to each disease are similar to the methods used by the American Diabetes Association diabetes reports (ADA, 2013; ADA, 2003). However, in this study, I have adjusted for potential bias in the estimation of relative risk parameters and, consequently, in the values of etiological fractions. As it can be seen in Table 3.4, if I hadn't estimated the adjusted relative risks, my estimation could be overestimating the impact of diabetes and its non-related and related clinical and functional complications.

These figures could provide a valuable contribution to the existing literature since it is the first cross-countries analysis looking at the burden of diabetes on nursing home use and costs. It is also pioneer in including functional impairment as one of the factors involved in predicting costs associated with diabetes. It is noteworthy that this factor not only helps to explain part of the cost, but it is the main one. Moreover, this relationship between functional status, risk for admission in nursing home and its associated costs are age-dependent, as they are clearly shown in people older than 65, but not so evident in people with ages ranging from 50 to 65. These results would be important for two main reasons: firstly, previous estimates about the costs and

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[16] Although there might be differences between countries due to the country-specific market liberalization of healthcare, especially after the 2008 economic crisis, Reeves et al. (2014) concluded that it was borrowing money from international institutions, budget cuts and the (decreases in) tax revenues what led to changes in healthcare expenditures, rather than the ideological orientation or the magnitude of economic recessions. However, it was not possible to control for these parameters (or their changes) in this analysis. Hence, differences between countries estimations should be interpreted with caution, as nursing home financing might be influenced by those aforementioned factors leading to variations in healthcare expenditures.

institutionalization estimates attributable to diabetes could be overestimating the impact of some other comorbidities that have traditionally been linked to diabetes, such as cerebrovascular diseases. Secondly, and due to the first reason, policymakers would have had the wrong focus when informing policies and diabetes guidelines, since the main surrogate of increasing costs is functional status.

Another remarkable results is the one related to informal care, which could also explain the existing differences across countries mentioned before. Traditionally, informal care has been regarded as a substitute of nursing home (Greene, 1983; Cantor, 1979). Actually, a study using data from SHARE showed that informal and formal care are substitutes as long as the elderly's disability is low (Bonsang, 2009). However, my results contradict this assumption. My estimation shows that informal care increases the risk of transit to nursing home in the total sample, as well as in most of the European countries. The Netherlands, Denmark and Czech Republic are the only countries that report the opposite results, although the coefficients are not statistically significant. Substitutability or complementarity between informal care and formal care outside the household have been largely discussed, highlighting that differences can be found regarding the disease, the services provided and the degree of disability of the care recipient (Jiménez and Vilaplana, 2012; Muramatsu et al., 2007; Viitanen, 2007; Chappel and Blandford, 1991; Greene, 1983). Furthermore, variation within use of informal care services is quite large within European countries, not only due to the population distribution and population ageing, but also due to the design of welfare programs in Europe, and the existing programs and the availability of support to these caregivers. For example, in Mediterranean countries, where informal care tradition is common, the benefits and support that informal caregivers receive for their services are quite low. On the other hand, in Northern European countries, informal care is not so extended, but social benefits and support are higher. Finally, in Central Europe, caregivers are provided with widely spread social support programs, benefits that vary within and across regions, but informal care is not so relevant (Mot et al., 2012; Kraus et al., 2010). Hence, the consequences behind this result can be ambiguous and probably vary across countries. Another noteworthy result regarding the association between nursing home admission and informal care is that the latter variable is only statistically significant in temporary admissions. In-depth analysis could try to investigate whether temporary nursing home admissions prevent from permanent placements, which could have implications for policy makers. So, further analysis about the interpretation of the coefficient of informal care should be made in order to analyze its potential endogeneity with my dependent variable and to establish a conclusion. One approach could be the inclusion of

instrumental variables in the regression model, as Bolin et al. did in their analysis (2008), in which they also used SHARE data.

Previous researchers have already analyzed the factors associated with nursing home admission in the elderly after adjusting for functional disability. Tomiak et al. (2000) concluded that chronic diseases, such as mental disorders, significantly raised such risk. Nevertheless, analyzing the determinants of institutionalization after adjusting for functional disability could have underestimated the effect of some chronic conditions that potentially lead to functional disability, as it is the case of diabetes. Still, a more recent report showed that the effect of diabetes or stroke on institutionalization disappears after controlling for functional status (Banaszak-Holl et al., 2004), which is consistent with my results. Furthermore, my expenditure figures are reliable when compared to the estimation provided in the report by the American Diabetes Association (2013). They concluded that, within the US population, 57% of the total costs incurred by people with diabetes are attributed to diabetes, which is higher than my estimate (37.27%), but still showing the great relevance of comorbidities when analyzing the economic burden of diabetes.

Some limitations should also be mentioned. Firstly, nursing home residents were not interviewed in SHARE, so only people who did not live in nursing home prior to the interview are part of the survey. Moreover, if an individual moves from home to a nursing home during the survey period, no additional information is registered, unless nursing home placement is temporary. Hence, the results that are reported here might be underestimating the effect of diabetes and its clinical and functional complications on institutionalization. Second of all, due to data restrictions, I have excluded seven countries from the analysis from the nineteen countries that SHARE provides information from. However, the results reported in this study are still accurate since I include a representative sample of the European population. Another caveat derived from data limitations is the costs imputation. Although SHARE includes one question about costs and care services, it has not been possible to use this information in the present analysis due to the great number of missing values and the inclusion of many care services, not exclusively nursing home care. However, values for national healthcare expenditure on nursing homes are obtained for most countries and all the years included in the survey period. Yet, no data was available for three of the countries included in my study (Sweden, Italy and Greece), so I have not been able to estimate the costs for these populations. In addition, interaction terms to measure the joint effect of diabetes and its complications and regressions by diabetes status could not be run for all the countries. Finally, the self-reported feature of the data , especially about health conditions, could bias the results, since it could lead to recall bias and, hence, the results here could over or underestimate the true impact of diabetes. Nevertheless, this possibility looks

unlikely as the data comes from three different waves of the study, showing a strong consistency among them. In addition, there are several findings showing the reliability of data from health conditions collected using self-reporting information (Dal Grande et al., 2012; Goebeler et al., 2007).

Overall, these findings have direct consequences for policy makers and governments. Deep knowledge of the economic drain of the disease, regarding the medical costs, is an essential matter in the healthcare policy making process. Diabetes prevalence is increasing and, together with the population ageing, its associated costs are highly likely to noticeably grow in the subsequent years. Some general European guidelines have already considered diabetic patients in nursing homes, but most of them are largely focused on individual's clinical management and not on functional dependency (IDF, 2013; EDWPOP, 2011). These results show for the first time that higher nursing home care expenditure due to diabetes all over Europe is mainly caused by functional impairment, which, in addition, increases the risk of institutionalization for older people with diabetes. Further analysis could assess the use of other healthcare resources by the population with diabetes in order to look at possible differences across Europe in terms of diabetes management and access to healthcare services. By doing so, an in-depth research would be carried out and efficient guidelines about diabetes and its complications could be written so as to help healthcare providers and policy makers and reduce disease burden.

APPENDIX CHAPTER 3

Table 3.A1: Diseases prevalence within the whole sample and by country

Population	Diabetes	Chronic lung disease	Cancer	Cognitive impairment	Heart attack
Whole sample	0.1181	0.054	0.049	0.0674	0.117
By country					
Austria	0.1064	0.0484	0.0477	0.0586	0.1103
Germany	0.1218	0.0561	0.0561	0.1122	0.1191
Sweden	0.0911	0.0327	0.0645	0.0907	0.158
The Netherlands	0.09	0.0641	0.0521	0.0596	0.1063
Spain	0.1588	0.0624	0.0328	0.0644	0.1157
Italy	0.1211	0.0731	0.0393	0.0356	0.1072
France	0.1008	0.054	0.0551	0.0888	0.1261
Denmark	0.0735	0.0633	0.0573	0.0647	0.0898
Greece	0.0976	0.0333	0.0188	0.0513	0.1065
Switzerland	0.0631	0.0357	0.0556	0.0578	0.0698
Belgium	0.0924	0.0551	0.0556	0.0752	0.1225
Czech Republic	0.1596	0.0583	0.0489	0.0489	0.1464

Population	Stroke	Mild functional impairment	Moderate functional impairment	Severe functional impairment
Whole sample	0.0344	0.0792	0.0088	0.0045
By country				
Austria	0.0431	0.0838	0.0079	0.0046
Germany	0.0368	0.0759	0.0096	0.0054
Sweden	0.0392	0.0723	0.0064	0.0036
The Netherlands	0.0359	0.0539	0.0051	0.0021
Spain	0.0216	0.0926	0.0186	0.0152
Italy	0.0321	0.0785	0.0141	0.0082
France	0.0289	0.0962	0.0068	0.003
Denmark	0.0415	0.0635	0.0066	0.0033
Greece	0.0271	0.0542	0.0077	0.004
Switzerland	0.0245	0.0571	0.002	0.0007
Belgium	0.0328	0.1111	0.0092	0.0023
Czechia	0.0479	0.0751	0.0086	0.0026

Source: authors of this chapter using data from SHARE

Table 3.A2: List of variables and coding

Variable	Label	Coding
Nursing home admission	"During the last twelve months, have you been in a nursing home overnight?"	1: respondent has been to a nursing home in the last twelve months, temporary or permanently; 0: otherwise
Age	Age of respondent	
Female	Gender of respondent	1: female; 0: male
Education	ISCED-97 coding of education	0: no education; 1: low education; 2: medium education; 3: high education
Marital status	Current marital status	1: married or with a registered partner; 2: never married; 3: separated, divorced or widowed
Low household income	Lowest income quintile when sample was split into three groups according to income	1: respondent's income is in the lowest quintile group; 0: otherwise
Medium household income	Medium income quintile when sample was split into three groups according to income	1: respondent's income is in the medium quintile group; 0: otherwise
High household income	Highest income quintile when sample was split into three groups according to income	1: respondent's income is in the highest quintile group; 0: otherwise
Retired	"How would you describe your current situation?"	1: respondent is retired; 0: otherwise
Homemaker	"How would you describe your current situation?"	1: respondent works as homemaker; 0: otherwise
Household size	Number of people living in the respondents' household	
Number of children	Number of children that are still alive	
Number of grandchildren	Number of respondents' grandchildren	
Children in household	Whether at least one child lives in the same household or the same building as respondent	1: child lives in the same household or building as respondent; 0: otherwise
Heart attack	Whether the respondent has been told by a doctor s/he has had a heart attack	1: respondent has had a heart attack; 0: otherwise
Hypertension	Whether the respondent has been told by a doctor s/he has hypertension	1: respondent has hypertension; 0: otherwise
Stroke	Whether the respondent has been told by a doctor s/he has had a stroke	1: respondent has had a stroke; 0: otherwise
Chronic lung disease	Whether the respondent has been told by a doctor s/he has any chronic lung disease	1: respondent has any chronic lung disease; 0: otherwise
Cancer	Whether the respondent has been told by a doctor s/he has cancer	1: respondent has cancer; 0: otherwise
Ulcer	Whether the respondent has been told by a doctor s/he has an ulcer	1: respondent has an ulcer; 0: otherwise
Cognitive impairment	Whether the respondent's performance has been impaired by some cognitive factors	1: some cognitive factors may have impaired respondent's performance; 0: otherwise
No functional impairment	Individuals reported no limitation in any ADLs	1: no limitation was present when performing ADLs; 0: otherwise
Mild functional impairment	Respondents declared being limited in one or two ADLs	1: there were some limitations when performing one or two ADLs; 0: otherwise
Moderate functional impairment	Respondents declared being limited in three to five ADLs	1: there were some limitations when performing three to five ADLs; 0: otherwise
Severe functional impairment	Respondents declared being limited in all ADLs	1: there were some limitations when performing all ADLs; 0: otherwise
Currently smoking	Smoking at the present time	1: respondent smokes currently; 0: otherwise
Ever smoked	Whether respondent has ever smoked daily	1: respondent has ever smoked daily; 0: otherwise

Table 3.A2: (continued)

Variable	Label	Coding
Informal care	"Have you received care from any person within or outside the household?"	1: respondent received care from household's members or from relatives or friends outside the household; 0: otherwise
Austria	Whether the respondent lives in Austria	1: respondent lives in Austria; 0: otherwise
Germany	Whether the respondent lives in Germany	1: respondent lives in Germany; 0: otherwise
Sweden	Whether the respondent lives in Sweden	1: respondent lives in Sweden; 0: otherwise
The Netherlands	Whether the respondent lives in The Netherlands	1: respondent lives in The Netherlands; 0: otherwise
Spain	Whether the respondent lives in Spain	1: respondent lives in Spain; 0: otherwise
Italy	Whether the respondent lives in Italy	1: respondent lives in Italy; 0: otherwise
France	Whether the respondent lives in France	1: respondent lives in France; 0: otherwise
Denmark	Whether the respondent lives in Denmark	1: respondent lives in Denmark; 0: otherwise
Greece	Whether the respondent lives in Greece	1: respondent lives in Greece; 0: otherwise
Switzerland	Whether the respondent lives in Switzerland	1: respondent lives in Switzerland; 0: otherwise
Belgium	Whether the respondent lives in Belgium	1: respondent lives in Belgium; 0: otherwise
Czech Republic	Whether the respondent lives in Czech Republic	1: respondent lives in Czech Republic; 0: otherwise
Wave 1	Whether the data collected belongs to wave 1	1: data was collected from wave 1; 0: otherwise
Wave 2	Whether the data collected belongs to wave 2	1: data was collected from wave 2; 0: otherwise
Wave 4	Whether the data collected belongs to wave 4	1: data was collected from wave 4; 0: otherwise

Table 3.A3: Average marginal effects from the regression models for the overall sample

VARIABLES	Average marginal effects Model 1	Average marginal effects Model 2	Average marginal effects Model 3	Average marginal effects Model 4
Diabetes	0.00218***	0.00184***	0.00104*	0.000923
	(0.000615)	(0.000612)	(0.000616)	(0.000656)
Age	0.000351***	0.000321***	0.000198***	0.000198***
	(3.24e-05)	(3.24e-05)	(3.07e-05)	(3.07e-05)
Female	-0.000201	-8.38e-05	-0.000382	-0.000351
	(0.000524)	(0.000526)	(0.000549)	(0.000551)
High or middle education	-0.000494	-0.000473	-0.000143	-0.000131
	(0.000320)	(0.000320)	(0.000317)	(0.000319)
Married	0.00151***	0.00151***	0.00124***	0.00125***
	(0.000302)	(0.000302)	(0.000309)	(0.000310)
Low household income	-0.00104*	-0.00111*	-0.00104*	-0.00105*
	(0.000629)	(0.000631)	(0.000626)	(0.000630)
Retired	-0.00108*	-0.00110*	-0.000391	-0.000405
	(0.000595)	(0.000595)	(0.000590)	(0.000592)
Household size	-9.66e-05	-0.000142	-0.000343	-0.000346
	(0.000401)	(0.000407)	(0.000431)	(0.000431)
Number of children	4.08e-05	3.03e-05	-1.85e-05	-2.85e-05
	(0.000259)	(0.000262)	(0.000255)	(0.000256)
Number of grandchildren	-0.000187*	-0.000192*	-0.000186*	-0.000187*
	(0.000109)	(0.000109)	(0.000105)	(0.000104)
Children in household	-0.00106	-0.00105	-0.00130*	-0.00126*
	(0.000670)	(0.000672)	(0.000679)	(0.000677)
Chronic lung disease	0.00116	0.000872	-0.000205	-0.000150
	(0.000850)	(0.000852)	(0.000862)	(0.000868)
Cancer	0.00172*	0.00144	0.00117	0.00118
	(0.000881)	(0.000874)	(0.000857)	(0.000854)
Cognitive impairment	0.00483***	0.00448***	0.00336***	0.00338***
	(0.000649)	(0.000640)	(0.000655)	(0.000652)
Heart attack		0.000639	-0.000124	-0.000138
		(0.000591)	(0.000596)	(0.000608)
Stroke		0.00618***	0.00354***	0.00350***
		(0.000686)	(0.000701)	(0.000712)
Mild functional impairment			0.00574***	0.00576***
			(0.000635)	(0.000635)
Moderate functional impairment			0.0104***	0.0104***
			(0.00104)	(0.00106)
Severe functional impairment			0.0123***	0.0120***
			(0.00121)	(0.00124)
Current smoker			-0.000615	-0.000580
			(0.000809)	(0.000811)
Ever smoked			0.000177	0.000161
			(0.000595)	(0.000600)
Informal care			0.00156***	0.00158***
			(0.000539)	(0.000537)
Observations	90,589	90,589	90,589	90,589

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.
Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment) and country dummies. Model 2 adds to the previous model diabetes-related clinical complications: heart attack and stroke. Model 3 includes the above variables and different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), which is also related to diabetes, lifestyle (current smoker and ever smoked), and informal care. Model 4 adds the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Table 3.A4: Regression models from the sensitivity analysis: by age group

VARIABLES	OR Model 1 Age 50 to 65	OR Model 3 Age 50 to 65	OR Model 1 Age 66 to 80	OR Model 3 Age 66 to 80	OR Model 1 Age > 80	OR Model 3 Age > 80
Diabetes	1.139	0.928	1.713***	1.287	1.839***	1.454*
	(0.320)	(0.281)	(0.318)	(0.246)	(0.388)	(0.322)
Age	1.031	1.027	1.070***	1.033*	1.067***	1.018
	(0.0282)	(0.0276)	(0.0189)	(0.0184)	(0.0221)	(0.0225)
Female	0.976	0.939	0.710*	0.709*	1.138	1.150
	(0.172)	(0.173)	(0.129)	(0.143)	(0.235)	(0.258)
High or middle education	1.051	1.088	0.770**	0.825*	0.937	1.040
	(0.121)	(0.126)	(0.0805)	(0.0866)	(0.123)	(0.141)
Married	0.964	0.950	1.420***	1.386***	1.543***	1.508***
	(0.121)	(0.121)	(0.153)	(0.161)	(0.216)	(0.224)
Low household income	1.078	1.007	0.810	0.802	0.822	0.805
	(0.226)	(0.214)	(0.158)	(0.162)	(0.193)	(0.192)
Retired	1.136	1.067	0.804	0.929	0.652*	0.650*
	(0.262)	(0.239)	(0.180)	(0.208)	(0.150)	(0.153)
Household size	0.950	0.923	0.942	0.897	0.890	0.842
	(0.133)	(0.130)	(0.141)	(0.154)	(0.196)	(0.201)
Number of children	0.791*	0.788*	1.097	1.074	1.005	1.000
	(0.110)	(0.108)	(0.0707)	(0.0678)	(0.0904)	(0.0942)
Number of grandchildren	1.003	0.994	0.954*	0.952*	0.966	0.961
	(0.0723)	(0.0711)	(0.0267)	(0.0266)	(0.0336)	(0.0342)
Children in household	0.906	0.913	0.769	0.744	0.601	0.538*
	(0.224)	(0.228)	(0.169)	(0.168)	(0.193)	(0.182)
Chronic lung disease	1.556	1.271	0.985	0.715	1.527	1.210
	(0.584)	(0.476)	(0.281)	(0.209)	(0.408)	(0.344)
Cancer	2.373***	2.135**	1.101	1.019	1.369	1.146
	(0.765)	(0.683)	(0.320)	(0.286)	(0.423)	(0.369)
Cognitive impairment	2.311***	1.961**	2.703***	2.068***	2.966***	2.230***
	(0.631)	(0.545)	(0.552)	(0.435)	(0.606)	(0.488)
Heart attack		1.196		1.142		0.741
		(0.355)		(0.214)		(0.148)
Stroke		2.466**		1.748**		2.319***
		(0.935)		(0.409)		(0.499)
Mild functional impairment		2.013**		3.094***		3.960***
		(0.644)		(0.608)		(0.908)
Moderate functional impairment		16.78***		11.03***		7.480***
		(7.573)		(3.193)		(2.348)
Severe functional impairment		17.51***		16.76***		11.67***
		(10.49)		(5.762)		(4.396)
Current smoker		1.180		0.748		0.748
		(0.301)		(0.218)		(0.347)
Ever smoked		0.685*		1.135		1.322
		(0.151)		(0.231)		(0.290)
Informal care		1.013		1.330		1.710***
		(0.276)		(0.236)		(0.339)
Observations	48,177	48,177	31,422	31,422	6,170	6,170
Log pseudolikelihood	-871.85	-843.91	-1013.25	-940.72	-624.15	-560.44
Country dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES

*** $p<0.01$, ** $p<0.05$, * $p<0.1$ Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 3 adds to the previous model diabetes-related clinical complications (heart attack and stroke) and the

different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), and informal care.

