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Socioeconomic differences in the associations between diabetes and hospital admission and mortality among older adults in Europe

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Highlights

- It is the first multi-country analysis to explore the association between diabetes and hospital admission and mortality among older people, differentiating by socioeconomic status.
- Older people with diabetes are more likely to be admitted to hospital than people without diabetes, and more prone to be admitted more often and stay longer.
- The potential bias in the effect of diabetes on hospital use and death is decreased when clinical and functional complications are included.
- Higher odds of hospital admission are reported by women with diabetes, individuals whose age range between 50 to 65 years old or people with medium educational level and household income.
- Diabetes is also significantly related with mortality risk and some differences have been reported in terms of socioeconomic status and risk of death.
- Only people older than 65 years old die later than healthy people.
- These findings have important implications for public policies to reduce socioeconomic-related health inequalities.

Abstract

The aim of this study is to explain the trends in socioeconomic inequality and diabetes outcomes in terms of hospital admission and death in old European people. The sample includes 73,301 individuals, across 16 European countries taken from the Survey of

Health, Ageing and Retirement in Europe (SHARE). People being diagnosed of diabetes were more likely to be admitted to hospital than those without diabetes, although its effect dropped after controlling for clinical and functional complications. Largest asscociations were observed in women, people aged 50 to 65 years old, with medium educational level and medium household income. Diabetes was significant and positively related to mortality in the whole sample. Diabetes is significantly associated with mortality risk especially in males, oldest old people, low education and medium income people. These findings have important implications for public policies to reduce socioeconomic-related health inequalities.

Keywords: Chronic disease; Diabetes; Hospital admission; Death; Socio economic factors; Older people

JEL Codes: I00; I10; I14; J01

1. INTRODUCTION

Diabetes is one of the largest factors increasing the risk of mortality, morbidity, and disability over the world and its economic burden is a major public health challenge to design new ways to curb diabetes health care expenditure (De Lagasnerie et al., 2017). The number of people with diabetes has rapidly increased, especially due to the rise of the prevalence of Type 2 Diabetes Mellitus (T2DM). Diabetes prevalence has been estimated to concern around 380 million people by 2025 all over the world (O´Shea et al., 2013), having a greater impact among older people. This increase in next years will be accompanied by population ageing, and together with the obesity pandemic, will make diabetes incidence greater than in the past.

Traditionally, the social impact of diabetes has been linked to the use of health and social resources, supporting that medical costs for patients with diabetes are up to three times higher than costs for patients without the disease (Clarke et al., 2010). Associated costs traditionally include visits to physicians, Emergency Room and hospitalization and drug costs (Oliva et al., 2004). In fact, the costs associated to the presence of complications and hospitalization in people with diabetes explain around 35-40% of the total costs (Bruno et al., 2008; Sortso et al., 2016). Hence, current single-disease approach of integrated diabetes care should be extended to meet the health care demands of patients with diabetes in the next future.

The aim of this study is to investigate how diabetes is related to hospital admission (and number of hospitalizations during the last 12 months and average length of stay per hospital admission) and mortality risk (and age at death) among older people in some European countries. Moreover, we aim to assess potential trends in such associations by socioeconomic groups. We make two important contributions to this literature. First, we obtain new evidence about the trends in socioeconomic differences and diabetes outcomes from older Europeans, using pooled country data. Second, we investigate why diabetes-related mortality has recently declined within individuals with diabetes, if so, and it suggests us the value of healthcare spending and avoidable mortality that comprises deaths from certain conditions "that should not occur in the presence of timely and effective healthcare" (Hejink et al., 2013).

Furthermore, poverty is associated not only with higher diabetes incidence, but also with inequality of diabetes care, despite universal health coverage (Hsu et al., 2012). In this regard, reducing financial barriers to primary care and pharmacy services may benefit diabetic patient populations, especially those in a worse economic condition. Prevalence of T2DM is usually higher in more deprived than affluent areas of developed countries, and socioeconomic deprivation seems to have a more marked impact on diabetes prevalence among women than among men in several populations as Walker et al. (2011) suggest for the case of Scotland. They concluded that socio-economic status modifies the association between T2DM and mortality so that relative risks for mortality are lower among more deprived populations, which was supported by a previous Danish study (Carstensen et al., 2008). Sortso et al. (2017), also for Denmark, demonstrate that, despite the Danish universal health care model, patients with lower and higher education and socioeconomic status show different healthcare use patterns. Similarly, for the case of Scotland a low socioeconomic status was found to be associated with poorer clinical outcomes for people with diabetes admitted to hospital (Wild et al., 2010). Hence, measures of socioeconomic status may be valuable in risk scores and in making valid comparisons of the quality of diabetes care. However, handling health inequalities can become very complicated and will only lead to success when social determinants of health are addressed (Marmot et al., 2012). Another study carried out in Germany has already shown that people with lower socioeconomic status do not receive the appropriate diabetes care according to their needs (Reisig et al., 2007).

Moreover, in case of the British National Health Service (NHS), Holman et al. (2013) showed that people with diabetes were 6.3 percentage points more likely to die during a hospital stay than those without a register of diabetes diagnosis, being significantly higher in small and medium provider trusts, concluding that diabetes may override the usual risk factors for hospital mortality.

Similar results are found in Nishino et al. (2015) also for the NHS and the effect of social deprivation and ethnicity on inpatient admissions due to diabetes. The authors demonstrate that people living in more deprived areas have higher rates of inpatient admissions and readmissions due to diabetes. Another study from the United Kingdom showed that mortality declined faster, but emergency hospitalization grew at a higher speed in more deprived neighborhoods (Fleetcroft et al., 2017) due to the increased diabetes prevalence and patients living longer. Nevertheless, another English study showed that, even though people with diabetes and lower socioeconomic status experience diabetes-related complications more often, they attended the hospital with a lower frequency and more to the GP (General Practitioner) consult (Bachmann et al., 2003). Despite all these issues and specificities, up to now there are not relevant and comprehensive studies about the true economic impact of diabetes focusing on older people nor its components and structure.

The structure of the paper is as follows. Section 2 describes the data and construction of the key determinants of socioeconomic differences and diabetes outcomes. In Section 3, the econometric model is set within the context of our dataset. After that, the empirical findings are presented in Section 4, including discussion of the main results, and Section 5 concludes, followed by several appendices that include background information.

2. DATA DESCRIPTION

The Survey of Health, Ageing and Retirement in Europe (SHARE)

Data for this study were taken from SHARE, which is a longitudinal study from individuals aged fifty and over from nineteen European countries, ranging from Scandinavia (Denmark and Sweden) through Central Europe (Austria, France, Germany, Switzerland, Belgium, and the Netherlands) to the Mediterranean countries (Spain, Italy and Greece), and Israel. Information about health status (self-reported health, chronic diseases) and healthcare resources use (hospital admission, nursing home admission), functional status (number of limitations in Activities of Daily Living, ADLs), socioeconomic characteristics (age, gender, country of residence, marital and employment status, education, etc.), lifestyle factors (Body Mass Index, smoking habits, alcohol consumption) and family networks are included in the survey.

We limited our study to sixteen of those countries, namely Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Greece, Italy, The Netherlands, Poland, Portugal, Slovenia, Spain, Sweden and Switzerland[1]. We pooled data from five different waves: wave 1 (year 2004), wave 2 (year 2006-07), wave 4 (year 2010), wave 5 (year 2013) and wave 6 (year 2015)[2].

Variables description

Dependent variables: hospital admission (and number of hospitalizations in the previous twelve months and average length of stay per hospitalization) and death (and age at death)

Bearing in mind the motivation of the paper and the related literature, we took two dichotomous variables as two of the main outcomes in our analysis: having been admitted to hospital in the last 12 months and having dead between SHARE waves. Moreover, within the case of hospital admission, for those individuals who were admitted, we also analysed the number of times being admitted to hospital and the average length of stay per hospitalization. In case of death, we also used as an outcome the age at the time of death of the deceased respondent.

In case of hospital admission, respondents were asked whether, during the last twelve months, they had been in a hospital overnight. Thus, it took value 1 if the respondent had been in a hospital overnight in the last twelve months and 0 otherwise. If they answered affirmatively, individuals also reported the number of times having stayed overnight in the hospital in the last year, as well as the total length of stay, which we will use as well as outcome measures in the present analysis. However, we modified the variable length of stay. Since the original variable referred to the total number of nights stayed in hospital in the previous twelve months, we calculated the mean length of stay per hospital admission dividing the total number of nights in hospital by the number of times having been admitted to hospital.