Table 3.A5: Regression models from the sensitivity analysis: Results from the regression with interaction terms by age group

VARIABLES	OR Model 4 Age 50 to 65	OR Model 4 Age 66 to 80	OR Model 4 Age > 80
Diabetes	0.637	1.482	1.169
	(0.391)	(0.551)	(0.672)
Diabetes#Chronic lung disease	0.589	0.955	0.470
	(0.521)	(0.612)	(0.301)
Diabetes#Cancer	2.472***	1.066	1.158
	(0.797)	(0.342)	(0.426)
Diabetes#Ulcer	1.000	0.526	2.349
	(1.119)	(0.349)	(1.519)
Diabetes#Cognitive impairment	0.315	0.689	0.756
	(0.431)	(0.353)	(0.402)
Diabetes#Heart attack	0.178**	1.299	0.954
	(0.143)	(0.514)	(0.444)
Diabetes#Stroke	0.519	1.263	1.017
	(0.569)	(0.671)	(0.493)
Diabetes#Mild functional impairment	1.907	1.041	0.739
	(1.770)	(0.479)	(0.447)
Diabetes#Moderate functional impairment	0.566	0.828	1.433
	(0.914)	(0.535)	(1.020)
Diabetes#Severe functional impairment	3.522	2.245	1.476
	(4.735)	(1.654)	(1.192)
Diabetes#Ever smoked	3.237*	1.136	1.426
	(2.153)	(0.438)	(0.710)
Diabetes#Informal care	2.023	0.436*	1.314
	(1.439)	(0.189)	(0.657)
Age	1.026	1.034*	1.016
	(0.0278)	(0.0184)	(0.0227)
Female	0.948	0.718	1.157
	(0.176)	(0.145)	(0.262)
High or middle education	1.084	0.833*	1.034
	(0.127)	(0.0886)	(0.140)
Married	0.957	1.378***	1.499***
	(0.121)	(0.161)	(0.226)
Low household income	0.991	0.799	0.802
	(0.211)	(0.163)	(0.193)
Retired	1.061	0.938	0.679
	(0.240)	(0.214)	(0.161)
Household size	0.918	0.892	0.836
	(0.129)	(0.156)	(0.207)
Number of children	0.790*	1.077	1.006
	(0.109)	(0.0701)	(0.0942)
Number of grandchildren	0.994	0.953*	0.962
	(0.0714)	(0.0264)	(0.0338)
Children in household	0.913	0.751	0.556*
	(0.227)	(0.169)	(0.189)
Chronic lung disease	1.391	0.736	1.287
	(0.560)	(0.252)	(0.426)
Cancer	2.472***	1.066	1.158
	(0.797)	(0.342)	(0.426)
Cognitive impairment	2.159***	2.274***	2.390***
	(0.609)	(0.527)	(0.585)
Heart attack	1.494	1.086	0.742
	(0.454)	(0.243)	(0.172)

Table 3.A5: (Continued)

VARIABLES	OR Model 4 Age 50 to 65	OR Model 4 Age 66 to 80	OR Model 4 Age > 80
Stroke	2.727**	1.623*	2.306***
	(1.105)	(0.446)	(0.583)
Mild functional impairment	1.792*	3.068***	4.284***
	(0.630)	(0.687)	(1.061)
Moderate functional impairment	19.40***	12.14***	7.196***
	(9.049)	(4.068)	(2.566)
Severe functional impairment	15.69***	12.81***	10.85***
	(10.96)	(5.192)	(4.578)
Current smoker	1.209	0.765	0.732
	(0.309)	(0.223)	(0.335)
Ever smoked	0.603**	1.093	1.250
	(0.143)	(0.245)	(0.314)
Informal care	0.913	1.610**	1.599**
	(0.278)	(0.308)	(0.348)
Observations	47,990	31,422	6,083
Log-pseudolikelihood	-836.92	-936.57	-553.86
Country effects	YES	YES	YES
Year effects	YES	YES	YES
Prob > chi2 interactions	0.0000	0.6072	0.9383

*** $p<0.01$, ** $p<0.05$, * $p<0.1$ Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Regression model includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment), diabetes-related clinical complications (heart attack and stroke), the different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), informal care and country dummies. It also includes the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Each of the interactions measures the effect of jointly having diabetes and any of the above variables compared with not having any of them.

Table 3.A6: Regression models from the sensitivity analysis: by gender

VARIABLES	OR Model 1 Females	OR Model 3 Females	OR Model 1 Males	OR Model 3 Males
Diabetes	1.252	1.012	1.994***	1.554**
	(0.213)	(0.176)	(0.359)	(0.294)
Age	1.073***	1.042***	1.074***	1.041***
	(0.00773)	(0.00797)	(0.0114)	(0.0113)
High or middle education	0.858*	0.922	0.964	1.039
	(0.0721)	(0.0792)	(0.0990)	(0.110)
Married	1.338***	1.274***	1.361***	1.326***
	(0.111)	(0.112)	(0.123)	(0.127)
Low household income	0.889	0.896	0.703*	0.669*
	(0.148)	(0.151)	(0.139)	(0.138)
Retired	0.927	1.012	0.690	0.891
	(0.130)	(0.146)	(0.173)	(0.220)
Household size	0.946	0.871	1.025	1.019
	(0.107)	(0.110)	(0.118)	(0.123)
Number of children	0.981	0.973	1.041	1.019
	(0.0693)	(0.0683)	(0.0806)	(0.0802)
Number of grandchildren	0.966	0.970	0.962	0.953
	(0.0283)	(0.0275)	(0.0309)	(0.0316)
Children in household	0.803	0.755	0.825	0.788
	(0.146)	(0.142)	(0.167)	(0.167)
Chronic lung disease	1.209	0.914	1.360	1.026
	(0.279)	(0.221)	(0.347)	(0.272)
Cancer	1.602**	1.440*	1.128	1.017
	(0.351)	(0.313)	(0.342)	(0.308)
Cognitive impairment	2.604***	2.006***	2.709***	1.984***
	(0.408)	(0.333)	(0.546)	(0.433)
Heart attack		1.036		0.918
		(0.165)		(0.177)
Stroke		2.065***		1.997***
		(0.379)		(0.448)
Mild functional impairment		3.488***		2.924***
		(0.543)		(0.581)
Moderate functional impairment		8.075***		9.346***
		(2.065)		(2.845)
Severe functional impairment		12.08***		13.54***
		(3.514)		(4.992)
Current smoker		0.760		0.962
		(0.197)		(0.209)
Ever smoked		1.076		1.052
		(0.187)		(0.184)
Informal care		1.112		1.897***
		(0.153)		(0.335)
Observations	51,152	51,152	38,234	38,234
Log pseudolikelihood	-1515.84	-1430.24	-1079.01	-1007.97
Country effects	YES	YES	YES	YES
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 3 adds to the previous model diabetes-related clinical complications (heart attack and stroke) and the different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), and informal care.

Table 3.A7: Regression models from the sensitivity analysis: Results from the regression with interaction terms by gender

VARIABLES	OR Model 4 Females	OR Model 4 Males
Diabetes	0.962	1.389
	(0.336)	(0.567)
Diabetes#Chronic lung disease	1.082	0.463
	(0.624)	(0.285)
Diabetes#Cancer	0.604	0.835
	(0.383)	(0.515)
Diabetes#Ulcer	0.922	0.962
	(0.472)	(0.587)
Diabetes#Cognitive impairment	0.852	0.474
	(0.366)	(0.282)
Diabetes#Heart attack	1.169	0.932
	(0.438)	(0.376)
Diabetes#Stroke	2.415**	0.362**
	(1.063)	(0.181)
Diabetes#Mild functional impairment	0.811	1.475
	(0.334)	(0.734)
Diabetes#Moderate functional impairment	1.006	1.085
	(0.639)	(0.661)
Diabetes#Severe functional impairment	0.741	5.784**
	(0.533)	(4.293)
Diabetes#Ever smoked	0.906	1.653
	(0.389)	(0.658)
Diabetes#Informal care	0.973	0.833
	(0.353)	(0.327)
Age	1.042***	1.041***
	(0.00798)	(0.0112)
High or middle education	0.918	1.049
	(0.0789)	(0.113)
Married	1.276***	1.329***
	(0.112)	(0.128)
Low household income	0.892	0.664**
	(0.151)	(0.138)
Retired	1.019	0.870
	(0.148)	(0.215)
Household size	0.872	1.020
	(0.111)	(0.123)
Number of children	0.972	1.018
	(0.0682)	(0.0840)
Number of grandchildren	0.969	0.950
	(0.0274)	(0.0321)
Children in household	0.755	0.799
	(0.142)	(0.169)
Chronic lung disease	0.881	1.285
	(0.248)	(0.383)
Cancer	1.548*	1.059
	(0.363)	(0.378)
Cognitive impairment	2.068***	2.345***
	(0.375)	(0.551)
Heart attack	1.006	0.951
	(0.186)	(0.216)
Stroke	1.682**	2.614***
	(0.370)	(0.640)

Table 3.A7: (Continued)

VARIABLES	OR Model 4 Females	OR Model 4 Males
Mild functional impairment	3.615***	2.640***
	(0.604)	(0.588)
Moderate functional impairment	7.871***	9.656***
	(2.254)	(3.373)
Severe functional impairment	12.63***	7.255***
	(4.022)	(3.600)
Current smoker	0.752	0.969
	(0.197)	(0.212)
Ever smoked	1.086	0.932
	(0.205)	(0.184)
Informal care	1.120	1.979***
	(0.167)	(0.390)
Observations	51,152	38,234
Log pseudolikelihood	-1427.53	-1001.33
Country effects	YES	YES
Year effects	YES	YES
Prob > chi2 interactions	0.7390	0.5382

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Regression model includes diabetes, sociodemographic characteristics (age, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment), diabetes-related clinical complications (heart attack and stroke), the different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), informal care and country dummies. It also includes the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Each of the interactions measures the effect of jointly having diabetes and any of the above variables compared with not having any of them.

Table 3.A8: Regression models from the sensitivity analysis: by length of stay

VARIABLES	OR Model 1 Permanent	OR Model 3 Permanent	OR Model 1 Temporary	OR Model 3 Temporary
Diabetes	1.435**	1.292	1.706***	1.176
	(0.244)	(0.226)	(0.304)	(0.220)
Age	1.060***	1.041***	1.090***	1.043***
	(0.00871)	(0.00874)	(0.00879)	(0.00950)
Female	1.048	0.960	0.864	0.874
	(0.151)	(0.143)	(0.132)	(0.151)
High or middle education	0.866*	0.909	0.946	1.040
	(0.0758)	(0.0799)	(0.0875)	(0.0993)
Married	1.354***	1.312***	1.333***	1.256**
	(0.101)	(0.103)	(0.133)	(0.132)
Low household income	0.701**	0.718**	0.984	0.955
	(0.117)	(0.121)	(0.187)	(0.187)
Retired	0.704**	0.778	1.001	1.183
	(0.109)	(0.121)	(0.196)	(0.238)
Household size	1.060	1.010	0.872	0.827
	(0.100)	(0.104)	(0.129)	(0.134)
Number of children	0.999	0.989	1.013	0.996
	(0.0729)	(0.0736)	(0.0749)	(0.0720)
Number of grandchildren	0.948	0.949	0.981	0.979
	(0.0312)	(0.0309)	(0.0283)	(0.0275)
Children in household	0.609***	0.575***	1.127	1.076
	(0.108)	(0.106)	(0.227)	(0.224)
Chronic lung disease	1.171	1.030	1.362	0.910
	(0.283)	(0.259)	(0.331)	(0.229)
Cancer	1.035	1.001	1.816***	1.524*
	(0.291)	(0.280)	(0.414)	(0.351)
Cognitive impairment	2.628***	2.021***	2.598***	1.900***
	(0.440)	(0.356)	(0.480)	(0.375)
Heart attack		0.543***		1.516**
		(0.108)		(0.254)
Stroke		1.647**		2.432***
		(0.342)		(0.470)
Mild functional impairment		2.128***		4.846***
		(0.367)		(0.922)
Moderate functional impairment		7.525***		9.867***
		(2.010)		(2.876)
Severe functional impairment		13.55***		11.46***
		(3.953)		(4.098)
Current smoker		1.105		0.602*
		(0.238)		(0.170)
Ever smoked		0.884		1.250
		(0.153)		(0.223)
Informal care		0.997		1.949***
		(0.149)		(0.332)
Observations	90,589	90,589	87,654	87,654
Log pseudolikelihood	-1603.83	-1543.58	-1281.07	-1162.99
Country effects	YES	YES	YES	YES
Year effects	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.
Standard errors were clustered at individual level. Model 1 includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household) and non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 3 adds to the previous model diabetes-related clinical complications (heart attack and stroke) and the

different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), and informal care.

Table 3.A9: Regression models from the sensitivity analysis: Results from the regression with interaction terms by length of stay

VARIABLES	OR Model 4 Permanent	OR Model 4 Temporary
Diabetes	0.887	1.678
	(0.333)	(0.709)
Diabetes#Chronic lung disease	1.276	0.433
	(0.696)	(0.258)
Diabetes#Cancer	0.286	0.992
	(0.288)	(0.517)
Diabetes#Ulcer	0.925	1.036
	(0.530)	(0.592)
Diabetes#Cognitive impairment	1.022	0.452
	(0.449)	(0.246)
Diabetes#Heart attack	1.054	1.068
	(0.439)	(0.401)
Diabetes#Hypertension	1.235	0.687
	(0.412)	(0.218)
Diabetes#Stroke	1.012	1.064
	(0.503)	(0.472)
Diabetes#Mild functional impairment	1.775	0.603
	(0.774)	(0.287)
Diabetes#Moderate functional impairment	0.773	1.217
	(0.518)	(0.732)
Diabetes#Severe functional impairment	0.989	2.997
	(0.728)	(2.168)
Diabetes#Ever smoked	1.331	1.574
	(0.491)	(0.595)
Diabetes#Informal care	1.115	0.791
	(0.423)	(0.305)
Age	1.041***	1.042***
	(0.00881)	(0.00950)
Female	0.954	0.903
	(0.143)	(0.158)
High or middle education	0.906	1.046
	(0.0804)	(0.101)
Married	1.314***	1.254**
	(0.104)	(0.132)
Low household income	0.713**	0.949
	(0.121)	(0.187)
Retired	0.776	1.178
	(0.122)	(0.237)
Household size	1.010	0.826
	(0.104)	(0.133)
Number of children	0.990	0.990
	(0.0742)	(0.0703)
Number of grandchildren	0.949	0.980
	(0.0308)	(0.0269)
Children in household	0.572***	1.102
	(0.105)	(0.229)
Chronic lung disease	0.962	1.113
	(0.289)	(0.307)
Cancer	1.178	1.531
	(0.346)	(0.402)
Cognitive impairment	2.015***	2.267***
	(0.392)	(0.475)

Table 3.A9: (continued)

VARIABLES	OR Model 4 Permanent	OR Model 4 Temporary
Heart attack	0.529***	1.515**
	(0.127)	(0.287)
Stroke	1.635**	2.397***
	(0.383)	(0.534)
Mild functional impairment	1.865***	5.287***
	(0.370)	(1.093)
Moderate functional impairment	8.082***	9.319***
	(2.312)	(3.219)
Severe functional impairment	13.71***	7.580***
	(4.348)	(3.492)
Current smoker	1.117	0.595*
	(0.242)	(0.169)
Ever smoked	0.839	1.145
	(0.155)	(0.230)
Informal care	0.980	2.069***
	(0.162)	(0.390)
Observations	90,589	87,654
Log pseudolikelihood	-1540.74	-1155.73
Prob > chi2 interactions	0.8936	0.1586
Country effects	YES	YES
Year effects	YES	YES

*** $p<0.01$, ** $p<0.05$, * $p<0.1$ Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Regression model includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment), diabetes-related clinical complications (heart attack and stroke), the different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), informal care and country dummies. It also includes the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Each of the interactions measures the effect of jointly having diabetes and any of the above variables compared with not having any of them.

Table 3.A10: Regression models from the sensitivity analysis: Results from the regression with interaction terms by country

VARIABLES	OR Model 4 Austria	OR Model 4 Germany	OR Model 4 Spain	OR Model 4 France
Diabetes	0.716	4.799	3.869	0.180
	(1.024)	(4.923)	(4.115)	(0.199)
Diabetes#Chronic lung disease	-	1.306	-	-
		(1.814)		
Diabetes#Cancer	2.314	1.679	-	-
	(2.794)	(1.680)		
Diabetes#Cognitive impairment	2.179	-	-	1.269
	(2.527)			(1.049)
Diabetes#Heart attack	12.34	0.501	0.0522**	0.204
	(19.22)	(0.418)	(0.0626)	(0.206)
Diabetes#Hypertension	0.868	1.818	0.823	0.802
	(0.854)	(1.708)	(0.776)	(0.605)
Diabetes#Stroke	0.271	0.148	-	11.06***
	(0.228)	(0.225)		(9.731)
Diabetes#Mild functional impairment	0.469	0.377	0.619	2.572
	(0.430)	(0.646)	(0.993)	(2.790)
Diabetes#Moderate functional impairment	-	1.062	2.051e+07***	-
		(1.223)	(2.718e+07)	
Diabetes#Severe functional impairment	-	-	13.95	-
			(27.68)	
Diabetes#Ever smoked	0.344	0.597	3.712	27.74***
	(0.458)	(0.843)	(4.276)	(21.09)
Diabetes#Informal care	1.631	0.330	1.415	-
	(1.451)	(0.366)	(2.253)	
Age	1.039*	1.062*	1.038	1.007
	(0.0223)	(0.0334)	(0.0319)	(0.0203)
Female	0.502*	1.448	0.663	1.004
	(0.204)	(0.740)	(0.500)	(0.439)
High or middle education	0.696	0.840	1.185	1.177
	(0.198)	(0.250)	(0.376)	(0.209)
Married	2.017**	0.928	1.070	1.002
	(0.657)	(0.290)	(0.267)	(0.221)
High household income	-	-	-	0.802
				(0.360)
Retired	0.566	0.419*	0.172**	4.845***
	(0.253)	(0.218)	(0.143)	(2.325)
Household size	1.020	0.544	0.621*	0.995
	(0.456)	(0.242)	(0.169)	(0.256)
Number of children	0.775	0.668	0.695	0.969
	(0.195)	(0.173)	(0.270)	(0.150)
Number of grandchildren	0.922	1.061	1.082	0.989
	(0.0830)	(0.122)	(0.181)	(0.0654)
Children in household	0.592	0.790	1.593	1.630
	(0.328)	(0.472)	(0.808)	(0.831)
Chronic lung disease	0.356	3.359*	0.879	2.058
	(0.460)	(2.177)	(0.540)	(1.157)
Cancer	1.778	1.924	0.610	1.928
	(1.510)	(1.143)	(0.552)	(0.985)
Cognitive impairment	3.373**	2.003	4.844**	2.325*
	(2.009)	(0.978)	(3.292)	(1.004)
Heart attack	1.690	1.246	1.508	1.173
	(0.968)	(0.669)	(1.089)	(0.570)

Table 3.A10: (continued)

VARIABLES	OR Model 4 Austria	OR Model 4 Germany	OR Model 4 Spain	OR Model 4 France
Stroke	2.701	4.311**	4.600*	1.823
	(1.767)	(2.555)	(3.767)	(1.144)
Mild functional impairment	2.128	4.191***	1.939	2.395*
	(1.316)	(2.115)	(1.484)	(1.237)
Moderate functional impairment	1.934	50.50***	4.02e-06***	3.291
	(2.396)	(33.11)	(2.67e-06)	(3.977)
Severe functional impairment	53.62***	6.145	3.238	12.96**
	(37.12)	(8.055)	(2.763)	(16.09)
Current smoker	0.198	2.813	0.767	0.133*
	(0.209)	(1.953)	(0.657)	(0.157)
Ever smoked	1.359	0.562	1.982	0.781
	(0.659)	(0.328)	(1.474)	(0.346)
Informal care	0.958	2.551*	1.016	1.951*
	(0.499)	(1.221)	(0.943)	(0.762)
Observations	5,854	5,014	5,648	8,112
Log pseudolikelihood	-139.94	-109.47	-107.76	-223.02
Year effects	YES	YES	YES	YES
Prob > chi2 interactions	0.2653	0.0335	0.0000	0.0000

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Regression model includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment), diabetes-related clinical complications (heart attack and stroke), the different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), informal care. It also includes the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Each of the interactions measures the effect of jointly having diabetes and any of the above variables compared with not having any of them.

Table 3.A10: (continued)

VARIABLES	OR Model 4 Denmark	OR Model 4 Greece	OR Model 4 Belgium	OR Model 4 Czech Republic
Diabetes	1.68e-06***	0.387	0.437	0.171
	(1.88e-06)	(0.274)	(0.570)	(0.231)
Diabetes#Chronic lung disease	-	-	0.842	13.64**
			(0.775)	(16.48)
Diabetes#Ulcer	9.867	-	2.698	0.711
	(0)		(3.224)	(0.823)
Diabetes#Cognitive impairment	-	4.631	3.703	0.657
		(5.060)	(3.521)	(0.991)
Diabetes#Heart attack	0.409	-	0.707	0.769
	(0)		(0.918)	(0.562)
Diabetes#Stroke	1.167e+13	50.11**	23.83***	1.680
	(0)	(85.93)	(27.48)	(1.584)
Diabetes#Mild functional impairment	1.904e+14***	5.394	1.296	1.673
	(3.505e+14)	(6.354)	(1.528)	(1.725)
Diabetes#Moderate functional impairment	-	-	3.651	-
			(5.667)	
Diabetes#Severe functional impairment	-	-	0.219	6.073
			(0.262)	(12.46)
Diabetes#Ever smoked	-	0.282	0.680	1.252
		(0.476)	(0.657)	(1.151)
Diabetes#Informal care	-	0.983	0.953	2.935
		(1.026)	(0.826)	(2.886)
Age	1.045	1.020	1.094***	0.999
	(0.0350)	(0.0234)	(0.0169)	(0.0239)
Female	0.302*	0.923	1.236	0.513*
	(0.202)	(0.294)	(0.478)	(0.186)
High or middle education	1.141	1.359	1.204	0.890
	(0.419)	(0.310)	(0.218)	(0.254)
Married	0.853	1.458**	1.481*	1.356
	(0.389)	(0.223)	(0.297)	(0.266)
Low household income	1.829	-	0.802	-
	(1.283)		(0.268)	
Mid household income	-	-	-	0.587
				(0.284)
High household income	0.556	-	0.564	-
	(0.543)		(0.274)	
Retired	0.445	0.901	0.958	1.124
	(0.447)	(0.352)	(0.311)	(0.580)
Household size	0.0160***	1.593***	1.017	1.005
	(0.0164)	(0.278)	(0.305)	(0.252)
Number of children	1.153	0.870	1.160	0.991
	(0.345)	(0.166)	(0.122)	(0.226)
Number of grandchildren	1.096	0.982	0.905*	1.044
	(0.120)	(0.0831)	(0.0470)	(0.0833)
Children in household	-	0.324***	0.654	0.707
		(0.109)	(0.301)	(0.303)
Chronic lung disease	0.214	0.641	1.100	0.351
	(0.205)	(0.685)	(0.623)	(0.377)
Cancer	0.822	3.935**	1.138	1.626
	(0.770)	(2.640)	(0.596)	(1.124)

Table 3.A10: (continued)

VARIABLES	OR Model 4 Denmark	OR Model 4 Greece	OR Model 4 Belgium	OR Model 4 Czech Republic
Cognitive impairment	7.927***	1.048	1.760	4.051***
	(4.489)	(0.792)	(0.800)	(1.805)
Heart attack	1.723	0.306	1.063	1.358
	(1.227)	(0.272)	(0.450)	(0.618)
Stroke	7.408**	0.660	0.955	1.639
	(5.771)	(0.595)	(0.610)	(1.058)
Mild functional impairment	10.26***	1.508	2.447***	2.242*
	(6.242)	(0.857)	(0.789)	(1.058)
Moderate functional impairment	887.1***	3.764	0.892	9.175***
	(1,457)	(4.178)	(0.996)	(7.708)
Severe functional impairment	4.786	-	42.83***	8.182
	(7.383)		(34.95)	(11.42)
Current smoker	0.191*	0.805	1.076	0.645
	(0.181)	(0.413)	(0.488)	(0.341)
Ever smoked	0.645	0.566	1.373	1.290
	(0.387)	(0.245)	(0.523)	(0.537)
Informal care	3.279**	1.225	1.379	1.141
	(1.622)	(0.570)	(0.465)	(0.462)
Observations	3,851	5,005	8,947	6,643
Log pseudolikelihood	-64.73	-259.10	-264.00	-205.72
Year effects	YES	YES	YES	YES
Prob > chi2 interactions	0.0000	0.0820	0.2476	0.1654

*** p<0.01, ** p<0.05, * p<0.1 Source: authors of this chapter using data from SHARE.

Standard errors were clustered at individual level. Regression model includes diabetes, sociodemographic characteristics (age, sex, education, marital status, household income, and employment status), family network, and household composition (household size, number of children and grandchildren, and children in household), non-diabetes-related complications (chronic lung disease, cancer and cognitive impairment), diabetes-related clinical complications (heart attack and stroke), the different degrees of functional impairment according to the number of limitations in ADLs (mild, moderate, and severe), lifestyle factors (current smoker and ever smoked), informal care. It also includes the interactions between the main disease of interest, diabetes, and all the clinical and functional complications, both nonrelated and related to diabetes, as well as the interactions between diabetes and lifestyle variables and informal care.