Independent variables

Given the scope of the analysis, self-reported information about doctor's diagnosis on individuals' chronic conditions and limitations in ADLs was also included. We used six dichotomous indicators of chronic medical conditions: chronic lung disease, gastric ulcer,

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[1] Hungary, Ireland and Luxembourg are not included due to their small size of sample or because they did not appear in, at least, two waves. Israel has also been dropped from the analysis since it is not a European country.

[2] 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 these Wave 3 was not useful for our analysis.

high cholesterol, hypertension, heart problems (which include heart attack and heart failure), stroke and cancer, in addition to diabetes, which was our main disease of interest. Since we focus on older adults whose main type of diabetes mellitus is type 2 but the dataset does not differentiate between diabetes type, we aimed to identify only those respondents with T2DM by applying the following approach:

1. The first criteria to be identified as having diabetes type 2 was to have answered affirmatively that the respondent had been told by a doctor that s/he suffered from diabetes.
2. Then, we also classified respondents as diabetes type 2 people if they replied they were taking drugs for diabetes.
3. Finally, we used information from the SHARELIFE questionnaire (wave 3) on childhood health to drop those individuals who answered they already suffered from diabetes when they were children.

Furthermore, in order to have some measure of functional impairment, SHARE includes data on the Katz Activities of ADLs Index used since 1963 (Katz et al., 1963), which evaluates functional status as a measurement of the person's ability to carry out six activities of daily living independently (bathing, dressing, toileting, transferring, continence and feeding). Survey respondents were asked about their limitations when carrying out each of these activities. According to their responses, four categories were generated referring to functional impairment: i) no impairment if respondents had no limitation when performing any of the ADLs; ii) mild functional impairment if respondents felt being limited in a maximum of two ADLs; iii) moderate functional impairment if participants perceived they had some limitations in three to five of these activities; and iv) severe functional impairment when individuals were limited in all ADLs.

We also included some sociodemographic variables at their baseline value to deal with endogeneity. Such sociodemographic variables were age, gender, marital and employment status and education level, as well as some healthy lifestyle factors[3] (Body Mass Index categories and being a current smoker). Finally, dummy variables for each European country and wave of SHARE were included.

Summary statistics

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[3] Alcohol consumption was not included in the analysis due to the response bias that could exist given the sensitivity of the topic. Moreover, frequency of alcohol consumption in the last three months reported a high number of missing values (23% of the sample).

In the main analysis, we consider the population aged 50 years old and above. Summary statistics, as well as a comparison of means test, are reported in Table A1, Appendix.

Our sample from SHARE consisted of 73,301 individuals, of whom around 13% of the sample reported to have diabetes.

Hospital admission rates were higher in people with diabetes than in those without the disease (21.97% and 13.42%, respectively), with a higher mean number of times being admitted (1.82 vs 1.63) and a higher length of stay per hospital admission (8.55 days vs 7.05 days) in the previous twelve months. Moreover, death rates were higher in individuals with diabetes (8.14% in people with diabetes vs 4.73% in those without), with a slight younger age at death.

People with diabetes are older (69.56 vs 66.25 years old), less likely to be female (53.75% vs 57.82%) and to be employed (12.97% vs 28.14%) when compared to their counterparts. Moreover, the mean annual household income is lower in respondents with diabetes (24,460.71) than in those who do not suffer from the disease (30,709.27). Individuals with diabetes are more prone to be less educated than those without (6.95% vs 3.80% in case of no education; 18.63% vs 17.50% in case of low secondary education or below) and to be obese (38.80% vs 18.11%). With respect to health and functional status, significant differences were observed between both subsamples, with people with diabetes reporting higher diseases prevalence than the individuals without the disease. For example, the prevalence rate of hypertension, heart problems, stroke and mild functional impairment in people with diabetes were 61.92%, 24.02%, 7.01% and 15.77%, respectively, compared to the group of people without diabetes, which reached 35.37%, 12.14%, 3.21% and 7.9%, respectively.

3. METHODOLOGY

Given the high proportion of people not having been admitted to hospital and people alive, we applied two-part models on both outcomes. Two-part models combine a model for the binary response variable, which would be having been admitted to hospital overnight and having died between SHARE waves, and a model for the outcome variable that is conditioned on the binary response (Farewell et al., 2017), conditional on having stayed in hospital overnight or having died. The outcome variables conditional on the binary response from the first model will be number of times being admitted to hospital and mean length of stay per hospital admission in case of hospitalization, and age at death in case of death.