Each of the interactions measures the effect of jointly having diabetes and any of the above variables compared with not having any of them.

Table 3.A11: Nursing home expenditures per capita by country and year, adjusted by PPP (current international $)

	2004	**2006/07**	**2010**	**AVERAGE**
Austria	204.7604	230.5729	313.7079	249.6804
Germany	236.0971	231.7317	330.5710	266.1333
The Netherlands	299.9008	853.2611	994.6301	715.9307
Spain	118.7421	155.4664	213.2555	162.4880
France	146.7926	183.1528	251.0871	193.6775
Denmark	367.5769	443.7908	551.6237	454.3305
Switzerland	669.6459	759.8198	915.9817	781.8158
Belgium	348.3664	457.4916	539.3053	448.3878
Czech Republic	15.5109	19.4042	27.9781	20.9644

Source: Self-generated using OECD Data and Statistics and World Bank dat.a

Table 3.A12: GDP per capita by country and year, adjusted by PPP (current international $)

	Wave 1	Wave 2		Wave 4
	2004	**2006**	**2007**	**2010**
Austria	33,809.8	37,649.5	39,238.3	41,804.2
Germany	30,662	34,667.6	36,735.8	39,553.2
The Netherlands	35,167	40,434.1	43,339.6	44,743
Spain	26,445	30,879.9	32,806.7	32,350.5
France	29,037.3	32,288.8	34,039.8	35,868.9
Denmark	33,152.6	37,189.7	38,674.4	41,806.9
Switzerland	37,771	43,377.8	47,409.5	51,321.5
Belgium	31,946.2	35,169	36,621.1	39,211.3
Czech Republic	20,990.3	24,415.9	26,683.2	27,051

Source: World Bank data.

THE RELATIONSHIP BETWEEN DIABETES, DIABETES-RELATED COMPLICATIONS AND PRODUCTIVE ACTIVITIES AMONG OLDER EUROPEANS[17]

4.1 INTRODUCTION

A number of studies have analysed the impact of health on productivity (Grossmeier et al., 2015; Lenneman et al., 2011; van den Heuvel et al., 2010; Bergstrom et al., 2009; Pauly et al., 2008; Burton et al., 2005) concluding that worse health status increases both measures of productivity impairment, absenteeism and presenteeism, forcing early labour-market exit (Rice et al., 2011). In this analysis, I aim to measure the effect that diabetes, a disease that mainly affects people in advanced age and more specifically, one in every four people aged 65 and above (Soriguer et al., 2012; Sloan et al., 2008), has on productivity through two different measures depending on the age group: being afraid health limits work for those who are still in the working age (up to 65) and being a formal volunteer in case people are in the retirement age (above 65

years old). In case of the former outcome, only a few studies have looked into the burden of diabetes in terms of productivity impairment (Rumball-Smith et al., 2014; ADA, 2013; Hex et al., 2012; Herquelot et al., 2011; Tunceli et al., 2005; Norlund et al., 2001; Songer et al., 1989); and when talking about the latter, considerably less research has been conducted (Leitjen et al., 2014; Di Gessa and Grundy, 2014; Hank, 2011; Hank and Erlinghagen, 2010; Hank and Erlinghagen, 2009; Hank and Stuck, 2007; Börsch-Supan et al., 2005), only self-perceived health has been supported to reduce volunteering rates (Komp et al., 2012).

Such a gap in the literature could be due to the difficulty in measuring the impact of diabetes on productivity, since it is a disease that does not impair individual's health itself, but through the complications that it generates. Actually, diabetes can impact productivity in several ways. Firstly, diabetes complications might impair the ability to work completely (Rumball-Smith et al., 2014; Herquelot et al., 2011; Norlund et al., 2001), increase the number of days absent from work due to health problems (ADA, 2013; Hex et al., 2012; Tunceli et al., 2005) or reduce productivity at work (ADA, 2013; Hex et al., 2012). Secondly, individuals with diabetes could be discriminated at work by their employers due to their concerns about low productivity (Songer et al., 1989), limiting the type of work they can do. While direct effects on actual productivity are hard to measure, perceptions of patients concerning productivity loss might be another related measure that is affected before actual job loss takes place. Especially in uncertain economic circumstances, such perceptions maybe importantly affected by diseases such as diabetes. I thus also aim to assess the relationship of diabetes and these two productivity measures during the crisis period that recently hit Europe, from 2006 to 2013, which has not been taken into account in any of the studies previously mentioned. During an economic crisis, both insecurity and solidarity might rise due to the instability of employment in case of the former and need for helping those who have been heavily affected by the crisis when talking about the latter. Observing the trends among that period of time could provide evidence of how relevant health is with respect to productivity in periods of economic uncertainty.

Bearing in mind that the effect of diabetes is generally mediated by its comorbidities, it seems sensible to assess the impact of diabetes on the individual´s perception to perform their work due to health problems and their commitment into volunteering, controlling for diabetes-related complications.

This chapter therefore proposes to take a cross-sectional perspective from some European countries to analyse the role of such a prevalent disease in old adults as well as a set of clinical and functional complications in determining individual's commitment with both paid and non-paid work. Having a cross-country dataset allows me to control for differences in labour market

regulations, which potentially affect the enrolment of people into productive activities, but also country-specific cultural differences.

My findings could be of special relevance in order to better determine how programs and policies should be designed and implemented to ensure and maximize the engagement of old people, in who diabetes is highly prevalent (Soriguer et al., 2012; Sloan et al., 2008), into productive activities.

The following section proposes six hypotheses about the link between diabetes and some diabetes-related and non-related clinical and functional complications with the measures I use to address self-commitment to productive activities. Then, I present the data and methods I use, followed by the analysis of the descriptive and multivariate results. Finally, I discuss the results and mention the limitations and implications derived from the study.

4.2 HYPOTHESES

As it has been previously mentioned and according to Figure 4.1, diabetes could potentially impair the individual´s participation on both paid, that is, job for which s/he receives a salary; and non-paid activities, such as volunteering.

Figure 4.1: Impact of diabetes on participation (modified from *"Towards a common language for functioning, disability and health: ICF, The International Classification of Functioning, Disability and Health"*, WHO, 2002)
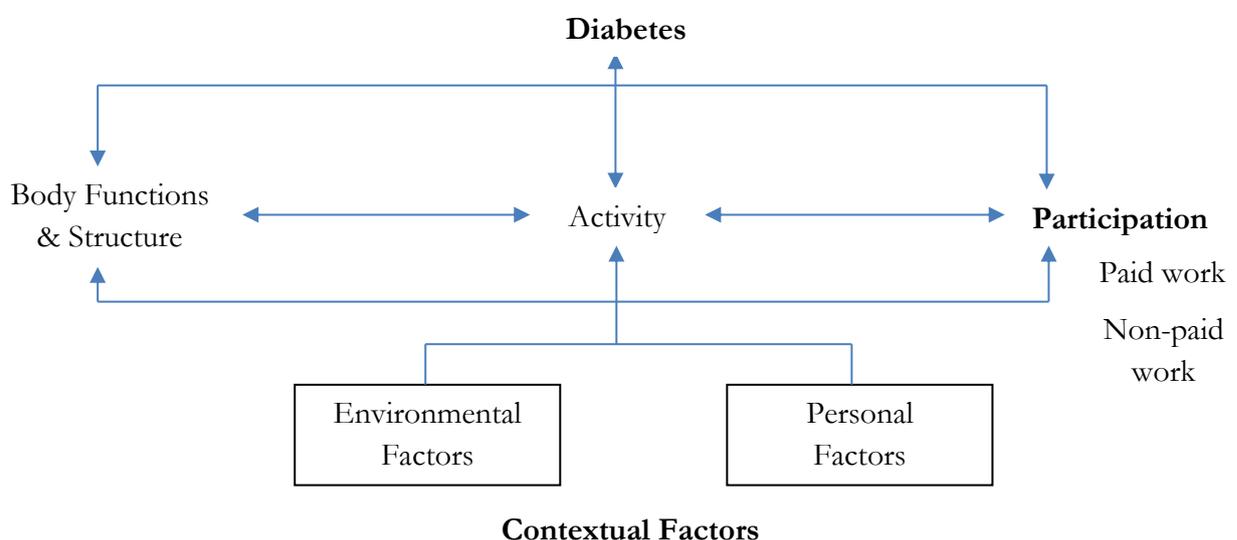
Some studies have already analysed the association between diabetes and lower productivity, concluding that people with diabetes reported higher numbers of disability days (Hank, 2011; von Korf et al., 2005; Yassin et al., 2002; Valdmanis et al., 2011), lost productivity time (Di Gessa and Grundy, 2014; Lavigne et al., 2003) and unemployment rates (Leijten et al., 2014; Hank, 2011; Hank and Erlinghagen, 2010; Hank and Erlinghagen, 2009; Hank and Stuck, 2007; von Korf et

al., 2005; Valdmanis et al., 2001). However, they used as outcome measure either the number of working days lost due to diabetes or employment transitions, that is, changing from being employed to be retired or disabled. Not so much analysis evaluated the potential impact of diabetes on work limitations. The study closest to my aim of analysis is the one by Tunceli et al. (2005), who used US data on 7,055 employees aged 51 – 61 years old from the first two waves (1992 and 1994) of the Health & Retirement Study (HRS). Individuals were asked if they had any impairments or health problems at the time of the interview that limited the kind or amount of paid work they could do, which is quite similar to the survey question I am using in this study. Authors concluded that, compared with individuals without diabetes, US men and women with diabetes were 5.4 and 6 percentage points, respectively, more likely to have work limitations. They controlled for health status using two self-reported measures: BMI and the number of other chronic conditions in addition to diabetes (hypertension, heart disease, chronic lung disease, stroke, cancer, arthritis and psychiatric problems). In my analysis I aim to assess the impact of diabetes and a list of clinical complications not on productivity losses or unemployment, but on the fear of health limiting work that people might feel. This leads to the first hypothesis:

Hypothesis 1: Diabetes increases the likelihood of people aged 50 to 65 years old being afraid health limits their work, although the magnitude of the effect will be reduced when diabetes-related complications are included in the regression.

Moreover, the aforementioned works tested their hypotheses using data prior to the economic crisis that took place in 2008. In fact, none of them looked at the relevance of time variables. Conversely, I am using data from the time before (2006), during (2010) and after (2013) that time threshold. Due to the uncertain situation, I expect people to be more afraid to lose their job during and after the crisis than before. One of the factors that could impair individual's ability to carry out his/her job appropriately could be health. The economic crisis might force employers to become stricter with regards to the job requirements and employees could experience more pressure while they are in their job position. Hence, people could expect that the fewer limitations they have in their working performance derived from their health status, the less likely it will be them to lose their job. Thus, the second hypothesis is:

Hypothesis 2: The fear of health limiting work of people between ages 50 and 65 will increase during 2010 and 2013 with respect to 2006.

As shown in the previous two hypotheses, I expect both diabetes and time variables to be positively associated with being afraid health limits work, I consequently presume the joint effect of both variables will lead to greater risk of being afraid health limits work. Given the effect of

the crisis, which is expected to become apparent in later years, and the impact of diabetes, especially high in old age groups and impairing individuals´ functioning, I establish the third hypothesis:

Hypothesis 3: Having diabetes will increase the perception of the individuals aged 50 to 65 years old being afraid health limits work more during the crisis years 2010 and 2013 with respect to 2006.

Furthermore, non-paid productive activities could be a useful tool to measure productivity in advanced ages, especially when individuals are retired. According to the existing literature, the likelihood of taking-up volunteering seems to be lower in higher ages (Rumball-Smith et al., 2014; ADA, 2013; Tunceli et al., 2005), due to their health status, also leading to withdrawals in those who were already performing non-paid work (Tunceli et al., 2005). Nevertheless, not so much literature has been found taking diabetes as the main health measure (ADA, 2008), leading me to the fourth hypothesis:

Hypothesis 4: Diabetes will significantly reduce the likelihood of being a formal volunteer (doing charity work), as well as the amount of time dedicated to this task in people aged 65 and older[18].

Moreover, as a consequence of the economic crisis, rates of volunteering have increased (Rumball-Smith et al., 2014; ADA, 2013; Hex et al., 2012; Herquelot et al., 2011; Tunceli et al., 2005), showing great differences within European countries (Hex et al., 2012; Herquelot et al., 2011; Tunceli et al., 2005). The rationale behind such increase could be due to a willingness to help people given the unstable situation rather than a self-decision to perform some productive activities as a real work could be. Moreover, individuals might do charity work because, due to the hit of the crisis, governments could have cut budgets and subsidies on this kind of social services, so someone else should do it instead. So, I settle the fifth hypothesis:

Hypothesis 5: Volunteering will increase during the years 2010 and 2013 with respect to 2006.

Finally, I aim to analyse the interaction between both independent variables, having diabetes and time, and to be a formal volunteer. I expect the interaction term to be significantly related with volunteering, although the sign of its coefficient is uncertain given the opposite interpretations of these variables separately.

Hypothesis 6: The association between diabetes and volunteering will be different during and after the crisis period for those older than 65 years old, that is, years 2010 and 2013.

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[18] I did not include the individuals younger than 65 in the analysis of volunteering since it could be considered as a substitute of a paid job, which would complicate the analysis.

4.3 METHODS AND DATA

4.3.1 Sample data

The data are drawn from waves 2, 4 and 5[19], corresponding to the years 2006/07, 2010 and 2013, respectively, from the Survey of Health, Ageing and Retirement in Europe (SHARE). The survey is a longitudinal survey that aims to provide comprehensive data on socioeconomic characteristics, health and healthcare use, and family networks from multiple European countries and Israel (Börsch-Supan et al., 2005).

I have limited the analysis to eleven of these countries: Austria, Belgium, Czech Republic, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden and Switzerland. Other countries are excluded from the analysis either because they only appear in one of the three waves or due to their small sample size. I then split the sample by age: given that the most common retirement age in Europe is 65 years old, I distinguish between those still in the working age (from 50 to 65 years old) and retired individuals[20] (above 65 years old).

Thus, the population of analysis consists on 53,631 observations between the ages 50 to 65 clustered in 34,393 individuals when the outcome is being afraid health limits their work and 45,384 figures grouped in 29,104 individuals when assessing volunteering and age is above 65 years old, that is, those who are already retired.

4.3.2 Selection of variables

<u>Outcome variables</u>

In order to evaluate the fear of health limiting work, I take the information from SHARE on the following question: *"Are you afraid health limits the kind or amount of work you do?"*, to which respondents could choose between "yes" or "no".

Data on respondents' commitment in volunteering is based on a question from SHARE that is formulated as follows:

"Have you done any of the following activities in the last month?

    1. Done voluntary or charity work

    2. Cared for a sick or a disabled adult

    3. Provided help to family, friends or neighbours"

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[19] Wave 3 was excluded due to a change in the questionnaire (the SHARELIFE questionnaire), which registered information on individuals' childhood health and, hence, the information provided in wave 3 was not useful for the analysis. However, I have used Wave 3 data to drop the observations already reporting to suffer diabetes in their childhood.

[20] According to the responses to the employment status question from the survey, only 2% of the people aged 65+ are employed or self-employed, whereas almost 85% are retired and another 11.5% declared to be homemakers.

According to Hank and Stuck (2007), volunteering could be divided into three categories: formal volunteering (having done voluntary or charity work), informal care (care for a sick or disabled adult) and carer (provided help to family, friends or neighbours). However, waves 4 and 5 do not include the latter two. Hence, I decide to take the more strict definition of volunteering: formal volunteering.

I then focus on whether respondents have been actively performing volunteering activities, instead of looking at, for example, membership of charity associations. The latter measure, although commonly used, might overestimate the actual engagement, whereas my chosen variable will likely give a more accurate estimation of the real volunteering figures across Europe (Hank and Erlinghagen, 2009) since respondents are asked about the volunteering made in the last month instead of longer time periods.

I also looked at the frequency of charity work, which could be i) daily, ii) weekly, and iii) less often than weekly.

<u>Independent variables</u>

Since the main independent variable is diabetes, I take self-reported information from SHARE about doctor's diagnosis on diabetes. Moreover, as I also want to evaluate the impact of comorbidities on both outcome measures, I also use information on individuals' other chronic conditions: heart attack, stroke, chronic lung disease, cancer, ulcer, hypertension, hip fracture. These are the main chronic conditions that are available in SHARE across all waves, as well as all diabetes related conditions that are available in SHARE. I consider the following conditions to be diabetes related: heart attack, stroke, ulcer, and hypertension.

Furthermore, SHARE contains data on the number of mobility problems that individuals might report, ranging from 0, that is, no mobility problems at all, to a maximum of 10. I then generate a dummy variable that takes value 1 if any number of mobility problems had been reported by the respondent and 0 otherwise. This variable is only included when assessing individual´s engagement in volunteering activities. Mobility problems can be regarded as a health limitation, so its consideration in the analysis of the fear health limited work could lead to estimation problems.

The second main variable of interest is time, so dummy variables for wave 4 (year 2010) and wave 5 (year 2013) are included in the analysis, being wave 2 (years 2006/07) the reference group.

Moreover, I include sociodemographic factors such as age. In case of the working age people, I generate dichotomous variables for age groups 50 – 55, 56 – 60 and 61 to 65, being the former the reference group. I do so to control for differences across group ages, since the oldest one might not perceive health as a big problem as the younger subpopulations, due to their proximity

to retirement. On the other hand, I include six age groups, age $65 - 70$, $71 - 75$, $76 - 80$, $81 - 85$, $86 - 90$ and older than 90 years old, in the volunteering analysis[21]. Common to both analyses is the natural logarithm of household income, which is actually my only continuous variable. I also incorporate dummy variables for gender, marital status, and education categories. A detailed explanation can be found in Appendix, 4.A1. Finally, I include country dummy variables so I control for potential differences across countries.

4.3.3 Statistical analyses

In a first step of analysis, I have estimated univariate logit models for the list of covariates and the two binary dependent variables: being afraid health limits work and doing formal volunteering activities. By doing so, I will be able to evaluate the relevance of the association between each independent variable and both outcome measures.

Then, I estimate a multivariate logistic regression with clustered standard errors, which is actually convenient when using data from different waves as I do, at the individual level to take into account within individual autocorrelation in the analysis of being afraid health limits work and at the household level when analyzing volunteering, so I take into account correlation between household members' decisions (Rabe-Hesketh and Skrondal, 2008; Heij et al., 2004).

In logit models, estimated coefficients capture the effects on the log-odds-ratio (see e.g. Heij, C. et al., 2004). Let $\Lambda(t) = e^t/(1 + e^t)$ be the logistic function with values stretching between zero and one, and let:

$$Pr[AHLW_{ict} = 1 \,|x_{it}] = \Lambda(\,\beta_0 + \,\beta_1 SE_{it} + \,\beta_2 diabetes_{it} + \,\beta_3 HI_{it} + \,\gamma_c + \,\zeta_t) \quad (1)$$

where i represents the individual, c country, and t year. $AHLW_{ict}$ is a dummy variable indicating that respondent i is afraid health limits his/her work in country c in year t. $x_{it} = (SE_{it}, diabetes_{it}, HI_{it}, \text{country dummies}, \text{time dummies})'$ is a vector of explanatory variables. SE_{it}, $diabetes_{it}$, HI_{it} denote the set of socioeconomic variables, having diabetes and chronic conditions, respectively.

Model A adjusts for demographic characteristics, socioeconomic status, chronic conditions not related to diabetes, time and country dummies. In this model some diseases such as cerebrovascular conditions are not included due to their relationship with diabetes. However, in order to evaluate the net impact of diabetes on being afraid health limit, I include diabetes-related clinical complications in model B. Moreover, and in order to measure the effect of diabetes

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[21] Although the retirment age is not fixed at the age of 65 across European countries, it is the mean retirement age in Europe. Moreover, only 2% of the people aged 65+ in the sample are employed or self-employed, whereas almost 85% are retired and another 11.5% declared to be homemakers.

together with the time dummy on the outcome according to the third and sixth hypotheses, the interaction between these two is included in a last regression (model C).

Same procedure has been followed for the second outcome of interest, to be a formal volunteer, but with an additional inclusion. In model B, I also look at the impact of having mobility problems.

After running these three regression models, I test which model better fits the data using Wald tests and the Akaike's (AIC) and Schwarz's Bayesian (BIC) information criteria. The Wald test compares the null hypothesis that a set of parameters is equal to zero, so, if the test fails to reject the null hypothesis, removing those variables from the model will not substantially damage the fit of such model. AIC and BIC provide information which model fits data better. When comparing AIC and BIC, models need to be nested. Both smaller AIC and BIC indicate a better fitting model. I compare Model B against Model A, as the former adds clinical complications and mobility problems in case of volunteering to the latter model, and Model C against Model B, testing for the statistical and explanatory relevance of the interactions between diabetes and years 2010 and 2013.

Besides, the aim is also to see how the independent variables affect the different intensities of volunteering. In order to do so, I will run Model C as an ordered logit model. As this kind of models are easier to estimate and interpret than multinomial logit models, it is advantageous to exploit the order nature of the outcomes of the dependent variable (Heij et al., 2004).

All the statistical analyses are run using Stata 14.0 software (Stata Corporation, College Station, TX).

4.4 RESULTS

4.4.1 Descriptive statistics

Characteristics of the study population by productive outcome are shown in Table 4.1. Moreover, the table shows a comparison of means test between the two groups.

With regards to those being afraid health limits their work, there seems to be meaningful differences between those with such fear and the ones without. First of all, diabetes prevalence more than doubles in the former with comparison to the latter (16.45% vs 6.79%). The same pattern holds for the other chronic conditions. For example, 11.72%, 14.15%, 38.61% and 6.32% of those being afraid suffer from chronic lung disease, heart attack, hypertension or stroke, respectively, in contrast with their comparison group, for who these rates drop to 3.27%, 3.71%, 27.66% and 0.97%, respectively.

In addition, there are differences regarding the time variable, but no wave is significant. The trend in the percentage of people answering they were afraid health limits work varies between

waves, since in wave 5 the percentage of people perceiving such fear was higher than those who did not (47.09% vs 46.76%), opposite to what is shown in waves 2 and 4, as 16.57% and 36.33% reported being afraid against the 16.35 and 36.89 who were not, respectively. Those who are afraid health limits their work are slightly older, with lower education level, with no current partner, and with lower income.

In terms of volunteering, significant differences have also been found between those doing charity work and those not. Those not being formal volunteers had higher rates of diabetes prevalence than their counterparts (16.12% vs 10.76%). The same pattern holds for the other chronic conditions and mobility problems. For example, 16.54%, 46.87% and 62.36% of the non-volunteers have heart attack, hypertension or mobility problems, respectively, in comparison to the volunteers, whose ratios decrease to 13.37%, 40.45% and 47.06%, respectively. In addition, the three time variables report no significant relationship with volunteering. Those who do not provide charity work are older, more likely to be women, with lower education, with no current partner, and with lower income.

Regarding both outcomes, country dummies also capture differences in reporting styles, which are likely to differ across countries. With respect to diabetes prevalence, some differences can also be observed between countries (Table 4.2). It can be seen that diabetes prevalence is the highest in the Czech Republic and Spain, with percentages of 20 - 23% of the population older than 65 years old. The lowest diabetes prevalence can be observed in Denmark and Switzerland, which barely get to 10% for people above 65 years old.

Table 4.1: Descriptive statistics[22]

Variables	Whole sample (N = 53,631)	Afraid health limits work (N = 11,259)	Not afraid health limits work (N = 42,372)	Univariate analysis	Whole sample (N = 45,384)	Formal volunteering (N = 8,281)	No formal volunteering (N = 37,103)	Univariate analysis
Afraid health limits work	20.99%							
Formal volunteering					18.24%			
No formal volunteering					81.76%	-	-	
Less often than weekly					5.61%	30.15%	-	
Weekly					9.05%	51.90%	-	
Daily					3.58%	17.95%	-	
Diabetes	8.81%	16.45%	6.79%	***	15.14%	10.76%	16.12%	***
Age categories				***				***
Age 50 to 55	25.74%	23.73%	26.27%					
Age 56 to 60	33.70%	35.03%	33.35%					
Age 61 to 65	40.56%	41.24%	40.38%					
Age 66 to 70					31.30%	39.85%	29.40%	
Age 71 to 75					28.16%	31.78%	27.36%	
Age 76 to 80					20.66%	18.13%	21.22%	
Age 81 to 85					12.67%	7.46%	13.83%	
Age 86 to 90					5.62%	2.38%	6.35%	

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[22] Percentages are presented referring to the mean percentage between waves, unless indicated otherwise.

Table 4.1: (continued)

Variables	Whole sample (N = 53,631)	Afraid health limits work (N = 11,259)	Not afraid health limits work (N = 42,372)	Univariate analysis	Whole sample (N = 45,384)	Formal volunteering (N = 8,281)	No formal volunteering (N = 37,103)	Univariate analysis
Age older than 90					1.57%	0.37%	1.83%	
Female	56.00%	56.66%	55.82%		54.25%	51.25%	54.92%	
Education categories				***				***
Low education	31.6%	38.81%	29.25%		45.15%	32.18%	48.04%	
Medium education	40.28%	39.00%	40.62%		30.11%	35.55%	28.90%	
High education	25.96%	18.28%	28.00%		18.09%	30.67%	15.28%	
Marital status categories				***				***
Non-single	75.11%	69.20%	76.68%		64.95%	68.69%	64.11%	
Never married	6.90%	8.22%	6.54%		4.01%	4.53%	3.90%	
Separated, divorced or widowed	17.12%	21.59%	15.93%		29.01%	25.26%	29.85%	
Mean (SD) Log-household income	10.33 (1.11)	10.09 (1.09)	10.39 (1.11)	***	10.12 (1.05)	10.42 (0.91)	10.05 (1.07)	***
Chronic lung disease	5.04%	11.72%	3.27%	***	7.36%	5.59%	7.75%	***
Cancer	3.92%	8.86%	2.61%	***	6.48%	6.63%	6.45%	
Ulcer	3.51%	7.19%	2.54%	***	4.12%	3.67%	4.23%	***
Heart attack	5.90%	14.15%	3.71%	***	15.96%	13.37%	16.54%	***

Table 4.1: (continued)

Variables	Whole sample (N = 53,631)	Afraid health limits work (N = 11,259)	Not afraid health limits work (N = 42,372)	Univariate analysis	Whole sample (N = 45,384)	Formal volunteering (N = 8,281)	No formal volunteering (N = 37,103)	Univariate analysis
Hypertension	29.96%	38.61%	27.66%	***	45.70%	40.45%	46.87%	***
Stroke	2.09%	6.32%	0.97%	***	4.99%	3.21%	5.38%	***
Hip fracture	0.96%	2.42%	0.58%	***	2.89%	2.11%	3.07%	***
Mobility problems					59.57%	47.06%	62.36%	***
Countries				***				***
Austria	8.74%	6.79%	9.26%		9.36%	9.12%	9.42%	
Germany	8.27%	11.16%	7.51%		7.07%	8.21%	6.81%	
Sweden	5.91%	5.90%	5.92%		9.16%	9.01%	9.19%	
The Netherlands	8.23%	9.06%	8.01%		7.38%	14.79%	5.72%	
Spain	9.20%	8.66%	9.35%		12.32%	2.54%	14.51%	
Italy	8.72%	5.38%	9.61%		9.83%	5.77%	10.73%	
France	10.92%	11.19%	10.85%		9.94%	11.65%	9.56%	
Denmark	8.19%	9.83%	7.76%		6.69%	10.34%	5.88%	
Switzerland	7.22%	4.09%	8.05%		6.78%	10.84%	5.87%	
Belgium	12.87%	13.84%	12.61%		10.54%	13.42%	9.90%	
Czech Republic	11.73%	14.10%	11.09%		10.93%	4.31%	12.41%	

Table 4.1: (continued)

Variables	Whole sample (N = 53,631)	Afraid health limits work (N = 11,259)	Not afraid health limits work (N = 42,372)	Univariate analysis	Whole sample (N = 45,384)	Formal volunteering (N = 8,281)	No formal volunteering (N = 37,103)	Univariate analysis
Waves								
Wave 2 (years 2006/07)	16.39%	16.57%	16.35%		13.58%	12.23%	13.88%	
Wave 4 (year 2010)	36.78%	36.33%	36.89%		32.79%	36.00%	32.08%	
Wave 5 (year 2013)	46.83%	47.09%	46.76%		53.63%	51.77%	54.04%	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Comparison of means tests cluster observations at the individual level in case of being afraid health limits work and at the household level in case of formal volunteering.

Table 4.2: Country specific data, by outcome

Countries	Whole sample		Afraid health limits work		Univariate analysis	Formal volunteering		Univariate analysis
	N	Diabetes prevalence N(%)	N	Diabetes prevalence N(%)		N	Diabetes prevalence N(%)	
Austria	8,934	1,030 (11.53%)	4,686	447 (9.54%)	***	4,248	583 (13.72%)	**
Germany	7,645	1,005 (13.15%)	4,437	434 (9.78%)	***	3,208	571 (17.80%)	***
Sweden	7,327	766 (10.45%)	3,171	253 (7.98%)	***	4,156	513 (12.34%)	
The Netherlands	7,763	765 (9.85%)	4,414	359 (8.13%)	***	3,349	406 (12.12%)	***
Spain	10,530	1,674 (15.90%)	4,936	511 (10.35%)	**	5,594	1,163 (20.79%)	***
Italy	9,136	1,089 (11.92%)	4,676	391 (8.36%)	***	4,460	698 (15.65%)	***
France	10,366	1,144 (11.04%)	5,856	538 (9.19%)	***	4,510	606 (13.44%)	***
Denmark	7,433	557 (7.49%)	4,395	229 (5.21%)	***	3,038	328 (10.80%)	***
Switzerland	6,946	459 (6.61%)	3,870	196 (5.06%)	***	3,076	263 (8.55%)	***
Belgium	11,684	1,197 (10.24%)	6,901	594 (8.61%)	***	4,783	603 (12.61%)	***
Czech Republic	11,251	1,912 (16.99%)	6,289	775 (12.32%)	***	4,962	1,137 (22.91%)	***
Overall sample	99,015	11,575 (11.69%)	53,631	4,344 (8.81%)	-	45,384	6,871 (15.14%)	-

*** $p<0.01$, ** $p<0.05$.

Comparison of means tests cluster observations at the individual level in case of being afraid health limits work and at the household level in case of formal volunteering.

4.4.2 Results from the multivariate regressions

<u>Being afraid health limits work</u>

Table 4.3 and Table 4.5 report the results for the overall sample for the outcome "being afraid health limits work", showing the coefficients and the average marginal effects. Having diabetes significantly increases the risk of being afraid health limits work, although its coefficient drops from 0.902 in Model A to 0.704 in Model B, when the regression is adjusted for clinical complications (Columns 1 and 3, Table 4.3). Stroke and hip fracture are the main complications increasing the likelihood of reporting being afraid health limits work.

Looking at the marginal effect of diabetes, I see that having diabetes increases the probability of reporting being afraid by 11.6 percentage points in Model B (4th Column, Table 4.3), slightly decreasing from Model A (2nd Column, Table 4.3), when its marginal effect without diabetes-related complications included is 16.2 percentage points. Moreover, the relevance of diabetes and its comorbidities is shown in Table 4.5, which shows the average marginal effect of each specific complication together with diabetes compared to not suffering from any of them. The greatest burden of the listed complications, jointly with diabetes, is given by cancer and heart attack (Average Marginal Effect 0.157 in both cases, Model B).

In addition, regarding the time variables, waves 4 and 5 emerge as significant variables in both regression models, A and B (Table 4.3). Being in the year 2010 increases the probability of reporting being afraid by 11 percentage points in both regression models (Column 2 and 4, Table 4.3), whereas living in the year 2013 increases such probability by 10.2 in Model A (2nd Column, Table 4.3), but 13.4 percentage points in Model B (4th Column, Table 4.3), with respect to wave 2, that is, year 2006/07. Besides, the interaction between diabetes and wave 4 is significant and positively associated with the outcome, increasing the probability of the fear by 12.7 percentage points (6th column, Table 4.3). Contrariwise, the interaction between diabetes and wave 5 is not significant. Moreover, if one looks at the p-value of the Wald test (Table 4.4) comparing the model with interactions to the model B, it lies below the 5% level of significance, meaning that the diabetes and time dummies are jointly significant and Model C is the model that better fits the data. This results is supported by the AIC coefficient, but not by BIC, which suggests that the best model would be Model B.

Some differences can also be observed across countries. Denmark is the only country reporting a positive association with the outcome, meaning that the Danish subsample is more afraid health limits the amount or type of work they can do then the German population, which is the reference category (average marginal effect, 0.0134 in Model C, Table 4.3). However, the effect of Denmark is not significant. On the other hand, living in Italy reduces the risk of being

afraid health limits work the most (average marginal effect, -0.168, Model C, Table 4.3), compared to Germany.

In model A, higher education, being non-single and higher income are the set of socioeconomic factors that significantly reduce the likelihood of reporting feeling the fear of health limiting their work. On the other hand, increasing age is a significant predictor of the outcome, but with opposite sign depending on the age group. In the age group closest to retirement, the average marginal effect of belonging to such group age is negative, signaling a lower probability of being afraid health limits work. A similar trend is followed in model B, being a woman also significant.

Formal volunteering: charity work

Table 4.6 and Table 4.8 report the results for the overall sample for the outcome "formal volunteering: charity work". Having diabetes significantly reduces the probability of being a formal volunteer, increasing its marginal effect from − 3.33 in Model A to − 2.69 percentage points in Model B, when the regression is adjusted for clinical complications and mobility problems (2nd and 4th Column, Table 4.6). Actually, stroke and mobility problems are the main complications that significantly reduce the most the probability of doing charity work. Moreover, the relevance of diabetes and its comorbidities is shown in Table 4.8. Comorbidities and mobility problems reduce its negative marginal effect when, in addition, respondents have diabetes.

In addition, both time variables are always significant across regression models, increasing the magnitude of its coefficient when all clinical and mobility problems are included (coefficient 0.431 in Model A and 0.406 in Model B in case of wave 4 and 0.362 in Model A and 0.287 in Model B in case of wave 5, Table 4.6). Actually, their average marginal effects on the outcome are 0.0562 and 0.0382 for wave 4 and 5, respectively, in Model B (4th Column, Table 4.6), increasing the likelihood of doing charity work. Furthermore, the interactions between diabetes and time are negatively associated with the outcome, but not significantly. Moreover, if we look at the p-value of the Wald test comparing Model B with Model C (Table 4.7), we see it is far above the 10% level of significance, meaning that the interactions are not jointly significant. The test suggests that Model B seems to be the best to explain the association between the set of explanatory variables and the outcome. Same conclusion is reached when looking at the AIC and BIC values.

Some differences can also be observed across countries. Southern countries, such as Italy and Spain report negative coefficients, signaling that living in any of these countries reduces the probability of being a formal volunteer, in comparison to Germany, the reference category, as well as in Austria, Sweden or the Czech Republic. The rest of the countries included in the analysis report positive coefficients.

In model A, increasing age, being woman, lower education and having a couple are the control variables that significantly reduce the likelihood of doing charity work. On the other hand, higher income is a significant predictors of the outcome, indicating that higher income is associated with a higher probability of being a formal volunteer. The same pattern holds in Model B.

Table 4.A2 in Appendix also shows that diabetes significantly reduces the amount of formal volunteering provided. The probability of not doing any amount of formal volunteer is increased by 2.50 percentage points if the individual has diabetes and this disease reduces the likelihood of doing charity work daily, weekly or less often than that by 0.6, 1.33 and 0.6 percentage points, respectively.

Table 4.3: Results from the logit regressions regarding the fear of health limiting work for the overall sample

VARIABLES	Coefficients Model A	Average marginal effects Model A	Coefficients Model B	Average marginal effects Model B	Coefficients Model C	Average marginal effects Model C
Diabetes	0.902***	0.162***	0.704***	0.116***	0.643***	0.101***
	(0.0410)	(0.00839)	(0.0433)	(0.00802)	(0.0836)	(0.00609)
Diabetes # Wave4					0.158**	0.127**
					(0.0784)	(0.0109)
Diabetes # Wave5					0.00970	0.111
					(0.0951)	(0.0095)
Age 55 to 60	0.0982***	0.0148***	0.0665**	0.00951**	0.0664**	0.00950**
	(0.0286)	(0.00432)	(0.0293)	(0.00419)	(0.0293)	(0.00419)
Age 60 to 65	-0.0220	-0.00332	-0.119***	-0.0171***	-0.119***	-0.0171***
	(0.0317)	(0.00478)	(0.0326)	(0.00467)	(0.0326)	(0.00466)
Female	0.0112	0.00168	0.101***	0.0144***	0.101***	0.0144***
	(0.0281)	(0.00424)	(0.0289)	(0.00410)	(0.0289)	(0.00413)
Low education	0.307***	0.0477***	0.277***	0.0406***	0.277***	0.0396***
	(0.0335)	(0.00535)	(0.0341)	(0.00515)	(0.0341)	(0.00488)
High education	-0.465***	-0.0662***	-0.437***	-0.0593***	-0.437***	-0.0625***
	(0.0382)	(0.00508)	(0.0388)	(0.00497)	(0.0388)	(0.00553)
Non-single	-0.273***	-0.0427***	-0.245***	-0.0362***	-0.245***	-0.0351***
	(0.0359)	(0.00580)	(0.0368)	(0.00560)	(0.0368)	(0.00526)
Never married	0.00916	0.00138	0.0413	0.00596	0.0410	0.00587
	(0.0591)	(0.00895)	(0.0606)	(0.00883)	(0.0606)	(0.00868)
Log-household income	-0.170***	-0.0256***	-0.164***	-0.0234***	-0.164***	-0.0234***
	(0.0194)	(0.00292)	(0.0196)	(0.00280)	(0.0196)	(0.00280)
Chronic lung disease	1.209***	0.232***	1.093***	0.195***	1.094***	0.156***
	(0.0505)	(0.0112)	(0.0528)	(0.0110)	(0.0528)	(0.00741)
Cancer	1.301***	0.252***	1.281***	0.235***	1.282***	0.183***
	(0.0551)	(0.0123)	(0.0577)	(0.0123)	(0.0577)	(0.00808)
Ulcer			0.828***	0.141***	0.828***	0.118***
			(0.0617)	(0.0121)	(0.0618)	(0.00878)
Heart attack			1.170***	0.212***	1.170***	0.167***
			(0.0502)	(0.0106)	(0.0502)	(0.00699)
Hypertension			0.253***	0.0373***	0.253***	0.0362***
			(0.0295)	(0.00445)	(0.0295)	(0.00421)
Stroke			1.639***	0.316***	1.639***	0.234***
			(0.0833)	(0.0184)	(0.0832)	(0.0117)
Hip fracture			1.378***	0.257***	1.379***	0.197***
			(0.112)	(0.0243)	(0.112)	(0.0159)
Austria	-0.787***	-0.0997***	-0.822***	-0.0986***	-0.821***	-0.117***
	(0.0650)	(0.00674)	(0.0676)	(0.00663)	(0.0676)	(0.00964)
Sweden	-0.308***	-0.0433***	-0.283***	-0.0380***	-0.283***	-0.0404***
	(0.0722)	(0.00939)	(0.0744)	(0.00935)	(0.0743)	(0.0106)
The Netherlands	-0.318***	-0.0448***	-0.271***	-0.0366***	-0.270***	-0.0387***
	(0.0666)	(0.00868)	(0.0679)	(0.00864)	(0.0679)	(0.00970)
Spain	-0.747***	-0.0958***	-0.677***	-0.0842***	-0.677***	-0.0968***
	(0.0649)	(0.00692)	(0.0655)	(0.00699)	(0.0655)	(0.00936)
Italy	-1.204***	-0.138***	-1.174***	-0.130***	-1.174***	-0.168***
	(0.0707)	(0.00585)	(0.0716)	(0.00590)	(0.0715)	(0.0102)
France	-0.422***	-0.0584***	-0.389***	-0.0516***	-0.388***	-0.0555***
	(0.0603)	(0.00760)	(0.0616)	(0.00753)	(0.0616)	(0.00881)
Denmark	0.0633	0.00967	0.0937	0.0137	0.0934	0.0134
	(0.0642)	(0.00994)	(0.0654)	(0.00973)	(0.0654)	(0.00936)

Table 4.3: (continued)

VARIABLES	Coefficients Model A	Average marginal effects Model A	Coefficients Model B	Average marginal effects Model B	Coefficients Model C	Average marginal effects Model C
Switzerland	-0.934***	-0.113***	-0.858***	-0.101***	-0.856***	-0.123***
	(0.0780)	(0.00726)	(0.0788)	(0.00744)	(0.0788)	(0.0113)
Belgium	-0.315***	-0.0447***	-0.333***	-0.0447***	-0.332***	-0.0474***
	(0.0580)	(0.00771)	(0.0595)	(0.00749)	(0.0595)	(0.00850)
Czech Republic	-0.567***	-0.0762***	-0.604***	-0.0767***	-0.603***	-0.0863***
	(0.0616)	(0.00730)	(0.0628)	(0.00702)	(0.0628)	(0.00898)
Wave 4 (2010)	0.0691***	0.0105***	0.0770***	0.0111***	0.0569**	0.0109***
	(0.0245)	(0.00373)	(0.0252)	(0.00363)	(0.0268)	(0.00359)
Wave 5 (2013)	0.0678**	0.0102**	0.0933***	0.0134***	0.0911***	0.0132***
	(0.0311)	(0.00469)	(0.0320)	(0.00457)	(0.0340)	(0.00455)
N (Observations)	53,631	53,631	53,631	53,631	53,631	53,631
N (Clusters)	34,393	34,393	34,393	34,393	34,393	34,393
Log pseudolikelihood	-25,349.102		-24,289.654		-24,287.479	
Wald chi²	2,773.22		3,627.48		3,634.48	
Prob > chi²	0.000		0.000		0.000	

Clustered standard errors at individual level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Reference categories: age 50 to 55, medium education, being separated/divorced/widowed, Germany and wave 2 (year 2006/07).