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

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

where *y** is a latent variable, which would denote having been admitted to hospital (vs no hospital admission) or having died (vs being alive); the vector x_1 denotes its determinants, which would be the independent variables aforementioned; 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 (having been admitted to hospital at least once at least for one day; or having died at a certain age), whereas R = 0 is equivalent to *y** = 0 (not admitted to hospital or alive).

After estimating τ using logit estimation techniques, the second stage involves a Generalized Linear Model (GLM) with Poisson 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:

$$E[y\ |R = 1, x_2] = E[y|y > 0, x_2] = x_2^T \beta + E(\epsilon_2\ |Y > 0, X_2)\ \ \ (2)$$

where x_2 includes the determinants of the dependent variable *y*, which will be the same used as in equation (1); and ϵ_2 is another error term. The expected value of the dependent variable *y* (hospital admission and death) then consists of two parts, with the first part resulting from the first stage (1), $P(y > 0) = \boldsymbol{\Phi}(\boldsymbol{x_1^T}\tau)$, and the second part being the conditional expectation E[y|y > 0] from the second stage (2).

However, given the panel nature of our data (SHARE survey), we can decide between two techniques, fixed-effects and random-effects models, to run the first part of the two-part models of our analyses (Heij et al., 2004; Berrington et al., 2006). Fixed-effects models aim to analyze the causes of changes within an individual. On the contrary, random-effects models do allow time-invariant factors to be associated with the outcome. We will perform a Hausman test on each outcome to choose between the random and the fixed-effects estimation (Greene, 2012)[4].

Taking into account the fact that having been admitted to hospital is a dummy variable, the baseline logistic regression model with fixed-effects for hospital admission is as follows:

$$Pr[HosAdm_{it} = 1\ |x_{it}] = \Lambda(\ \beta_0 +\ \beta_1 SE'_{it} * T_t +\ \beta_2 diabetes_{it} +\ \gamma_c C_c +\ \varphi_t T_t + u_{it})$$

(3 ~~1~~)

where *i* represents the individual, *c* country, and *t* year. $HosAdm_{it}$ is a dummy variable indicating that respondent *i* has been admitted to hospital in the last 12 months in year *t*. Λ

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[4] According to the Hausman test, fixed-effects models should be used for hospital admission and random-effects regression models should be run in case of death as the outcome (see Appendix Table A2).

is the logistic function, $\Lambda(t) = e^t/(1 + e^t)$, with values ranging from zero to one. $x_{it} = (\mathrm{SE}_{\mathrm{it}},\ \mathrm{diabetes}_{\mathrm{it}},\ \text{country dummies, time dummies})'$ is a vector of explanatory variables. $\mathrm{SE}_{\mathrm{it}}$ and $\mathrm{diabetes}_{\mathrm{it}}$ denote the set of socioeconomic variables at baseline and the dummy variable for having diabetes, respectively; γ_c represents the coefficient for the country-specific dummies, having c-1 variables introduced in the model; φ_t is the coefficient for the binary time variable; T_t represents time as a dichotomous variable, having t-1 time periods; and u_{it} denotes the error term.

Four different regression models will be run in this paper. Firstly, Model A adjusted for sociodemographic characteristics (age, gender, marital and employment status, and education level at their baseline values), healthy lifestyle factors (having underweight, overweight or obesity, and being a current smoker at their original values in the first wave of participation) and having diabetes, as well as time and country dummies, as it has been outlined in the explanation of equation (3). In this model, diabetes was the only chronic condition included. In Model B, we also control for non-related diabetes clinical complications, such as chronic lung disease, and gastric ulcer. However, some diseases, which are diabetes-related, are not included. These were included in model C (cancer, cardiovascular risk factors (hypertension and cholesterol), and cardiovascular diseases (heart problems and stroke). Moreover, to also account for the association between diabetes and functional impairment as people get older, we added in Model D the three categories referring to functional impairment, being the reference category no functional impairment: mild, moderate and severe impairment.

Same procedure was followed for our second outcome of interest, having died between SHARE waves, but using random effects specifications. We will evaluate potential differences in the age at death by using Kaplan-Meier survival curves and the log-rank test, which compares survival curves by diabetes status.