Model A includes diabetes, sociodemographic characteristics (age, gender, education, marital status and household income), and non-diabetes related complications (chronic lung disease and cancer). Model B adds to the previous model diabetes-related clinical complications: ulcer, heart attack, hypertension, stroke and hip fracture. Model C includes the above variables and the interactions between the main disease of interest, diabetes, and the time variables, wave 4 (year 2010) and wave 5 (year 2013).

Table 4.4: Wald test for the outcome "being afraid health limits work"

	χ²	Prob > χ²	AIC	BIC
Model B vs Model A	177.29	0.0000	-	-
Model C vs Model B	6.88	0.0321	-	-
Model A	-	-	50,746.2	50,959.56
Model B	-	-	48,637.31	48,895.11
Model C	-	-	48,636.96	48,912.54

Table 4.5: Average marginal effects of clinical and functional complications if individuals have diabetes from the logistic regressions

VARIABLES	Average marginal effects Model A	Average marginal effects Model B	Average marginal effects Model C
No chronic lung disease	0.161***	0.115***	0.0992***
	(0.00839)	(0.00799)	(0.00600)
Chronic lung disease	0.208***	0.156***	0.149***
	(0.00916)	(0.00977)	(0.00906)
No cancer	0.161***	0.115***	0.0991***
	(0.00838)	(0.00798)	(0.00600)
Cancer	0.206***	0.157***	0.153***
	(0.00898)	(0.00963)	(0.00930)
No ulcer		0.116***	0.0998***
		(0.00799)	(0.00604)
Ulcer		0.150***	0.139***
		(0.00973)	(0.00867)
No heart attack		0.115***	0.0990***
		(0.00797)	(0.00600)
Heart attack		0.157***	0.151***
		(0.00972)	(0.00911)
No hypertension		0.113***	0.0973***
		(0.00791)	(0.00598)
Hypertension		0.125***	0.110***
		(0.00840)	(0.00654)
No stroke		0.116***	0.100***
		(0.00803)	(0.00608)
Stroke		0.154***	0.157***
		(0.00919)	(0.00947)
No hip fracture		0.116***	0.100***
		(0.00801)	(0.00607)
Hip fracture		0.156***	0.154***
		(0.00943)	(0.00941)
N (Observations)	53,631	53,631	53,631

Clustered standard errors at individual level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The coefficient on not having each disease denotes the individual effect of having diabetes on the outcome. The coefficient on having each disease represents the jointly effect of having diabetes and each condition on the probability of being afraid health limits work.

Table 4.6: Results from the logit regressions on formal volunteering for the overall sample

VARIABLES	Coefficients Model A	Average marginal effects Model A	Coefficients Model B	Average marginal effects Model B	Coefficients Model C	Average marginal effects Model C
Diabetes	-0.261***	-0.0333***	-0.209***	-0.0269***	-0.177	-0.0279***
	(0.0486)	(0.00587)	(0.0491)	(0.00605)	(0.126)	(0.00660)
Diabetes # Wave4					-0.0319	-0.0017
					(0.129)	(0.0083)
Diabetes # Wave5					-0.0386	-0.0398
					(0.130)	(0.0062)
Age 70 to 75	-0.106***	-0.0142***	-0.080**	-0.011**	-0.080**	-0.011**
	(0.0339)	(0.0045)	(0.0341)	(0.0046)	(0.0341)	(0.0046)
Age 75 to 80	-0.361***	-0.048***	-0.310***	-0.041***	-0.310***	-0.041***
	(0.0435)	(0.0058)	(0.0443)	(0.0059)	(0.0443)	(0.0059)
Age 80 to 85	-0.853***	-0.114***	-0.773***	-0.103***	-0.773***	-0.103***
	(0.0572)	(0.0076)	(0.0584)	(0.0077)	(0.0584)	(0.0077)
Age 85 to 90	-1.199***	-0.161***	-1.094***	-0.146***	-1.094***	-0.146***
	(0.2068)	(0.0123)	(0.0935)	(0.0124)	(0.0935)	(0.0124)
Age 90+	-1.781***	-0.239***	-1.668***	-0.223***	-1.668***	-0.223***
	(0.2068)	(0.0277)	(0.2076)	(0.0277)	(0.2076)	(0.0277)
Female	-0.0290	-0.00388	0.0125	0.00167	0.0125	0.00167
	(0.0302)	(0.00405)	(0.0311)	(0.00415)	(0.0311)	(0.00415)
Low education	-0.278***	-0.0369***	-0.273***	-0.0362***	-0.273***	-0.0365***
	(0.0403)	(0.00530)	(0.0404)	(0.00529)	(0.0404)	(0.00539)
High education	0.475***	0.0688***	0.459***	0.0660***	0.459***	0.0613***
	(0.0427)	(0.00662)	(0.0428)	(0.00659)	(0.0428)	(0.00569)
Non-single	-0.0192	-0.00258	-0.0248	-0.00332	-0.0248	-0.00331
	(0.0404)	(0.00544)	(0.0405)	(0.00543)	(0.0405)	(0.00541)
Never married	0.154*	0.0214*	0.163*	0.0226*	0.163*	0.0218*
	(0.0860)	(0.0124)	(0.0863)	(0.0124)	(0.0863)	(0.0115)
Log-household income	0.110***	0.0147***	0.104***	0.0140***	0.104***	0.0140***
	(0.0175)	(0.00234)	(0.0175)	(0.00233)	(0.0175)	(0.00233)
Chronic lung disease	-0.299***	-0.0374***	-0.236***	-0.0299***	-0.235***	-0.0315***
	(0.0604)	(0.00704)	(0.0609)	(0.00730)	(0.0609)	(0.00814)
Ulcer			0.0733	0.00996	0.0735	0.00982
			(0.0737)	(0.0102)	(0.0737)	(0.00984)
Heart attack			-0.00411	-0.000549	-0.00418	-0.000559
			(0.0418)	(0.00557)	(0.0418)	(0.00558)
Hypertension			-0.0345	-0.00460	-0.0345	-0.00461
			(0.0310)	(0.00413)	(0.0310)	(0.00414)
Stroke			-0.289***	-0.0360***	-0.289***	-0.0386***
			(0.0747)	(0.00864)	(0.0747)	(0.00998)
Hip fracture			-0.0348	-0.00461	-0.0348	-0.00464
			(0.0905)	(0.0119)	(0.0905)	(0.0121)
Mobility problems			-0.255***	-0.0344***	-0.255***	-0.0340***
			(0.0352)	(0.00481)	(0.0352)	(0.00470)
Austria	-0.227***	-0.0291***	-0.229***	-0.0292***	-0.229***	-0.0306***
	(0.0786)	(0.00959)	(0.0788)	(0.00958)	(0.0788)	(0.0105)
Sweden	-0.188**	-0.0243**	-0.207**	-0.0265***	-0.207**	-0.0277**
	(0.0820)	(0.0102)	(0.0823)	(0.0101)	(0.0824)	(0.0110)
The Netherlands	0.924***	0.148***	0.886***	0.141***	0.886***	0.118***
	(0.0783)	(0.0144)	(0.0784)	(0.0142)	(0.0784)	(0.0104)
Spain	-1.571***	-0.144***	-1.588***	-0.145***	-1.588***	-0.212***
	(0.108)	(0.00611)	(0.109)	(0.00607)	(0.109)	(0.0145)
Italy	-0.509***	-0.0612***	-0.506***	-0.0607***	-0.506***	-0.0676***
	(0.0912)	(0.00969)	(0.0912)	(0.00969)	(0.0912)	(0.0122)

Table 4.6: (continued)

VARIABLES	Coefficients Model A	Average marginal effects Model A	Coefficients Model B	Average marginal effects Model B	Coefficients Model C	Average marginal effects Model C
France	0.197**	0.0274**	0.189**	0.0262**	0.189**	0.0253**
	(0.0784)	(0.0113)	(0.0786)	(0.0113)	(0.0786)	(0.0105)
Denmark	0.353***	0.0509***	0.323***	0.0461***	0.323***	0.0431***
	(0.0828)	(0.0128)	(0.0829)	(0.0126)	(0.0829)	(0.0111)
Switzerland	0.400***	0.0582***	0.363***	0.0522***	0.362***	0.0484***
	(0.0807)	(0.0126)	(0.0810)	(0.0125)	(0.0810)	(0.0108)
Belgium	0.228***	0.0319***	0.231***	0.0322***	0.231***	0.0309***
	(0.0774)	(0.0113)	(0.0777)	(0.0113)	(0.0777)	(0.0104)
Czech Republic	-1.067***	-0.113***	-1.057***	-0.111***	-1.057***	-0.141***
	(0.0885)	(0.00702)	(0.0887)	(0.00707)	(0.0887)	(0.0119)
Wave 4 (2010)	0.431***	0.0599***	0.406***	0.0562***	0.409***	0.0542***
	(0.0397)	(0.00567)	(0.0398)	(0.00565)	(0.0418)	(0.00530)
Wave 5 (2013)	0.362***	0.0482***	0.287***	0.0382***	0.291***	0.0382***
	(0.0518)	(0.00679)	(0.0529)	(0.00695)	(0.0540)	(0.00703)
N (Observations)	45,384	45,384	45,384	45,384	45,384	45,384
N (Clusters)	18,647	18,647	18,647	18,647	18,647	18,647
Log pseudolikelihood	-19,224.709		-19,035.365		-19,035.274	
Wald chi²	2,262.79		2,437.11		2,439.53	
Prob > chi²	0.000		0.000		0.000	

Clustered standard errors at household level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Reference categories: age 65 to 70, medium education, being separated/divorced/widowed, Germany and wave 2 (year 2006/07).

Model A includes diabetes, sociodemographic characteristics (age, gender, education, marital status and household income), and non-diabetes related complications (chronic lung disease). Model B adds to the previous model diabetes-related clinical complications: ulcer, heart attack, hypertension, stroke, hip fracture and mobility problems. Model C includes the above variables and the interactions between the main disease of interest, diabetes, and the time variables, wave 4 (year 2010) and wave 5 (year 2013).

Table 4.7: Wald test for the outcome "formal volunteering: charity work"

	χ²	Prob > χ²	AIC	BIC
Model B vs Model A	168.73	0.0000	-	-
Model C vs Model B	0.21	0.8998	-	-
Model A	-	-	38,550.6	38,777.39
Model B	-	-	38,439.91	38,719.04
Model C	-	-	38,443.83	38,740.41

Table 4.8: Average marginal effects of clinical and functional complications if individuals have diabetes from the logistic regressions

VARIABLES	Average marginal effects Model A	Average marginal effects Model B	Average marginal effects Model C
No chronic lung disease	-0.0333***	-0.0272***	-0.0281***
	(0.00817)	(0.00611)	(0.00666)
Chronic lung disease	-0.0290***	-0.0238***	-0.0248***
	(0.00723)	(0.00540)	(0.00594)
No ulcer		-0.0269***	-0.0278***
		(0.00604)	(0.00659)
Ulcer		-0.0279***	-0.0289***
		(0.00637)	(0.00691)
No heart attack		-0.0269***	-0.0279***
		(0.00605)	(0.00660)
Heart attack		-0.0269***	-0.0278***
		(0.00607)	(0.00662)
No hypertension		-0.0271***	-0.0281***
		(0.00608)	(0.00664)
Hypertension		-0.0266***	-0.0276***
		(0.00602)	(0.00657)
No stroke		-0.0271***	-0.0281***
		(0.00610)	(0.00665)
Stroke		-0.0230***	-0.0240***
		(0.00525)	(0.00578)
No hip fracture		-0.0269***	-0.0279***
		(0.00605)	(0.00660)
Hip fracture		-0.0264***	-0.0274***
		(0.00609)	(0.00663)
No mobility problems		-0.0291***	-0.0300***
		(0.00654)	(0.00711)
Mobility problems		-0.0254***	-0.0263***
		(0.00570)	(0.00626)
N (Observations)	45,384	45,384	45,384

Clustered standard errors at household level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The coefficient on not having each disease denotes the individual effect of having diabetes on the outcome. The coefficient on having each disease represents the jointly effect of having diabetes and each condition on the probability of being a formal volunteer

4.5 DISCUSSION

In this analysis, I aim to assess the relationship between diabetes and productivity using European data for three different periods around the financial crisis. I use two measures of productivity, depending on age: for those in their working age, that is, from 50 to 65 years old, I have employed being afraid health limited their work as the outcome; and for the individuals above 65, I have modelled productivity through volunteering activities.

This study shows that diabetes increases the likelihood people aged 50 to 65 years old report being afraid health limits work by 16 percentage points, falling to 12, after controlling for clinical complications, suggesting a positive relationship between diabetes and the fear of health limiting work in people still in the working age. In addition, my results suggest that the fear of health limiting work increases during the years after the crisis, 2010 and 2013, with respect to the time before the crisis, 2006, even after including clinical complications. This could reflect the increased uncertainty of the employment situation after the economic crisis. In my third hypothesis, I expected that the fear of health limiting work of people in the working age and diabetes was higher in the years 2010 and 2013, compared to 2006. My hypothesis is only confirmed in case of the interaction between diabetes and year 2010, increasing the probability of being afraid by 13 percentage points, but no significant results are found for 2013. This result might be driven by the combination of the impairing effect of diabetes together with the fact that the economic crisis hit stronger in the early years of the crisis, leading to a greater fear of limiting the individual´s performance at work.

Regarding volunteering in people older than 65 years old, it is shown that having diabetes reduces the likelihood of performing volunteering work by about 3 percentage points in comparison to those people without diabetes, as well as it reduces the frequency of carrying out such activity. Year 2010 increases the probability of doing charity work by 6 percentage points, which is larger than the average marginal effect of the year 2013, 4 percentage points, even after adjusting by clinical complications and mobility problems. The rationale behind such increase might be greater solidarity or greater need for charity work rather than the individual willingness to be productive. Finally, my results do not support the last hypothesis about the joint effect of having diabetes in people aged 65 and above in the year 2010 and 2013 on doing charity work.

Moreover, some differences have been observed across countries. With regards to the first outcome, only Denmark reports to increase the likelihood of being afraid health limits the amount or type of work one can do in comparison to Germany, although not significantly, whereas a negative association between Italy, Spain, Austria, Sweden and the Czech Republic and volunteering is displayed, also compared to the German population. However, these differences

should be interpreted with caution in case of both outcomes in addition to the potential differences existing in their reporting styles (Jürges, 2007): with regards to the former, a reporting bias could be present in this analysis due to the culture and the specific characteristics of each country; and also regarding the second outcome, since it has been shown that, especially in Southern countries (OECD, 2013), the frequency of volunteering has increased more than in other areas, but maybe not the amount of people doing so.

Therefore, the results about the first outcome support those obtained by Tunceli et al. in 2005, though I use a different outcome measure. The main driver behind the difference in size of the effects can be the subjective feature of the outcome used in this chapter, being afraid health limits work, compared to the objective character of the question used by Tunceli et al. (2005), whether the individuals had any impairments or health problems that limited work. Hence, latter respondents report actual health problems that impair work, whereas former individuals report their personal perceptions. Moreover, this variation can also stem from the increase in diabetes prevalence or from the difference in the composition of the sample and the time selection. Tunceli et al. in 2005 used US data from 7,055 respondents from 1992 to 1994 and the results presented here are driven by 34,393 individuals from 2006 to 2013. Another explanation could be the different reporting style between the United States and some countries, such as Europe, as the literature has already shown (Kapteyn et al., 2007). Moreover, the results regarding volunteering activities and diabetes confirm the findings of the American Diabetes Association (2008), who included volunteering within the productivity measure of those not in the labour force. However, the single analysis between diabetes and volunteering is not available in the published document, so I cannot compare the magnitude of my results to theirs.

Some limitations should also be mentioned. First of all, my measure of productivity for those in the workforce does not include the number of days lost due to health or reduced productivity at work, which are the most common measures of productivity losses. Such kind of information is not available in the dataset used, so I take being afraid health limits work as one of the main outcomes in the study, which, as it is subjective, can be very sensitive to changes in individual's situation. Individual perception about his/her ability to perform some activities due to health problems has previously been used in the literature (Disney et al., 2006). Authors aimed to assess the relationship between health and retirement in the United Kingdom. They built their health main measure from two different health-related measures: having certain health problems and difficulties, and feeling that their health limits their ability to perform certain daily activities. The latter is a close measure to the subjective outcome I use in the analysis, which supports the use of individual's feelings together with other more objective health measures. However, the

interpretation of the results in the current analysis could lead to lower or higher productivity. For example, it is clear that if individual health gets worse, being diagnosed of diabetes in this case, the fear of health limiting work is going to increase and also productivity decreases due to health problems. However, when interpreting the association between the time variables and the outcome, an increase of the fear could also result in higher productivity so as to prove that the individual should not be fired. Second, I could not obtain information on other types of volunteering, care for family or informal care, which are available in wave 2, but some changes have been made to the question in wave 4. So, I could only stick to the most strict definition of volunteering, which refers to charity work (Börsch-Supan et al., 2005). Thirdly, due to data restrictions, I exclude seven countries from the analysis from the nineteen countries that SHARE provides information from[23]. However, the results reported in this study are still accurate since I include a representative sample of the European population. Finally, the self-reported feature of the data, especially health conditions, could bias the results, as it could lead to recall bias and, hence, the results here could over or underestimate the true impact of diabetes. Nevertheless, there are several findings showing the reliability of data from health conditions collected using self-reporting information (Dal Grande et al., 2012; Goebeler et al., 2007).

The results contribute to the literature in three ways: First, much has been written regarding the association between diabetes and number of days lost due to health reasons or reduced productivity at work, but little is known about the relationship with being afraid health limits work and non-paid productivity measures, such as volunteering. Second, not all the existing studies have included diabetes-related clinical and functional complications. Actually, one study showed that, by excluding those, one could underestimate the impact of diabetes (Norlund et al., 2001). Finally, I have also assessed the influence of uncertain economic periods, which has not been done before, and its association with both productivity alone and jointly with diabetes. While three waves is a relatively modest number, the observed patterns over the years 2006, 2010 and 2013 are suggestive for the effect of an uncertain economic situation on both subjective (fear of health limiting work) and objective (volunteering participation) measures of the impact of diabetes on productivity. The results provide evidence that diabetes affects patients, employers, and society by contributing to work loss through work limitations and decreases in volunteering activities, even in unstable environments, such as the economic crisis that hit Europe recently. Moreover, the economic burden associated with diabetes is likely to increase as diabetes becomes more prevalent.

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[23] For example, Portugal and Greece, which were deeply hit by the debt crisis during the economic recession, were two of the countries excluded from the analysis.

APPENDIX CHAPTER 4

Table 4.A1: List of variables included in the analysis

Variable	Coding
Being afraid health limits work	1: respondent has been afraid health limited the kind or amount of work s/he did; 0: otherwise
Formal volunteering	1: respondent has done voluntary or charity work in the last month; 0: otherwise
Age 50 - 55	1: respondent's age lies between 50 and 55 years old; 0: otherwise
Age 56 – 60	1: respondent's age lies between 56 and 60 years old; 0: otherwise
Age 61 – 65	1: respondent's age lies between 61 and 65 years old; 0: otherwise
Age 66 – 70	1: respondent's age lies between 66 and 70 years old; 0: otherwise
Age 71 - 75	1: respondent's age lies between 71 and 75 years old; 0: otherwise
Age 76 – 80	1: respondent's age lies between 76 and 80 years old; 0: otherwise
Age 81 – 85	1: respondent's age lies between 81 and 85 years old; 0: otherwise
Age 86 - 90	1: respondent's age lies between 86 and 90 years old; 0: otherwise
Age 90+	1: respondent is older than 90; 0: otherwise
Female	1: female; 0: male
Low education	1: respondent had completed primary education or first stage of basic education and lower secondary or second stage of basic education; 0: otherwise
Medium education	1: respondent had completed (upper) secondary education and post-secondary non-tertiary education; 0: otherwise
High education	1: respondent had completed first and second stage of tertiary education; 0: otherwise
Non-single	1: married or with a registered partner; 0: otheriwse
Never married	1: never married; 0: otherwise
Separated, divorced or widowed	1: separated, divorced or widowed; 0: otherwise
Log household income	1: respondent's income is in the lowest quintile group; 0: otherwise
Chronic lung disease	1: respondent has any chronic lung disease; 0: otherwise
Cancer	1: respondent has cancer; 0: otherwise
Ulcer	1: respondent has an ulcer; 0: otherwise
Heart attack	1: respondent has had a heart attack; 0: otherwise
Hypertension	1: respondent has hypertension; 0: otherwise
Stroke	1: respondent has had a stroke; 0: otherwise
Hip fracture	1: respondent has had a hip fracture; 0: otherwise
Mobility problems	1: any number of mobility problems had been reported by the respondent; 0: otherwise
Austria	1: respondent lives in Austria; 0: otherwise
Germany	1: respondent lives in Germany; 0: otherwise
Sweden	1: respondent lives in Sweden; 0: otherwise

Table 4.A1: (continued)

Variable	Coding
The Netherlands	1: respondent lives in The Netherlands; 0: otherwise
Spain	1: respondent lives in Spain; 0: otherwise
Italy	1: respondent lives in Italy; 0: otherwise
France	1: respondent lives in France; 0: otherwise
Denmark	1: respondent lives in Denmark; 0: otherwise
Greece	1: respondent lives in Greece; 0: otherwise
Switzerland	1: respondent lives in Switzerland; 0: otherwise
Belgium	1: respondent lives in Belgium; 0: otherwise
Czech Republic	1: respondent lives in Czech Republic; 0: otherwise
Wave 2 (years 2006/07)	1: data was collected from wave 1; 0: otherwise
Wave 4 (year 2010)	1: data was collected from wave 2; 0: otherwise
Wave 5 (year 2013)	1: data was collected from wave 4; 0: otherwise

Table 4.A2: Average marginal effects from the ordered logit regression regarding frequency of formal volunteering for the overall sample

VARIABLES	Average marginal effects: no formal volunteering	Average marginal effects: less often than weekly	Average marginal effects: weekly	Average marginal effects: daily
Diabetes	0.0250***	-0.00602***	-0.0133***	-0.00568***
	(0.00645)	(0.00155)	(0.00344)	(0.00147)
Age 70 to 75	0.0069	-0.0017	-0.0037	-0.0016
	(0.0043)	(0.0010)	(0.0023)	(0.0010)
Age 75 to 80	0.0384***	-0.0093***	-0.0205***	-0.0087***
	(0.0056)	(0.0013)	(0.0030)	(0.0013)
Age 80 to 85	0.0979***	-0.0236***	-0.0522***	-0.0222***
	(0.0075)	(0.0019)	(0.0040)	(0.0018)
Age 85 to 90	0.1411***	-0.0340***	-0.0752***	0.0319***
	(0.0123)	(0.0030)	(0.0067)	(0.0029)
Age 90+	0.2419***	-0.0583***	-0.1289***	-0.0547***
	(0.0301)	(0.0074)	(0.0161)	(0.0071)
Female	-0.00187	0.000450	0.000996	0.000423
	(0.00397)	(0.000956)	(0.00212)	(0.000899)
Low education	0.0353***	-0.00850***	-0.0188***	-0.00799***
	(0.00525)	(0.00127)	(0.00281)	(0.00122)
High education	-0.0549***	0.0132***	0.0292***	0.0124***
	(0.00544)	(0.00133)	(0.00292)	(0.00130)
Non-single	0.00400	-0.000962	-0.00213	-0.000905
	(0.00521)	(0.00125)	(0.00278)	(0.00118)
Never married	-0.0180	0.00433	0.00957	0.00407
	(0.0115)	(0.00276)	(0.00611)	(0.00261)
Log-household income	-0.0121***	0.00291***	0.00645***	0.00274***
	(0.00223)	(0.000540)	(0.00119)	(0.000515)
Chronic lung disease	0.0276***	-0.00664***	-0.0147***	-0.00624***
	(0.00797)	(0.00193)	(0.00425)	(0.00182)
Ulcer	-0.00757	0.00182	0.00403	0.00171
	(0.00981)	(0.00236)	(0.00523)	(0.00222)
Heart attack	0.000967	-0.000233	-0.000515	-0.000219
	(0.00533)	(0.00128)	(0.00284)	(0.00121)
Hypertension	0.00723*	-0.00174*	-0.00385*	-0.00164*
	(0.00398)	(0.000959)	(0.00212)	(0.000904)
Stroke	0.0358***	-0.00862***	-0.0191***	-0.00811***
	(0.00974)	(0.00235)	(0.00520)	(0.00222)
Hip fracture	0.00756	-0.00182	-0.00403	-0.00171
	(0.0117)	(0.00282)	(0.00624)	(0.00265)
Mobility problems	0.0327***	-0.00788***	-0.0174***	-0.00741***
	(0.00452)	(0.00110)	(0.00242)	(0.00105)
Austria	0.0454***	-0.0109***	-0.0242***	-0.0103***
	(0.0101)	(0.00242)	(0.00536)	(0.00231)
Sweden	0.0289***	-0.00695***	-0.0154***	-0.00654***
	(0.0103)	(0.00248)	(0.00549)	(0.00234)
The Netherlands	-0.110***	0.0264***	0.0584***	0.0248***
	(0.00957)	(0.00234)	(0.00519)	(0.00229)
Spain	0.211***	-0.0507***	-0.112***	-0.0477***
	(0.0149)	(0.00373)	(0.00816)	(0.00362)
Italy	0.0622***	-0.0150***	-0.0332***	-0.0141***
	(0.0119)	(0.00288)	(0.00635)	(0.00269)
France	-0.0188*	0.00452*	0.01000*	0.00425*
	(0.0100)	(0.00242)	(0.00535)	(0.00228)

Table 4A2: (continued)

VARIABLES	Average marginal effects: no formal volunteering	Average marginal effects: less often than weekly	Average marginal effects: weekly	Average marginal effects: daily
Denmark	-0.0364***	0.00875***	0.0194***	0.00823***
	(0.0102)	(0.00247)	(0.00547)	(0.00233)
Switzerland	-0.0357***	0.00860***	0.0190***	0.00809***
	(0.0101)	(0.00243)	(0.00537)	(0.00228)
Belgium	-0.0257***	0.00619***	0.0137***	0.00582***
	(0.00990)	(0.00238)	(0.00527)	(0.00226)
Czech Republic	0.171***	-0.0412***	-0.0911***	-0.0387***
	(0.0124)	(0.00304)	(0.00675)	(0.00306)
Wave 4 (year 2010)	-0.0286***	0.00687***	0.0153***	0.00651***
	(0.00482)	(0.00117)	(0.00257)	(0.00111)
Wave 5 (year 2013)	-0.0130**	0.00312**	0.00694**	0.00296**
	(0.00652)	(0.00158)	(0.00347)	(0.00148)
Observations	45,384	45,384	45,384	45,384

Clustered standard errors at household level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Reference categories: age 65 to 70, medium education, being separated/divorced/widowed, Germany and wave 2 (year 2006/07).

Model includes diabetes, sociodemographic characteristics (age, gender, education, marital status and household income), non-diabetes related complications (chronic lung disease), a list of diabetes-related clinical complications (ulcer, heart attack, hypertension, stroke, hip fracture and mobility problems), dummy variables for countries and waves part of the analysis.

HEALTH-RELATED QUALITY OF LIFE AND DIABETES AMONG OLDER PEOPLE: THE KEY INFLUENCE OF CLINICAL COMPLICATIONS AND FRAILTY[24]

5.1 INTRODUCTION AND BACKGROUND

The number of adults suffering from diabetes mellitus (DM) has nearly doubled in the last thirty years, from 4.7% in 1980 to 8.5% in 2014 (OECD/EU, 2016) and these figures will keep increasing until 2030 (O'Shea et al., 2013; Wild et al., 2004). Especially relevant is the rise in the prevalence of type 2 DM (T2DM), which represents more than 90% of the diabetes diagnoses and mainly affects people aged 65 and older, whose diabetes prevalence is around 25% (Wild et al., 2004).

The existing literature has provided evidence on the negative impact that diabetes has on quality of life (Vadyia et al., 2015; Schunck et al., 2012; Papadopoulos et al., 2007; Rubin and Peyrot, 1999), being consistent across health-related quality of life (HRQoL) instruments (Kontodimopoulos et al., 2012; Fu et al., 2011).

Furthermore, people with diabetes are at greater risk of additionally suffering from cardiovascular diseases, such as heart attack or stroke (OECD/EU, 2016; Engelmann et al., 2016; Constantino et al., 2013); kidney failure (OECD/EU, 2016); foot ulcers that might lead to amputation (Lombardo et al., 2014; Chand et al., 2012; Group, 2000); and functional impairment, which is actually the main consequence of worse individuals' autonomy and quality of life among old people with diabetes (Sinclair et al., 2015). In this regard, Burden of Diabetes has been ranked as the seventh and eighth cause of years of life lost and Disability-Adjusted Life Years (DALYs)

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respectively in Western Societies (Murray and López, 2013) and the 14th cause all over the world in the ranking of causes of DALYs (Murray et al., 2012), accounting for 1.9% of total DALYs. So, when analysing the burden of diabetes in the elderly, disability should be taken into account.

Given the association between diabetes and the consequent development of the aforementioned complications, knowing the burden of diabetes and diabetes-related complications on health-related quality of life should be of great interest not only for those suffering from the disease, but also for policymakers and the society as a whole. Using data from the Toledo Study on Health Ageing (TSHA), a representative sample of Spanish old adults (Appendix, Table 5.A1), I analyse the impact that diabetes-related and non-related complications have on HRQoL of old people with diabetes, adding to the existing literature the inclusion of the frailty syndrome (FS). This syndrome has been found to worsen as age increases and to increase the risks of disability, hospitalization and mortality (Ensrud et al., 2009; Avila-Funes et al., 2008; Cawthon et al., 2007; Fried et al., 2001). Moreover, the joint burden of these complications on quality of life will be assessed.

The literature has widely analysed the impact of micro and macrovascular diseases in people with diabetes quality of life (Javanbakht et al., 2012; Redekop et al., 2002), concluding that the quality of life in people with diabetes is affected by complications and not by diabetes itself (Venkataraman et al., 2013). Within 1,348 T2DM European patients from the CODE-2 study whose most participants were older than 65 years old, suffering from micro or macrovascular diseases significantly reduced HRQoL, increasing its impact when the individual had both (Redekop et al., 2002). Using data from 2,601 individuals with mean age equal to 48 years old from Singapore, Venkataraman et al. (2013) concluded that people with diabetes and any of the micro or macrovascular complications included had lower HRQoL than the individuals solely with diabetes, being peripheral neuropathy the complication showing the greatest impact on quality of life. Other authors found that, within 356 Norwegians with T2DM and a mean age of 64 years old, neuropathy and stroke were the main complications reducing HRQoL (Solli et al., 2010). Another study including 1,141 US participants initially aged 13 to 39 years old reported that, after 23.5 years of follow-up, the clinical conditions that reported lower HRQoL scores were retinopathy, nephropathy and neuropathy (Jacobson et al., 2013). In a population of 6,317 US individuals with type 2 or type 1 diabetes aged 60 to 75 years old, congestive heart failure and myocardial infarction were the complications reducing the most physical HRQoL, whereas hypoglycaemia and congestive heart failure were associated with lower mental HRQoL (Laiteerapong et al., 2011).

However, little is known about the influence of chronic conditions, including functional impairment, on quality of life of people with diabetes when being evaluated together. Taking into account that older people have several diseases simultaneously, which is known as comorbidity, knowing how chronic conditions and frailty interact with respect to quality of life and other outcomes, such as disability (Verbrugge et al., 1989) or life expectancy (van Baal et al., 2006), would be of special relevance in the elderly. By doing so, I could assess whether diseases and conditions work independently or whether they interact synergistically to increase or reduce HRQoL. Some authors have already analysed the joint impact of suffering from diabetes and additional diseases on HRQoL (Banegas et al., 2007; Wee et al., 2005; Gaynes et al., 2002), but still, they do not estimate the joint effect of chronic diseases on people with diabetes, compared to people without diabetes.

In this study, the aim is to build on the existing literature by analysing the relationship between some factors that could determine the differences in HRQoL among people with and without diabetes, adding not only the clinical complications, but also the frailty syndrome as a measure of functional impairment. Moreover, their joint effect will be quantified.

The structure of the chapter is as follows. In Section 5.2, the data that has been used to run the analyses is presented, as well as the variables selected and the empirical methods used for the estimation of the determinants of HRQoL associated with diabetes and the clinical complications and the frailty syndrome. The results that have been obtained are presented in Section 5.3. Finally, a discussion of the results and the derived implications for policymakers are presented in Section 5.4, besides the limitations of the analysis.

5.2   DATA AND METHODS

5.2.1 Sample data

The analysis is run using data from the Toledo Study on Healthy Ageing (TSHA). TSHA is a population-based longitudinal study containing information of both institutionalized and community-dwelling people aged 65 and above living in the province of Toledo, Spain, composed by two cohorts. The first one includes the survivors of a previous study (the Toledo Study), which contained data among people aged 77 and older. The second cohort collected data from individuals 65-76 years of age who just joined the study. Subjects from both cohorts were randomly selected by a two-stage random sampling from the Toledo census, according to gender, age and town-size groups. The study sample included 24% of the population aged 65 and older living in Toledo. Selection of study participants (Figure 5.1) and data collection at baseline were

conducted from June 2006 to September 2009. Signed informed consent was obtained from all participants[25].

Figure 5.1: Participants flow of the Toledo Study of Healthy Ageing, first wave (García-García et al., 2011)
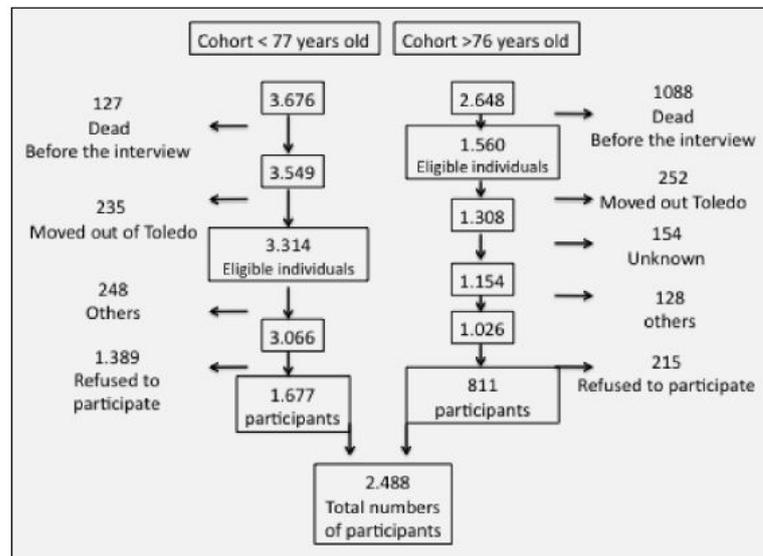
A second collection of data took place between 2011 and 2013, including 2,360 participants, from which 847 were new in the study. From the 2,488 participants in wave 1 (years 2006 – 2009), 1,513 took part in the second cohort, 452 died before the second interview took place, 193 did not want to participate in the second wave, 68 were not possible to contact and additional 40 individuals did want to be part of the study but did not finally do so.

Data was collected in three stages. In the first one, six psychologists conducted computed assisted interviews at the subjects' home. The questionnaires referred to background characteristics, social support, activities of daily living, HRQoL, clinical history, physical activity, and healthy lifestyle information, such as smoking and drinking habits, and depressive symptoms and an extensive neuropsychology assessment.

In the second stage, three nurses performed a physical examination and some clinical tests, also at the survey respondent's home. Nurses measured heart rate, blood pressure and anthropometry. They also made an electrocardiogram, a spirometry test, determined the ankle-brachial index, and evaluated physical performance (extremity strength, walking speed, balance and a sit-and-stand from chair). Nurses also evaluated cognition skills and inquired about urinary incontinence. Both the psychologists and nurses were trained specifically for this study.

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[25] The study was approved by the Clinical Research Ethics Committee of the Toledo Hospital.

In the third stage, study participants went to their health center to provide a fasting blood sample.

The study includes information about socioeconomic status (age, gender, country, marital status, education, etc.), family networks, health and functional status (self-perceived health, diagnoses, number of limitations in Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL); and frailty syndrome), quality of life and use of healthcare resources (being admitted to hospital, drugs use, etc.).

The data used for the purpose of this chapter includes 2933 observations, with information on 2156 individuals from the first two waves that are currently available: wave 1, whose data was collected from the years 2006 to 2009; and wave 2, which corresponds to the time period from 2011 to 2013.

5.2.2 Selection of variables

Outcome measure: Health-Related Quality of Life

Health-Related Quality of Life (HRQoL) is measured using the multi-attribute utility questionnaire known as EQ-5D-3L, which refers to five different dimensions: mobility, self-care, usual activities, pain or discomfort and anxiety or depression. Respondents answer whether they have experienced any problems in any of these dimensions according to three different levels: no problems; moderate or some problems; and severe or many problems.

The EQ-5D is a generic tool to measure HRQoL for both healthy individuals and for patients with several pathologies. The different health states as respondents indicate them on the EQ-5D questionnaire are given different values using country specific tariffs that have been previously obtained in separate studies in the general population using a valuation technique as it is the time trade-off (Herdman et al., 2001). Values range between 1 (best possible health state) and 0 (death), although negative values can be found, signalling health states worse than death.

Although there are some other instruments (Quality of Wellbeing Scale, Health Utilities Index), the EQ-5D is the only one that has been adapted and validated in Spain (Herdman et al., 2001). For the TSHA dataset, EQ-5D answers were translated into EQ-5D index utilities using the Spanish Time-Trade Off (TTO) tariffs (Herdman et al., 2001).

Independent variables

Diabetes is self-reported, but also checked with medical records and drugs use. So, in order to be classified as having diabetes, the first step is to having answered affirmatively to "Have you ever been told by a doctor that you suffer from diabetes?". Then, those answers are double checked with people who reported taking drugs for diabetes, which is also contained in the

dataset. If an individual has not responded affirmatively to having been diagnosed of diabetes, but takes any drug for diabetes, that person is also classified as suffering from diabetes. Finally, information is verified using medical records provided by the hospital.

Clinical complications are also self-reported and later checked with medical records. These are classified as: i) non-diabetes related, which include chronic lung disease, asthma, cancer and gastric ulcer; ii) diabetes-related complications, which refer to hypertension, microvascular (nephropathy, retinopathy) and macrovascular diseases (heart attack, stroke and peripheral arterial disease).

Frailty is measured according to the Fried criteria (Fried et al., 2001), whose test was performed by trained nurses at the survey participant's home. The criteria that have been used to determine whether the individual is frail, pre-frail or robust are:

- *Weakness*, defined as the lowest quintile (20%) of maximum strength on the dominant hand by gender and body mass index

- *Low energy*, meaning by "low energy" when individuals answered affirmatively to any of the following two questions: "I felt that anything I did was a big effort" and "I felt that I could not keep on doing things" at least 3 to 4 days a week.

- *Slowness,* referring to the lowest quintile (20%) in the three-meter walking speed test, by gender and height.

- *Low physical activity,* according to Physical Activity Scale for the Elderly (PASE) score, which is a weighted score referring to the kilocalories expended per week. Low physical activity is defined as having an score in the lowest quintile (20%), which, by gender, are less than 383 Kcals/week for males and less than 270 Kcals/week for women

- *Weight loss,* as unintentional weight loss of 4.5 kg or more in the last year.

Then, one point is assigned to each of these categories if the individuals meet the above criteria and a final score is built as the sum of the five criteria. According to this score, subjects are classified as non-frail (0 points), pre-frail (1-2 points) and frail (3-5 points) (García-García et al., 2011). The Fried phenotype of frailty has extensively been used in the literature and validated (Bieniek et al., 2016; Chen et al., 2015; Drey et al., 2011), signaling the good applicability of the Fried criteria to identify frail individuals in older people, as it is the case in my study.

Sociodemographic factors are also included, such as age and the quadratic form of age in order to control for its potential decreasing marginal effect, which are actually my only continuous demographic variables in the model. Dummy variables for gender, marital and employment status, and education categories are also part of the analyses.

A detailed description of the variables included in the analysis can be found in Appendix, Table 5.A2.

5.2.3 Statistical analyses

Given the panel nature of the data, I am able to take into account individual heterogeneity across time. Two main estimation techniques are used when having panel data: fixed-effects and random-effects models (Berrington et al., 2006; Heij et al., 2004). Fixed-effects models explore the relationship between variables that vary over time (for example, age, marital status, disease diagnosis) within an individual; the impact of the time-invariant variables cannot be identified (i.e. gender, date of birth). Hence, fixed-effects models are aimed to analyze the causes of changes within an individual. On the other hand, random-effects models allow time-invariant factors to be associated with the outcome and, hence, the variation across individuals is assumed to be random, exogeneous and uncorrelated with the independent variables. A random-effects linear regression model will be used so as to take into account individual variation between the two waves included in the analysis.

The baseline model with random-effects is as follows:

$$HRQoLscore_{it} = \beta'_1 SE_{it} + \beta_2 diabetes_{it} + \varphi_t + c_i + u_{it} \quad (1)$$

where $HRQoLscore_{it}$ is a continuous variable that represents the HRQoL score from individual i in time t year; SE_{it} is a vector of explanatory variables referring to age, gender, marital and employment status, and education; $diabetes_{it}$ denotes a dummy variable with value 1 indicating that the individual suffers from diabetes, and 0 otherwise; φ_t denotes the fixed time effects and c_i represents the random effects term, where $E(c_i|s_i, diabetes_i) = 0,$ signaling that the conditional mean of the random-effects is independent of the right-hand side variables. u_{it} denotes the idiosyncratic error term.

In the above regression model, diabetes non-related and related complications have been excluded. These will be added in subsequent models. Model 2 will also take into account the diabetes non-related clinical conditions, such as chronic obstructive pulmonary disease (COPD), asthma, cancer and gastric ulcer. In a third regression model, the diabetes-related diseases will be added to Model 2: hypertension, micro (retinopathy and neuropathy) and macrovascular diseases (heart attack, stroke and peripheral arterial disease). Finally, in a fourth model the diagnosis of frailty syndrome (pre-frail and frail) will be included.

It has already been mentioned in the literature that the greater the prevalence of comorbidities in addition to diabetes, the greater the reduction in HRQoL. However, little is known about the joint impact that suffering from more than one complication has on quality of life in people with

diabetes, constituting an empirical challenge. Moreover, it is not known how big this reduction is compared to the population without diabetes. Hence, the following regression model is proposed to be run for both subsamples, those with diabetes and those without, separately:

$$HRQoLscore_{it} = \beta'_1 SE_{it} + \gamma_1 nondiarel_{it} + \gamma_2 diarel_{it} + \gamma_3 frailty_{it} + \varphi_t + c_i + u_{it} \quad (2)$$

where $nondiarel_{it}$ denotes the number of non-diabetes related clinical complications; $diarel_{it}$ refers to the number of diabetes-related chronic complications; and $frailty_{it}$ represents the two categories of the frailty syndrome, being pre-frail and frail.

Finally, the interactions between the number of non-diabetes related complications and frailty and between the number of diabetes-related chronic conditions and frailty, for both subsamples, will be added to the regression model specified in equation (2).

All the statistical analyses have been performed using STATA 14.0 software (Stata Corporation, College Station, TX).

5.3 RESULTS

5.3.1 Summary statistics

Characteristics of the general study population and by diabetes status are shown in Table 5.1, as well as a comparison of means test between people with and without diabetes.

The overall prevalence of diabetes is 20% and mean EQ-5D utilities equal to 0.83. The mean age is 75.02 years old and 56% of the sample are women, 71% are married, 61% are retired and 38% are homemakers, and 56% have no education degree. With respect to health conditions, the most prevalent ones are hypertension, pre-frailty and peripheral arterial disease, which affect 59%, 36% and 33% of the whole sample, respectively. The average number of non-diabetes related conditions suffered in the whole sample is 0.21, whereas the number, on average, of diabetes-related complications increases to 1.02.

Table 5.1 also shows that there are some differences between the general sample and the individuals with and without diabetes. Those with diabetes show lower utilities scores than the ones without diabetes (0.81 vs 0.84, respectively). Moreover, people with diabetes are older (75.49 vs 74.90), with a lower percentage of women (52% vs 57%) and more likely to be retired (64% vs 61%).