To analyze potential differences by socioeconomic status, we will run the estimation also by gender (females and males), age groups (age 50 – 65, 65 – 80 and individuals older than 80 years old), educational level, household income and country groups. Educational level was divided into three different groups: low education (no education and low secondary education), medium education (upper secondary education and non-tertiary education) and high education (short tertiary education and bachelor). Additionally, three diverse groups were generated for household income, creating three quintiles of annual household income: low household income, which ranged from 0€ to 14,135.92€; medium household income, from 14,136.05€ to 29,083.05€; and high household income, with values equal or above 29,084.47€. Finally, countries were grouped according to their geographical area into four groups: Central and Eastern Europe (Czech Republic, Poland, Slovenia); Northern Europe (Denmark, Estonia, Sweden); Southern Europe (Greece, Italy, Portugal, Spain); and Western Europe (Austria, Belgium, Germany, France, The Netherlands, Switzerland).

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

4. EMPIRICAL RESULTS

In this section, we present the estimation results of the effect of diabetes on the probability of having been admitted to hospital in the previous twelve months and the likelihood of having died between SHARE waves and by socioeconomic status.

Diabetes and hospital admission

Table 2 shows the average marginal effects of diabetes for having been admitted to hospital, as well as the coefficient for the number of times having been admitted in the previous twelve months and the mean length of hospital admission per stay. More detailed results on the four regression models and the other covariates can be found in Table A2, Appendix.

Model A shows that a new diagnosis of diabetes[5] between waves is associated with a significant increase in the probability of being admitted to hospital by 1 percentage points (p.p.), the number of hospital admissions by 7.66 percentage points and the mean length of stay per hospital admission by 11.5%. In case non-diabetes related complications are included, Model B, diabetes association effect falls to 0.93 p.p., but still significant. The number of hospital admissions and the average length of stay follow the same trend, whose coefficients for the diabetes variable drop to 7.42% and 11.3%, respectively. Chronic lung disease is associated with an increase in the risk of being hospitalized by 9.24 p.p., but the increase in the number of times being hospitalized increases in a larger amount than in case of diabetes (by 10%) (Table A2, Appendix). The drop in the diabetes effect is greater when clinical complications are included in the analysis, falling to 0.68 p.p., and increasing again to 0.87 p.p. when functional complications are included (Table 2). Diabetes is related to an

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[5] Since fixed-effects logistic regression models are used for hospital admission, average marginal effects could be interpreted as the effect on the probability of being admitted to hospital from a one-unit change in any of the independent variables. That is why when the average marginal effect of diabetes is explained, we refer to a new diabetes diagnosis (that is, changing the value of the diabetes variable from 0 (no diabetes) to 1 (having been diagnosed of diabetes.

increase in the number of times being admitted to hospital by 6.83% and 5.79% in models C and D, respectively. Being diagnosed of diabetes is associated with a higher mean length of stay, in days, by 12.1% in model C and by 9.12% in model D, when both clinical and functional complications are included. In Model C, suffering from cancer is the clinical complication associated with a higher increase in the probability of being admitted to hospital and the number of hospitalizations[6] (Table A2, Appendix). Stroke is the clinical complication associated with the largest effect on the mean length of stay. In Model D, it is severe functional impairment the complication related to the largest increase of the likelihood of hospitalization, as well as the number of times being admitted to hospital and the mean length of stay.

The results show that the potential bias in the estimated association of diabetes and hospital use is reduced when clinical and functional complications are included. This conclusion would be in line with previous findings about diabetes and healthcare resource use among older people (Rodríguez-Sánchez et al., 2017), signaling the overestimation of the diabetes effect if comorbidities are not considered in the analysis (Struijs et al., 2006).

Diabetes and hospital admission by socioeconomic status

When we run the analysis according to gender (Table 2), diabetes is significant and positively related with hospital admission for both women and men in Model A, when diabetes is the only clinical variable included in the estimation. Diabetes is associated with an increase in the risk of being admitted to hospital by 1.15 p.p. in women and 0.76 p.p. in men. When all clinical and functional complications enter the regression (Model D), diabetes is a significant predictor of hospital admission only for women. In females, being diagnosed of diabetes is associated with a higher risk of hospitalization by 0.99 p.p. Severe functional impairment is associated with the higher increase of the probability of being hospitalized, by 5.10 p.p. (Table A3, Appendix). For men, it is also severe functional impairment the main driver of hospital admission, increasing the risk by 4.48 percentage points. In both females and males, diabetes is associated with a greater number of hospital admissions and mean length of stay, with a greater impact on women than men (Table 2).