When talking about health status, the most prevalent diagnoses are equal to the ones in the whole sample, although the prevalence varies. Within people with diabetes, 71% and 40% suffer from hypertension and pre-frailty; whereas in case of those without diabetes, these percentages are 56% and 35%, respectively. Significant differences between both subsamples can be observed in the number of the so-called diabetes-related conditions prevalent in each subsample, as the average number is 1.33 in the group with diabetes and 0.95 in those without diabetes.

Table 5.1: Descriptive statistics[26]

Variables	Whole sample (N = 2,933)	Diabetes (N = 589)	Without diabetes (N = 2,344)	Comparison of means
				p-value
Mean (SD) EQ-5D Time Trade Off score	0.83 (0.18)	0.81 (0.18)	0.84 (0.18)	0.000***
Diabetes	0.2	-	-	-
Mean (SD) Age	75.02 (5.92)	75.49 (5.55)	74.90 (6.00)	0.034**
Female	0.56	0.52	0.57	0.052*
Marital status				0.233
Married	0.71	0.68	0.72	
Widowed	0.23	0.26	0.22	
Never married	0.06	0.06	0.06	
Employment status				
Retired	0.61	0.64	0.61	0.094*
Homemaker	0.38	0.35	0.38	
Employed	0.01	0.02	0.01	
Education				0.297
No education	0.56	0.58	0.56	
Low education	0.32	0.32	0.32	
Medium or high education	0.12	0.11	0.12	
Chronic lung disease	0.04	0.06	0.04	0.155
Asthma	0.04	0.04	0.04	0.913
Cancer	0.07	0.06	0.07	0.295
Ulcer	0.06	0.07	0.05	0.112
Mean (SD) Number of non-diabetes-related conditions	0.21 (0.49)	0.23 (0.42)	0.21 (0.48)	0.317
Hypertension	0.59	0.71	0.56	0.000***
Microvascular complications	0.03	0.15	-	-
Nephropathy	0.01	0.03	-	-
Retinopathy	0.03	0.13	-	-
Macrovascular complications	0.35	0.38	0.34	0.082*
Heart attack	0.05	0.07	0.04	0.012**
Stroke	0.02	0.04	0.02	0.113
Peripheral arterial disease	0.33	0.35	0.32	0.189
Both micro and macrovascular	0.01	0.06	-	-
Mean (SD) Number of diabetes-related conditions	1.02 (0.81)	1.33 (0.91)	0.95 (0.76)	0.000***
Frailty Syndrome				0.000***
Non-frail	0.58	0.52	0.60	
Pre-frail	0.36	0.40	0.35	
Frail	0.06	0.08	0.05	
Wave 1 (years 2006/09)	0.43	0.37	0.45	0.000***
Wave 2 (years 2011/13)	0.57	0.63	0.55	0.000***

*** p<0.01, ** p<0.05, * p<0.1. Comparison of means tests cluster observations at the individual level

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[26] Percentages are presented referring to the mean percentage between waves, unless indicated otherwise.

5.3.2 Regression results

Table 5.2 shows the results for the overall sample obtained in the four regression models. Model 1 shows that having diabetes significantly decreases HRQoL (Coefficient = -0.034, p<0.01), compared to people without diabetes. Being a woman (Coeff. = -0.121, p<0.01) also decreases HRQoL scores. On the contrary, having low and medium or high education increase health-related quality of life by 0.0408 (p<0.01) and 0.0575 (p<0.01), respectively, compared to those with no education.

When non-related clinical diseases are included in the analysis (Model 2, Table 5.2) diabetes is still significant and negatively related to the outcome (Coeff. = -0.0331, p<0.01). All the clinical complications are also significant in reducing HRQoL scores, having asthma the greatest impact on reducing quality of life (Coeff. = -0.0465, p<0.05). Moreover, when diabetes-related complications are part of the regression model (Model 3, Table 5.2), diabetes still reduces health-related quality of life significantly, but its coefficient drops to -0.0159 (p<0.1). Within the clinical complications, nephropathy (Coeff. = -0.120, p<0.05) and stroke (Coeff. = -0.0659, p<0.01) bear the greatest effect in decreasing quality of life. Finally, a fourth model adding two categories of the frailty syndrome, being pre-frail and frail, show that it is being frail and pre-frail the complications with the greatest impact on HRQoL score, reducing it by 0.267 (p<0.01) and by 0.0815 points (p<0.01), respectively. Diabetes is no longer significantly related to HRQoL in Model 4.

Table 5.2: Results from the random-effects linear regression models regarding Health-related Quality of Life score for the overall sample

VARIABLES	Coeff. Model 1	Coeff. Model 2	Coeff. Model 3	Coeff. Model 4
Diabetes	-0.0340***	-0.0331***	-0.0159*	-0.00716
	(0.00812)	(0.00806)	(0.00839)	(0.00760)
Age	0.0119	0.0117	0.0133	-0.00115
	(0.0105)	(0.0104)	(0.0104)	(0.00892)
Age²	-0.000120*	-0.000119*	-0.000127*	-8.64e-06
	(6.89e-05)	(6.81e-05)	(6.79e-05)	(5.81e-05)
Female	-0.121***	-0.125***	-0.123***	-0.107***
	(0.00807)	(0.00808)	(0.00815)	(0.00738)
Married	0.0189	0.0202	0.0204	0.0172
	(0.0137)	(0.0136)	(0.0138)	(0.0124)
Widowed	0.0172	0.0190	0.0190	0.0120
	(0.0157)	(0.0157)	(0.0157)	(0.0141)
Retired	-0.0278	-0.0268	-0.0317	-0.0139
	(0.0210)	(0.0213)	(0.0214)	(0.0202)
Homemaker	-3.37e-06	-0.000599	-0.00759	-0.00947
	(0.0217)	(0.0220)	(0.0221)	(0.0208)
Low education	0.0408***	0.0396***	0.0378***	0.0290***
	(0.00745)	(0.00743)	(0.00738)	(0.00667)
Medium or high education	0.0575***	0.0559***	0.0540***	0.0420***
	(0.00902)	(0.00901)	(0.00900)	(0.00826)
Chronic lung disease		-0.0380**	-0.0340**	-0.0234*
		(0.0160)	(0.0155)	(0.0140)
Asthma		-0.0465***	-0.0465***	-0.0263*
		(0.0154)	(0.0153)	(0.0136)
Cancer		-0.0246**	-0.0232*	-0.0139
		(0.0123)	(0.0121)	(0.0109)
Ulcer		-0.0380***	-0.0382***	-0.0241*
		(0.0147)	(0.0145)	(0.0134)
Hypertension			-0.0179***	-0.0200***
			(0.00626)	(0.00571)
Nephropathy			-0.120**	-0.103***
			(0.0473)	(0.0387)
Retinopathy			-0.0645***	-0.0721***
			(0.0220)	(0.0206)
Heart attack			-0.0361**	-0.0212
			(0.0148)	(0.0131)
Stroke			-0.0659***	-0.0472**
			(0.0247)	(0.0223)
Peripheral arterial disease			0.0133**	0.00800
			(0.00640)	(0.00588)
Both micro and macrovascular complications			-0.0396	-0.00229
			(0.0369)	(0.0317)
Pre-frail				-0.0815***
				(0.00624)
Frail				-0.267***
				(0.0147)
Constant	0.657	0.670*	0.613	1.068***
	(0.402)	(0.397)	(0.396)	(0.341)
N (Observations)	2,933	2,933	2,933	2,933
N (Individuals)	2,156	2,156	2,156	2,156
Year FE	YES	YES	YES	YES

Table 5.2: (continued)

VARIABLES	Coeff. Model 1	Coeff. Model 2	Coeff. Model 3	Coeff. Model 4
σ_u	0.0830	0.0813	0.0788	0.0566
σ_e	0.1356	0.1356	0.1354	0.1317
ϱ	0.2726	0.2643	0.2531	0.1562
χ^2-test value for the joint significance of the new variables		31.30***	66.91***	433.59***

Clustered standard errors at the individual level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Model 1 includes diabetes and sociodemographic characteristics: age, gender, marital and employment status, and education. Model 2 adds to the previous model non-related diabetes complications, such as chronic obstructive pulmonary disease (COPD), asthma, cancer and gastric ulcer. Model 3 includes the above variables and diabetes-related clinical complications, like hypertension and micro (nephropathy and retinopathy) and macrovascular diseases (heart attack, stroke and peripheral arterial disease). Model 4 adds two categories of the frailty syndrome: being pre-frail and frail.

<u>Comparing people with and without diabetes</u>

Table 5.3 reports the results from the regression models with the number of diabetes-related and non-related chronic diseases as well as the frailty syndrome categories by diabetes status and the interactions between the number of clinical complications and frailty.

Model 1 shows that females have significantly lower HRQoL scores than males in both groups, with and without diabetes. The gender effect is larger in people without diabetes (Coeff. = -0.103, p<0.01 in people with diabetes; Coeff. = -0.108, p<0.01 in people without diabetes). Being married (Coeff. = 0.0247, p<0.1), having low (Coeff. = 0.0316, p<0.01) and medium or high education (Coeff. = 0.0526, p<0.01) are positively associated with HRQoL scores only in the individuals without diabetes.

With respect to the health variables, within the sub-population with diabetes, not suffering from any of the diabetes-related complications increases HRQoL scores by 0.115 (p<0.01). When any of them is present, its effect on quality of life depends on the number of conditions suffered: if the person suffers from one single diabetes-related complication, quality of life is reduced by 0.0856 (p<0.01); and if two diabetes-related conditions are given, HRQoL scores decrease by 0.0921 (p<0.01). Moreover, being pre-frail and frail also reduce quality of life in people with diabetes, by 0.0851 (p<0.01) and 0.271 (p<0.01) points, respectively.

On the other hand, for the group of people without diabetes, having one non-diabetes related disease reduces quality of life by 0.0333 (p<0.01) and by 0.0325 points (p<0.1) if the person has two non-diabetes related diseases. Moreover, if the individual suffers from two diabetes-related complication, quality of life is reduced by 0.0248 (p<0.01). In addition, pre-frailty and frailty also reduce quality of life in people without diabetes, by 0.0831 (p<0.01) and 0.262 (p<0.01) points, respectively. Differences between both subgroups are statistically significant according to the Chow test value (39.61, p<0.01).

When the interactions between the number of chronic conditions and the frailty syndrome are included, some differences, which are significant according to the Chow test (45.43, p<0.05), can also be observed between both subsamples. In case of people with diabetes, suffering from two diabetes-related complications and pre-frailty reduce quality of life by 0.0199 points (p<0.1) and by 0.0841 (p<0.05) points if the individual has four diabetes-related conditions and pre-frailty. Being frail and having one diabetes-related disease decreased HRQoL scores by 0.0932 (p<0.1); by 0.116 (p<0.05) points if three diabetes-related conditions are additionally suffered to frailty; and by 0.187 (p<0.01) points if four conditions. On the contrary, quality of life in people without diabetes is reduced when individuals have three non-diabetes-related chronic conditions and are pre-frail by 0.192 points (p<0.05).

Table 5.3: Results from the random-effects linear regression models with the number of chronic conditions and interaction terms regarding Health-related Quality of Life score for the sub-samples with and without diabetes

VARIABLES	Coeff. Model 1 people with diabetes	Coeff. Model 1 people without diabetes	Coeff. Model 2 people with diabetes	Coeff. Model 2 people without diabetes
Age	-0.0151	-0.000770	-0.0168	-0.000501
	(0.0256)	(0.00967)	(0.0256)	(0.00977)
Age²	8.05e-05	-1.07e-05	9.03e-05	-1.24e-05
	(0.000168)	(6.30e-05)	(0.000168)	(6.36e-05)
Female	-0.103***	-0.108***	-0.103***	-0.108***
	(0.0184)	(0.00804)	(0.0184)	(0.00807)
Married	-0.0109	0.0247*	-0.0155	0.0260*
	(0.0252)	(0.0140)	(0.0253)	(0.0141)
Widowed	-0.0103	0.0171	-0.00962	0.0184
	(0.0281)	(0.0160)	(0.0281)	(0.0160)
Retired	-0.0544	0.00246	-0.0516	0.00260
	(0.0375)	(0.0238)	(0.0378)	(0.0243)
Homemaker	-0.0456	0.00440	-0.0462	0.00466
	(0.0387)	(0.0244)	(0.0392)	(0.0249)
Low education	0.0237	0.0316***	0.0232	0.0318***
	(0.0146)	(0.00760)	(0.0149)	(0.00762)
Medium or high education	0.00266	0.0526***	-0.00134	0.0526***
	(0.0219)	(0.00900)	(0.0220)	(0.00904)
Number of non-diabetes related complications				
0	0.514	-	0.659	-
	(1.038)		(1.037)	
1	0.504	-0.0333***	0.651	-0.0315***
	(1.036)	(0.00910)	(1.037)	(0.00975)
2	0.431	-0.0325*	0.637	-0.0305
	(1.039)	(0.0190)	(1.039)	(0.0231)
3	0.490	0.0289	0.640	-0.105
	(1.040)	(0.0410)	(1.040)	(0.0856)
Number of diabetes-related complications				
0	0.115***	-	0.0496	-
	(0.0297)		(0.0435)	
1	-0.0856***	-0.0104	0.0255	-0.00302
	(0.0289)	(0.00720)	(0.0409)	(0.00799)
2	-0.0921***	-0.0248***	0.0404	-0.0161
	(0.0293)	(0.00927)	(0.0409)	(0.00995)
3	0.0321	-0.0399	0.0150	-0.0220
	(0.0372)	(0.0255)	(0.0517)	(0.0264)
4	-	0.00632	-	0.0118
		(0.00839)		(0.00864)
Pre-frail	-0.0851***	-0.0831***	-0.0712**	-0.0670***
	(0.0139)	(0.00710)	(0.0304)	(0.0122)
Frail	-0.271***	-0.262***	-0.242***	-0.249***
	(0.0295)	(0.0169)	(0.0345)	(0.0359)
Number of non-diabetes related complications # Pre-frail				
1			-0.0159	0.00448
			(0.0315)	(0.0207)

Table 5.3: (continued)

VARIABLES	Coeff. Model 1 people with diabetes	Coeff. Model 1 people without diabetes	Coeff. Model 2 people with diabetes	Coeff. Model 2 people without diabetes
2			-0.0320	-0.00998
			(0.0929)	(0.0399)
3			-	-0.192**
				(0.0943)
Number of non-diabetes related complications # Frail				
1			0.0399	-0.0480
			(0.0684)	(0.0460)
2			-0.144	0.0160
			(0.109)	(0.0441)
3			-	0.134
				(0.112)
Number of diabetes-related complications # Pre-frail				
1			0.00597	-0.0212
			(0.0362)	(0.0155)
2			-0.0199*	-0.0308
			(0.0369)	(0.0190)
3			-0.0812	-0.0387
			(0.0625)	(0.0635)
4			-0.0841**	-
			(0.0615)	
Number of diabetes-related complications # Frail				
1			-0.0932*	0.00119
			(0.0544)	(0.0393)
2			-0.0531	0.0291
			(0.0659)	(0.0498)
3			-0.116**	-0.0332
			(0.0739)	(0.0571)
4			-0.187***	-
			(0.0499)	
N (Observations)	589	2,344	589	2,344
N (Individuals)	474	1,753	474	1,753
Year FE	YES	YES	YES	YES
Chow test value	39.61***		45.43**	

Clustered standard errors at the individual level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Model 1 includes sociodemographic characteristics (age, gender, marital and employment status, and education); the number of non-related diabetes complications (chronic obstructive pulmonary disease (COPD), asthma, cancer and gastric ulcer); the number of diabetes-related clinical complications (hypertension, nephropathy, retinopathy, heart attack, stroke and peripheral arterial disease) and two categories of the frailty syndrome (pre-frailty and frailty). Model 2 adds the interaction between the number of non-related and diabetes-related clinical complications and the two categories of the frailty syndrome.
Each of the interactions measures the effect of jointly having the number of chronic diseases (non-related and diabetes-related) and frailty categories compared with robust individuals (non-frail).

5.4 DISCUSSION

This analysis aims to assess the main drivers of (higher/lower) quality of life among a representative sample of the Spanish population older than 65 years old. The focus is placed on one disease, diabetes, and a set of clinical complications, both non-related and diabetes-related chronic conditions, plus frailty/pre-frailty status. Moreover, I estimate their joint impact on HRQoL scores by diabetes status: with and without diabetes.

The results confirm that diabetes is a predictor of lower quality of life in older people, compared to people with diabetes. Diabetes reduces HRQoL scores in the overall sample by 0.034 and 0.033 points (within a range variable of $0 - 1$) in both scenarios when it is the only clinical variable and when only non-related diabetes clinical complications, respectively, are part of the regression model. These results support the literature in which a negative association between HRQoL scores and diabetes has already been suggested (Schunk et al., 2012; Papadopoulos et al., 2007; Rubin and Peyrot, 1999), showing a similar effect of diabetes on HRQoL than another study using data from 229 old Greek adults with a mean age of 70 years old (Wee et al., 2005). Authors concluded that when diabetes is measured alone, HRQoL was reduced by 0.03 points. However, they used a different instrument to evaluate HRQoL, so the comparison between studies should be interpreted with caution.

However, when diabetes-related chronic conditions are included in the regression, diabetes is still significant, but its coefficient decreases till 0.016 points. This detrimental effect would show that the variables remaining in the model explain part of the effect of diabetes as a risk factor for lower quality of life. More remarkably, in case the two categories of the frailty syndrome, being pre-frail and frail, enter to the analysis, diabetes is no longer significant. Actually, it is the frailty syndrome what reduces quality of life the most. Hence, it could be concluded that the effect of diabetes is mediated by the clinical complications, but more importantly by frailty, reducing its impact on HRQoL. This is one of the main findings from the current research, as the mediation effect of clinical and functional complications on diabetes and healthcare resources has already been stated in the literature (Rodriguez-Sanchez et al., 2017), but never on quality of life.

When I compare the population with diabetes with those without diabetes, the findings show that frailty bears the greatest impact in both subsamples and differences between groups are significant. Within the sub-population with diabetes, being pre-frail and frail reduce quality of life by 0.0851 and 0.271 points (within a range variable of $0 - 1$), respectively. When any diabetes-related disease is present, its effect on quality of life increases with the number of conditions suffered: in case of one single diabetes-related complication, quality of life is reduced by 0.0856; and if two diabetes-related conditions, HRQoL scores decrease by 0.0921. In case of people

without diabetes, the effect of these conditions is still negative, but lower than in the subgroup with diabetes. If the individual suffers from two diabetes-related complications, quality of life is reduced by 0.0248. Pre-frailty and frailty also reduce quality of life in people without diabetes by 0.0831 and 0.262 points, respectively. Non-diabetes related complications do reduce quality of life in people without diabetes, as having one of them reduces quality of life by 0.0333 points and by 0.0325 if the individual suffers from two non-diabetes related conditions.

Within the determinants of lower HRQoL in people with diabetes, both micro and macrovascular diseases, as they have been included in the analysis, can be widely found in the literature (Javanbakht et al., 2012; Papadopoulos et al., 2007; Redekop et al., 2002). More specifically, Jacobson et al. (2013) found that within people with diabetes, microvascular complications reduce HRQoL the most. However, they did not include frailty in their analysis as in here. It can be seen from the results that, after frailty, the number of diabetes-related conditions lead to greater reductions in quality of life in people with diabetes. The results would then confirm the detrimental effect of single and multiple complications on HRQoL scores among individuals with diabetes that has already been reported in the literature (Laiteerapong et al., 2011; Solli et al., 2010; Morgan et al., 2006).

When looking at the joint effect of chronic conditions and frailty, in case of people with diabetes, having two diabetes-related complications and pre-frailty reduces quality of life by 0.0199 and by 0.0841 points if the individual has four diabetes-related conditions together with pre-frailty. In case of being frail, additionally having one diabetes-related disease decreases HRQoL scores by 0.0932; and by 0.187 points if four conditions. Quality of life in people without diabetes is reduced when three non-diabetes-related chronic conditions are given jointly to pre-frailty by 0.192 points.

Although no other previous study has been found assessing the joint impact of chronic conditions on HRQoL in people with and without diabetes, the literature has already established that, for example, the effect of micro and macrovascular diseases in individuals with diabetes increases when these are suffered together (Morgan et al., 2006; Redekop et al., 2002), but the combination of these conditions with the frailty syndrome, as it is done in this analysis, has not been assessed before.

Some limitations should also be mentioned. Although I have been able to run a longitudinal analysis with the current data, only two waves are available. So, little variation could be expected within individuals between time periods. A longer follow-up period would allow for a more in-depth knowledge of potential changes in HRQoL when survey respondents are newly-diagnosed of any of the chronic conditions included in the analysis and the frailty syndrome. Further

analysis could include more survey-years data. Moreover, in order to construct the HRQoL values, the EQ-5D-3L questionnaire is used and its corresponding tariffs for the Spanish population. However, the discriminatory power of the 3 level version has been a matter of debate in the literature (Janssen et al., 2012), being the 5-level version more preferred. In the present cohort, only the 3-level version has been provided to survey respondents. Finally, the self-reported feature of the data, especially about health conditions, could bias the results, since it could lead to recall bias and, hence, the results here could over or underestimate the true impact of diabetes. Nevertheless, this possibility looks unlikely as the data comes from two different waves of the study, showing a strong consistency among them. Furthermore, the self-reported information was checked with the drugs use and the medical records, so it is not self-reported information only.

These figures could provide a valuable contribution to the existing literature since it is the first analysis looking at the burden of diabetes on quality of life in older people, compared to people without diabetes, analyzing the impact of a list of chronic conditions by subgroup using a representative wide sample of the Spanish elderly population. It is also pioneer in including the frailty syndrome as one of the factors involved in predicting HRQoL scores in both sub-populations, with and without diabetes. It is noteworthy that this factor not only helps to explain part of the effect of diabetes on quality of life, but it is the main one, emerging as the main mediator of the negative burden of diabetes on the outcome. Moreover, I also contribute to the literature by measuring the joint impact of chronic conditions and frailty on HRQoL in people with and without diabetes. This input would be of special relevance given the raise in diabetes prevalence (O'Shea et al., 2013) and its associated high risk of multimorbidity in people with diabetes (OECD/EU, 2016) and development of disability (Sinclair et al., 2015; Murray and López, 2013; Murray et al., 2012). My results could be of great utility for policymakers when informing diabetes prevention and management programs. Given that the loss in HRQoL at individual level varies by the number of chronic conditions suffered and, especially, by frailty status, these should be then the focus in this particular aged group. Running appropriate preventive programs for the onset of diabetes and its complications, especially frailty, would help to increase health related quality of life in people with diabetes or, at least, reduce HRQoL losses.

APPENDIX CHAPTER 5

Table 5.A1: Health statistics comparing Spanish population and the Toledo Study on Healthy Ageing sample

Spanish population (Source: National Institute of Statistics)

	Hypertension	Heart attack	Asthma	Chronic lung disease	Diabetes	Stroke	Cancer
Age 65 – 74	44.4	1.5	4.4	7.8	17.6	1.2	3.0
Age 75 – 84	49.4	2.5	4.9	11.8	21.9	2.2	3.4
Age 85+	51.1	3.3	7.1	14.1	18.3	5.3	4.0
Total	48.3	2.5	5.5	11.2	19.2	2.9	3.4

Toledo Study on Healthy Ageing sample

	Hypertension	Heart attack	Asthma	Chronic lung disease	Diabetes	Stroke	Cancer
Age 65 – 74	56.6	3.15	4.5	3.8	17.9	1.9	7.9
Age 75 – 84	60.6	6.32	3.8	4.7	22.7	2.8	6.9
Age 85+	64.6	8.59	4.5	5.6	17.2	4.5	2.5
Total	58.9	4.91	4.2	4.3	20.0	2.5	7.1

Table 5.A2: List of variables included in the analysis

Variable	Coding
EQ-5D Time Trade Off (TTO) score	HRQoL score, which goes from 0 (death) to 1 (best possible health status), although negative values are possible, signaling health states worse than death
Age	Age of respondent
Female	1: female; 0: male
Marital status	
Married	1: married; 0: otheriwse
Widowed	1: widowed; 0: otherwise
Never married	1: never married; 0: otherwise
Employment status	
Retired	1: retired; 0: otheriwse
Homemaker	1: homemaker; 0: otherwise
Employed	1: employed; 0: otherwise
Education	
No education	1: respondent had not completed primary or first stage of basic education; 0: otheriwse
Low education	1: respondent had completed primary education or first stage of basic education and lower secondary or second stage of basic education; 0: otherwise
Medium or high education	1: respondent had completed (upper) secondary education and post-secondary non-tertiary education or respondent had completed first and second stage of tertiary education; 0: otherwise
Chronic lung disease	1: respondent has ever been diagnosed of chronic obstructive pulmonary disease; 0: otherwise
Asthma	1: respondent has ever been diagnosed of asthma; 0: otherwise
Cancer	1: respondent has ever been diagnosed of malignant tumor or cancer; 0: otherwise
Ulcer	1: respondent has ever been diagnosed of gastric ulcer; 0: otherwise
Number of non-diabetes-related conditions	Number of non-diabetes-related conditions suffered from the ones included in the analysis (chronic lung disease, asthma, cancer and gastric ulcer). Values range from 0 to 4
Hypertension	1: respondent has ever been diagnosed of hypertension; 0: otherwise
Microvascular complications	
Nephropathy	1: respondent has ever been diagnosed of nephropathy; 0: otherwise
Retinopathy	1: respondent has ever been diagnosed of retinopathy; 0: otherwise
Macrovascular complications	
Heart attack	1: respondent has ever had a heart attack; 0: otherwise
Stroke	1: respondent has ever had a stroke; 0: otherwise
Peripheral vascular disease	1: respondent has ever been diagnosed of peripheral vascular disease; 0: otherwise
Both micro and macrovascular disease	1: respondent has ever been diagnosed of both micro and macrovascular complications included in the analysis; 0: otherwise
Number of diabetes-related conditions	Number of diabetes-related conditions suffered from the ones included in the analysis (hypertension, nephropathy, retinopathy, heart attack, stroke and peripheral vascular disease). Values range from 0 to 6
Frailty syndrome	
Non-frail	1: respondent does not meet any of the Fried criteria of frailty; 0: otherwise

Table 5.A2: (continued)

Variables	Coding
Pre-frail	1: respondent meets 1 to 2 of the Fried criteria of frailty; 0: otherwise
Frail	1: respondent meets more than 2 of the Fried criteria of frailty; 0: otherwise
Wave 1 (years 2006/09)	1: data was collected from wave 1; 0: otherwise
Wave 2 (years 2011/13)	1: data was collected from wave 2; 0: otherwise

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SAMENVATTING IN NEDERLANDS

Alhoewel het al is vastgesteld dat de economische last van diabetes voor de nationale gezondheidszorg en overheidsuitgaven vrij groot is (OECD/EU, 2016; Alva et al., 2015; ADA, 2013), zijn er, voor zover ik weet, geen relevante en uitgebreide studies over de bredere economische impact van diabetes onder oudere volwassenen, waarbij de speciale aandacht schenken aan de rol van functionele status. De huidige uitdaging omarmt methodologische kwesties aangaande het analyseren van gezondheidskosten (Wu et al, 2012), of het gewicht van functionele beperkingen ten opzichte van co morbiditeit en complicaties in het bepalen van de kosten.

Het scenario voor de volgende decennia laat een toename in de kosten geassocieerd met het beheer van diabetici door de vergrijzing van de bevolking en de hogere kosten per inwoner onder oudere volwassenen (Waldeyer et al, 2013). Deze toename in de kosten vormt een nieuwe uitdaging voor de Health Systems dat modellen zou moeten uitvoeren die zijn toegespitst op de behoeften van deze bevolkingsgroep (Sinclair et al, 2011).

Dit proefschrift streeft ernaar om bij te dragen aan de bestaande literatuur door een nieuw en breder inzicht op de lasten van diabetes onder de oudere bevolking aan te dragen door niet alleen het gebruik van en de kosten van de traditionele gezondheidszorgmiddelen voor diabetes onder oudere volwassenen (de kosten van zorg voor mensen met diabetes) mee te nemen, maar ook andere, minder vaak geëvalueerde, kosten, zoals uitgaven voor een verzorgingstehuis, en de impact van diabetes op de levenskwaliteit en productieve activiteiten. Tevens bouw ik voort op de bestaande literatuur door in mijn analyse niet alleen klinische complicaties die mogelijk ontstaan door diabetes mee te nemen, maar ook functionele beperkingen. Diabetes heeft een toenemend negatief effect op de functionele autonomie naarmate mensen ouder worden (Kalyani et al., 2010; Wong et al., 2013), en het is de achtste oorzaak van DALYs in westerse maatschappijen (Murray en López, 2013). Bovendien gebruik ik een verscheidenheid aan datasets in dit proefschrift: administratief (Vektis en ZODIAC data in Hoofdstuk 2) en enquête datasets (the Survey of Health, Ageing and Retirement in Europe, SHARE, in Hoofdstukken 3 en 4; en de Toledo Study on Healthy Ageing, TSHA, in Hoofdstuk 5), waardoor ik in staat ben om

verschillende informatiebronnen (vorderingen, klinische en zelf-gerapporteerde data) over individuen die leven in verschillende institutionele instellingen te onderzoeken.

In de volgende sectie beschrijf ik de hoofdstukken die onderdeel zijn van mijn proefschrift en de specifieke doelstellingen die ik wil analyseren.

SAMENVATTING EN BELANGRIJKSTE BEVINDINGEN

In Hoofdstuk 2 gebruik ik Nederlandse vorderingen data (Vektis), gecombineerd met Nederlandse huisartsenregister data (ZODIAC) om de associatie tussen gemiddelde glucose controle en zorgkosten voor mensen met diabetes, maar niet noodzakelijk dankzij diabetes, te onderzoeken. Bovendien onderzoek ik de cohorteffecten van diabetes diagnoses en behandelingsmodaliteit. Ik maak een onderscheiding tussen het type kosten (totale zorg, huisarts, medicijnen, ziekenhuis en specialist, en kosten voor de apparaten). De data is samengesteld uit deze twee gekoppelde datasets, waardoor ik in staat ben om over een vierjarige periode (2008 – 2011) administratieve data te gebruiken van alle medische behandelingen die vergoed worden door Nederlandse verzekeringsmaatschappijen binnen het wettelijk verplichte verzekeringspakket en klinische metingen.

De resultaten laten zien dat gemiddelde glucose controle significant geassocieerd wordt met hogere zorgkosten voor mensen met diabetes, alhoewel het effect op de kosten gemedieerd worden door diabetes behandelingsmodaliteit. Wanneer ik orale medicatie en insuline als diabetesbehandelingsvariabelen toevoeg, wordt een 1% hogere HbA1c alleen significant geassocieerd met een verhoging van de totale zorgkosten, als de persoon niet behandeld wordt, noch met insuline, noch met orale medicatie; er wordt geen significante associatie tussen HbA1c en hogere zorgkosten gerapporteerd wanneer de persoon orale medicatie tot zich neemt of insuline gebruikt. Echter, insuline wordt significant geassocieerd met hogere zorgkosten, ongeacht de covariaten in de analyse. Een andere belangrijke bevinding is dat de positieve effecten van de diabetesduur op de zorgkosten toenemen wanneer ik controleer voor cohort effecten van het jaar van aanvang van diabetes. Zonder toevoeging van de cohort effecten nemen de totale kosten toe voor een diabetesduur tot 25 jaar en nemen ze daarna af, maar wanneer ik de jaar van aanvang categorieën meeneem, is de drempelwaarde vanaf waar zorgkosten beginnen af te nemen een diabetesduur van 35 jaar. McBrien et al. (2012) concludeerden dat zorgkosten voor mensen met diabetes altijd toenemen met de tijd sinds de diagnose na de eerste vijf jaar, net zoals ik vind, maar ik vind ook dat de stijging van de kosten een afnemend effect hebben nadat mensen 35 jaar met diabetes geleefd hebben, iets wat eerder nog niet is gerapporteerd in de literatuur.

Tenslotte, corrigeren voor behandelingsmodaliteit, diabetesduur en jaar van aanvang cohorten, heeft geleid tot een ander innovatieve bevinding: leeftijd is niet significant gerelateerd met zorgkosten, terwijl het wel is gelinkt aan stijgende zorgkosten (Trogdon en Hylands, 2008; Nichols en Brown, 2002). Niet alleen kijk ik naar de impact van gemiddelde glucose controle op zorgkosten voor mensen met diabetes, maar ook naar behandelingsmodaliteit, diabetesduur, en jaar van aanvang effecten, welke niet eerder gezamenlijk zijn beoordeeld. Het uitsluiten van deze factoren kan leiden tot vertekende schattingen.

Hoofdstuk 3 richt zich op de rol van diabetes en een lijst met klinische en functionele complicaties op de waarschijnlijkheid van opname in een verpleeghuis voor mensen ouder dan 50 jaar, waarbij gebruik wordt gemaakt van data van de Survey of Health, Ageing and Retirement in Europe (SHARE). Ik gebruik data van drie verschillende golven: golf 1 (2004), golf 2 (2006-07) en golf 4 (2010); en van twaalf landen (België, Denemarken, Duitsland, Frankrijk, Griekenland, Italië, Nederland, Oostenrijk, Spanje, Tsjechië, Zweden en Zwitserland). Bovendien streef ik ernaar om te analyseren of er verschillen zijn tussen Europese landen en andere subgroepen die onderdeel zijn van de analyse (naar leeftijd of geslacht en naar verblijfsduur) in de relatie tussen plaatsing in een verpleeghuis en de belangrijkste variabelen waarin we geïnteresseerd zijn. Nadat ik deze resultaten heb verkregen, gebruik ik de schattingen om de uitgaven van verpleeghuizen te bepalen die te wijten zijn aan diabetes en de complicaties ervan in Europa en om mogelijke verschillen tussen Europese landen te onderzoeken.

Mijn resultaten bevestigen dat diabetes positief en significant geassocieerd wordt met plaatsing in een verpleeghuis. Diabetes verhoogt het risico op institutionalisering, hoewel het effect ervan afneemt wanneer diabetes gerelateerde klinische complicaties worden meegenomen en met name wanneer functionele status wordt geïntroduceerd. Het effect van diabetes wordt zodoende gemedieerd door klinische en functionele complicaties, waardoor de impact van diabetes op de kans op opname in een verpleeghuis wordt verminderd. Bovendien is het effect van functionele beperkingen op het risico van institutionalisering leeftijdsafhankelijk, waardoor het risico op plaatsing in een verpleeghuis groter wordt naarmate mensen ouder worden. De totale gemiddelde kosten van verpleeghuizen bedroegen \$12.66 per hoofd van de bevolking over alle landen, wat neerkomt op de verschillende gradaties van functionele beperkingen 78%.

Hoewel in de totale steekproef de interactie tussen diabetes en complicaties niet significant is, worden sommige verschillen tussen landen wel gemeld. In België, Griekenland en Frankrijk zijn diabetes en een beroerte significant gerelateerd aan het risico van institutionalisering, terwijl diabetes samen met functionele beperkingen de kans verhoogt op toelating tot een verpleeghuis in Spanje. Nederland is het land met de hoogste uitgaven voor verpleeghuizen voor mensen met

diabetes, waarvan 25% van de uitgaven te wijten zijn aan gematigde functionele beperkingen. Het substantiële karakter van functionele beperkingen wordt ook bevestigd wanneer we kijken tussen landen, en het vertegenwoordigt het grootste deel van de kosten, voornamelijk in Duitsland, Nederland en Spanje, meestal gevolgd door beroertes. Bovendien, wanneer de kosten van institutionalisering worden geïnterpreteerd als percentage van het Bruto Binnenlands Product (BBP) per hoofd van de bevolking, is Spanje het land waar de kosten die strikt te wijten zijn aan diabetes complicaties de grootste waarde vertegenwoordigen als percentage van het BBP per hoofd van de bevolking, waarvan functionele beperkingen de grootste last draagt. De resultaten dragen bij aan de literatuur door aan te tonen dan functionele beperkingen niet alleen een deel van de kosten helpen te verklaren, maar ook door aan te tonen dat ze de belangrijkste oorzaak zijn van hogere kosten voor verpleeghuizen. Bovendien is het de eerste tussen-landen-analyse die de last van diabetes op het gebruik van en kosten voor verpleeghuizen voor oudere Europeanen bekijkt.

Hoofdstuk 4 richt zich op de relatie tussen diabetes en twee maten van productieve activiteiten, het bang zijn dat hun werk beperkt wordt door hun gezondheid voor oudere mensen die nog in de werkende leeftijd zijn (50 tot 65 jaar oud), en het zijn van een formele vrijwilliger voor mensen van 65 en ouder die al gepensioneerd zijn. Voor deze analyse gebruik ik data van golven 2, 4 en 5, wat overeenkomt met respectievelijk de jaren 2006/07, 2010 en 2013, en elf Europese landen (België, Denemarken, Duitsland, Frankrijk, Italië, Nederland, Oostenrijk, Spanje, Tsjechië, Zweden en Zwitserland) van SHARE. Het observeren van trends in deze periode zou meer licht kunnen werpen op de vraag hoe relevant gezondheid is met betrekking tot de productiviteit in periodes van economische onzekerheid. Bovendien controleer ik voor klinische en functionele complicaties, omdat het effect van diabetes in het algemeen gemedieerd wordt door comorbiditeiten.

Ik laat zien dat diabetes geassocieerd wordt met productieve activiteiten bij oudere volwassenen, zowel betaald als onbetaald. Diabetes verhoogt de kans dat mensen tussen 50 en 65 jaar oud rapporteren dat ze bang zijn dat hun werk beperkt wordt door hun gezondheid, wat een positieve relatie suggereert tussen diabetes en de angst dat hun werk beperkt wordt door hun gezondheid voor mensen die nog in de werkende leeftijd zijn. De angst dat gezondheid een beperking voor het werk kan zijn neemt toe in de jaren na de crisis, 2010 en 2013, zelfs na het meenemen van klinische complicaties. Dit zou de toegenomen onzekerheid over de werkgelegenheid na de economische crisis kunnen reflecteren. Bovendien neemt de kans dat mensen bang zijn dat hun gezondheid het werk beperkt significant toe met de interactie tussen diabetes en het jaar 2010, maar geen er zijn geen significante effecten gevonden voor de interactie

met het jaar 2013. Dit resultaat kan worden gedreven door de combinatie van het verstorende effect van diabetes en het feit dat de economische crisis sterker toesloeg in de eerste jaren van de crisis, wat leidt tot een grotere angst voor individuele prestaties op het werk die lijden onder de gezondheid. Met betrekking tot vrijwilligerswerk bij mensen ouder dan 65 jaar, vermindert diabetes de kans op het doen van liefdadigheidswerk in vergelijking met mensen zonder diabetes, evenals de frequentie van het uitvoeren van dergelijke activiteiten. Het jaar 2010 verhoogt de kans op het doen van liefdadigheid in grotere mate dan het geval is in het jaar 2013. De beweegreden voor een dergelijke toename kan een grotere solidariteit zijn of een grotere behoefte aan liefdadigheidswerk in plaats van de individuele bereidheid om productief te zijn. De interacties tussen het hebben van diabetes en de jaren 2010 en 2013 zijn geen significante voorspellers van het doen van vrijwilligerswerk. Bovendien worden er verschillen tussen landen waargenomen. Alleen in Denemarken wordt een positief, maar insignificant, effect gerapporteerd in de associatie met de kans op de angst voor dat het werk lijdt onder de gezondheid, terwijl een significant en negatieve relatie wordt aangetoond tussen Italië, Oostenrijk, Spanje, Tsjechië en Zweden en het doen van vrijwilligerswerk. De resultaten zouden op verschillende manieren kunnen bijdragen aan de bestaande literatuur. Ten eerste door het opvullen van het hiaat in de literatuur over onbetaalde activiteiten van oudere mensen, daar veel is geschreven over productiviteitsverlies en de lonen die mensen met diabetes ontvangen, maar er is weinig bekend over de relatie met het doen van vrijwilligerswerk. Ten tweede heb ik bovendien gecontroleerd voor klinische complicaties en mobiliteitsproblemen, en niet alleen voor diabetes als de belangrijkste klinische factor. Ten slotte heb ik ook de invloed van onzekere economische periodes beoordeeld, wat nog niet eerder is gedaan, suggererend dat er een effect kan zijn van onzekere economische situaties op zowel subjectieve (angst dat de gezondheid het werk beperkt) en objectieve (deelname aan vrijwilligerswerk) productiviteitsmaten.

In Hoofdstuk 5 is het doel om voort te bouwen op de bestaande literatuur over gezondheids-gerelateerde kwaliteit van leven (HRQoL/GKvL) en diabetes door de relatie tussen sommige factoren te analyseren die de verschillen in HRQoL tussen oudere mensen met en zonder diabetes kunnen bepalen. We voegen niet alleen klinische complicaties toe, maar ook het kwetsbaarheidssymdroom, dat verslechtert naarmate de leeftijd toeneemt en leidt tot een hoger risico op invaliditeit, ziekenhuisopname en sterfte, als een maat voor functionele beperkingen. In de analyse maken we gebruik van data uit de eerste twee golven, wat overeenkomt met de jaren 2006/07 (golf 1) en 2011-2013 (golf 2) van de Toledo Study on Healthy Ageing (TSHA). Bovendien zal de associatie tussen kwetsbaarheid en het aantal comorbiditeiten gezamenlijk

worden geanalyseerd, waarbij ik onderscheid maak tussen diabetesstatus om de bestaande verschillen tussen mensen met en zonder diabetes te onderzoeken.

De resultaten bevestigen dat diabetes wordt geassocieerd met een lagere kwaliteit van leven bij oudere mensen in vergelijking met mensen zonder diabetes, hoewel het effect afneemt wanneer diabetes-gerelateerde klinische complicaties worden meegenomen. Maar als de verschillende categorieën van het kwetsbaarheidssyndroom (zijnde pre-zwak en zwak) deel uitmaken van de analyse, dan wordt diabetes niet langer significant geassocieerd met kwaliteit van leven. De last van diabetes op de kwaliteit van leven bij oudere mensen wordt dus gemedieerd door klinische complicaties, maar nog belangrijker, door kwetsbaarheid. Wanneer ik de bevolking met diabetes vergelijk met diegenen zonder diabetes, heeft kwetsbaarheid de grootste en een meer negatieve impact op de kwaliteit van leven in beide deelsteekproeven. De verschillen tussen beide groepen zijn significant, waarbij de voorwaarden die worden meegenomen in de analyse een groter negatief effect hebben op de kwaliteit van leven van mensen met diabetes dan van diegenen zonder diabetes. De resultaten tonen aan dat, na kwetsbaarheid, het aantal diabetes-gerelateerde aandoeningen leiden tot een grotere afname van de kwaliteit van leven van mensen met diabetes, wat de nadelige gevolgen van enkele en meerdere complicaties op de kwaliteit van leven bevestigt. Wanneer we kijken naar het gezamenlijke effect van chronische aandoeningen en kwetsbaarheid, in het geval van mensen met diabetes en die kwetsbaar zijn, heeft het hebben van vier diabetes-gerelateerde aandoeningen de meeste negatieve invloed op de kwaliteit van leven. De kwaliteit van leven van mensen zonder diabetes neemt het meest af wanneer drie niet-diabetes-gerelateerde chronische aandoeningen. Deze cijfers kunnen een waardevolle bijdrage leveren aan de bestaande literatuur, aangezien het de eerste analyse is die kijkt naar de last van diabetes op de kwaliteit van leven van oude mensen, waarbij de impact van een lijst van chronische aandoeningen wordt geanalyseerd, waarbij bovendien mensen met en zonder diabetes worden vergeleken. Het is ook de eerste analyse dat het kwetsbaarheidssyndroom meeneemt als één van de factoren die betrokken zijn bij het voorspellen van HRQoL scores, wat naar voren komt als de belangrijkste mediator van de negatieve last van diabetes op de uitkomst.