In case of stratification by age (Table 2), diabetes and hospital admission are significant and positively related only in those individuals aged 50 to 65 years old, but only when diabetes was the only clinical complication included. Diabetes is associated with an increase

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[6] This result should be interpreted with caution as around 5% of the sample has reported to have been diagnosed of cancer. This group of individuals might have had a planned hospitalization for chemotherapy services or any other cancer-related treatment or intervention.

in the risk of being admitted to hospital by 4.83 percentage points. When all clinical and functional complications enter the regression, the main drivers of hospitalization differ between age groups. For the youngest subgroup, moderate functional impairment (AME = 21.8 p.p.) is associated with a higher hospital admission risk (Table A4, Appendix). For those aged 66 to 80 years old, severe (AME = 0.92 p.p.) functional impairment is related to the greatest increase in the probability of hospital admission. Diabetes is significantly associated with the number of hospital admission and the average length of stay in those aged 50 to 65 years old and in people aged 66 to 80 years old, reporting a larger association in the former group (Table 2).

Diabetes stands as a significant predictor of hospital admission for those individuals with low and medium education, but only when clinical and functional complciations are not included (Table 2). Diabetes is associated with an increase in the likelihood by 1.72 p.p. in Model A for low educated individuals and by 1.32 p.p. in medium educated people. When all clinical and functional complications enter the regression, the main drivers of hospitalization also differ across education level. For the low-educated people, cancer (AME = 5.51 p.p.) is the complication associated with the greatest increase in the risk of being admitted to hospital. For the middle-educated subgroup, severe mild functional impairment (AME = 5.87 percentage points) is related to the greatest increase in the probability of hospital admission. In case of the high-educated ones, cancer (AME = 2.21 p.p.) is associated with the largest rise in the probability of hospital admission (Table A5, Appendix). Diabetes is significantly associated with the number of hospital admission and the average length of stay in those with medium education, regardless of the variables included in the regression model. In the low educated survey respondents, diabetes is associated with an increase in the number of hospitalizations.

When we divide the sample according to household income (Table 2), diabetes is significant and positively related with the probability of being admitted to hospital only in those individuals with medium household income in both Models A and D. Diabetes is associated with an increase in the risk of hospital admission by 4.54 and 4.98 percentage points, respectively. When all clinical and functional complications are part of the analysis, significant associations between complications and hospital admission also vary across income groups. In the low-income individuals, severe functional impairment is associated with a higher risk of hospital admission by 1.36 p.p. and by 13.4 p.p. in case of middle-income indiviuals (Table A6, Appendix). On the other hand, cancer (AME = 2.85 p.p.) is associated with the greatest increase in hospitalization risk in the high-income subgroup.

Diabetes is significantly associated with the number of hospital admission and the average length of stay in every household income group, reporting a larger association in the highest household income survey respondents (Table 2).

Hence, our findings are consistent with previous results found in the literature (Nishino et al., 2015), showing that diabetes does vary the risk of being admitted to hospital by socioeconomic group, although the significant impact of diabetes depends on the covariates included in the regression model. However, our results should be interpreted with caution, as we are not trying to disentangle and to understand inequalities in diabetes outcomes (hospital admission and mortality), as it has been previously done in the literature (Sortso et al., 2016; Lamy et al., 2017). If we aim to disentangle inequalities, we could also infer differences in diabetes prevalence and incidence due to the socioeconomic group and how such differences would lead to different patterns of healthcare resources use. In spite of not being fully comparable studies, it could also be concluded from our analyses that the use of healthcare services differs between socioeconomic groups.

Diabetes and hospital admission by country group

When we stratify the sample by country group (Table 2), diabetes and hospital admission are significant and positively related only in those individuals living in Southern and Western European countries, when clinical and functional complications are excluded. Diabetes is associated with an increase in the risk of being admitted to hospital by 3.37 p.p. in Model A in case of Southern European countries and by 0.71 p.p. if Western countries.

When all clinical and functional complications enter the regression, the main drivers of hospitalization differ between countries (Table A7, Appendix). In Central and Eastern European countries, no complication is significantly related to hospital admission likelihood. In Southern and Western European countries, severe functional impairment (AME = 22.7 p.p. in Southern countries and AME = 3.73 p.p. in Western Europe) is associated with a higher hospital admission risk. For those residents in Northern countries, cancer (AME = 1.36 p.p.) is related to the greatest increase in the probability of hospitalization. Diabetes is significantly associated with the number of hospital admission and the average length of stay in every country group, except for Northern European countries, reporting the largest associations in case of people living in Western countries (Table 2).

<u>Diabetes and mortality</u>

Table 3 shows the average marginal effects of diabetes for having died between SHARE waves, as well as the coefficient for the age at death of the deceased. Table A8, Appendix, displays the detailed results from the four models and the whole set of covariates.

Model A shows that having diabetes is significantly associated with an increase in the probability of dying by 2.77 p.p. However, diabetes is not significantly related to the age at death of the deceased (Table 3). In case non-diabetes related complications are included, Model B, diabetes effect falls to 2.72 p.p., but still significant (Table A8, Appendix). Chronic lung disease is associated with a higher risk of death by 3.29 p.p., and with a lower age at death by 0.25 years. The drop in the diabetes effect is greater when clinical complications are included in the analysis, falling to 2.63 p.p. (Table A8, Appendix), and to 2.30 p.p. (Table 3) when functional complications are included. In Model C, suffering from cancer is the clinical complication associated with the largest increase in the probability of death and with the largest decrease in the age at death of the deceased. In Model D, it is severe functional impairment the complication associated with the greatest increase in the mortality risk, as well as with the lowest reduction in the age at death.

Our results show that, although we controlled for clinical and functional complication, diabetes is significantly related with mortality risk, contradicting some authors (Fleetcroft et al., 2017) who concluded that, at least in the United Kingdom, there is a trend in the mortality decline due to diabetes. The difference might be due to country-specific caseness, as the United Kingdom was not included in our analysis.

Diabetes and mortality by socioeconomic status

When we run the analysis according to gender (Table 3), diabetes is significant and positively related with mortality risk for both women and men, regardless of the covariates included. Diabetes is associated with an increase in the death likelihood by 1.89 p.p. (Model A) and 1.64 p.p. (Model D) in women, whereas these coefficients increase to 3.24 p.p. and 2.69 p.p., respectively, in men. In both women and men, severe functional impairment is related to the largest increase in the probability of dying, by 7.11 p.p. and 11.4 p.p., respectively (Table A9, Appendix). However, diabetes is never associated with the age at death, regardless of gender (Table 3).

In case of stratification by age (Table 3), diabetes and mortality are significant and positively related in every age group. Diabetes is associated with an increase in the risk of death by 1.79 p.p. and 1.63 p.p. in models A and D, respectively, in those individuals aged 50 to 65 years old. These effects increase to 5.57 p.p. and 4.64 p.p. among subjects older than 80 years old. Diabetes is not significantly associated with the age at death in any of the age groups. When all clinical and functional complications enter the regression, the main drivers of mortality differ between age groups (Table A10, Appendix). For the youngest subgroup, severe functional impairment (AME = 6.77 p.p.) is associated with a higher risk of death, rising to 21.0 p.p. in those aged 66 to 80 years old and 33.6 p.p. in the oldest subgroup.

Diabetes stands as a significant predictor of death in every educational level group (Table 3). In low educated individuals, diabetes is associated with an increase in the likelihood of dying by 2.18 and 1.56 p.p. in Model A and D, respectively, when all clinical and functional complications are included. In case of middle-educated individuals, diabetes is related to a higher risk of death by 1.97 p.p. only in Model A, but non-significant in Model D, when both clinical and functional complications are part of the analysis. For those people with high education, diabetes is associated with an increase of the odds of dying by 1.39 and 1.27 p.p. Diabetes is never significantly associated with the age at death in the education groups. When all clinical and functional complications enter the regression, the main drivers of mortality also differ across education level (Table A11, Appendix). For low and high-educated individuals, severe functional impairment (AME = 10.2 in case of low educated individuals; and AME = 4.99 in people with high education) is the complication associated with the greatest increase in the risk of dying.

When the sample is divided by household income (Table 3), diabetes is significant and positively related with the probability of death in every household income group. In low income individuals, diabetes is related to an increase in the likelihood of dying by 3.26 and 2.73 p.p. in Model A and D, respectively, when all clinical and functional complications are included. In case of people with medium household income, diabetes is related to a rise in the risk of death by 3.72 and 3.16 p.p., respectively. For those people with high income, diabetes is associated with an increase the odds of dying by 1.43 and 1.06 p.p. Diabetes is significantly associated with the age at death in both people with medium and high household income, but with opposite sign: in case of the former, suffering from diabetes increases the age at death, whereas in case of those with high household income, having diabetes is associated with an earlier age at death. When all clinical and functional complications enter the regression, the main drivers of mortality also vary across household income group (Table A12, Appendix). For all household income level, severe functional impairment (AME = 20.1 p.p. in case of low-income individuals; AME = 20.4 p.p. in people with medium household income and AME = 10.4 p.p. in high-income people) is the complication associated with the greatest increase in the risk of dying.

As it has been mentioned when discussing the results on diabetes and hospital admission by socioeconomic group, also in case of mortality, our aim is not to disentangle the pathway between socioeconomic status and morbidity, which might lead to death. However, our results might be comparable in terms of the association between socioeconomic status and risk of mortality with the results obtained by Sortso et al. (2016; 2018). The authors found that individuals with high education and income have lower risks of death than those with short education and low income, respectively.

Figure 1 shows the Kaplan-Meier curves for the age at death by diabetes status by population group. In case of people aged 65 years old and above, individuals with diabetes die before than healthy people[7]. Our results would contradict those previously reported in the literature among European populations concluding that mortality trends in people with diabetes depend on socioeconomic position, with greater inequalities between genders (Espelt et al., 2011). We found no statistical differences in the age at death by gender, education or income; we did find differences in terms of age.

Diabetes and mortality by country group

When the analysis is made by country group (Table 3), diabetes and mortality risk are significant and positively related in every country group, regardless of the covariates included in the analysis. Diabetes is associated with an increase in the risk of dying by 2.70 p.p. in Model A in case of Central & Eastern European countries and by 2.25 p.p. in Model D. In Northern countries, diabetes is related to a higher probability of death by 2.89 and 2.34 p.p. in Models A and D, respectively. The largest association between diabetes and mortality risk is shown in Southern countries, where diabetes is associated with an increase in the death risk by 4.48 and 3.66 p.p., respectively. Finally, in Western countries, diabetes is related with a higher probability of dying by 1.87 and 1.61 p.p. in Model A, when diabetes is the only clinical variable included, and Model D, when all functional and clinical complications are included. No significant association between diabetes and age at death is reported in any group of countries.

When all clinical and functional complications enter the regression, the main driver of higher risk of death within th listed complications is severe functional impairment (Table A13, Appendix), although its average marginal effect ranges from 16.8 p.p. in Western countries to 21.5 p.p. in Southern countries.

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[7] Healthy people refers to the healthy individuals with no diabetes nor any other chronic disease included in the analysis (chronic lung disease, gastric ulcer, cancer, high blood pressure, cholesterol, heart problems, stroke, mild functional impairment, moderate functional impairment, and severe functional impairment).

5. CONCLUSIONS

Diabetes is significantly related to both outcomes, the risk of death and hospital admission, with significant differences across socioeconomic groups and countries. Moreover, our results also show that such differences are also observed in specific characteristics of hospitalization (number of hospital admission and mean length of stay per hospitalization) and death (age at death of the deceased).

We have demonstrated that the effect of diabetes on hospital utilization and mortality is influenced by clinical and functional complications. We have observed differences by socioeconomic status: higher odds of hospital admission are found in women with diabetes, individuals whose age range between 50 to 65 years old or people with medium educational level and household income. Some studies have already reported that, after controling for need, the use of healthcare resources is greater among higher-income groups (van Doorslaer et al., 2004a; 2004b). Moreover, some studies among older populations have also shown differences in healthcare use by income (Merlo et al., 2003; Allin et al., 2006) and education (Santos-Eggimenn et al., 2005). On the other hand, males, older people, low educated people and individuals with medium household income are associated with greater mortality risk. The differences between effects education and income, which might be used as indicators of socioeconomic status, may reflect reverse causality, with incomes being influenced by the individuals´ morbidity status. However, the reverse causality between education and morbidity should be lower, since the education level might have been acquired before the morbidity appears. More research will be needed to confirm our interpretation because there were mixed reactions to this econometric analysis. Still, previous authors have confirmed the gender differences that have been found in terms of diabetes outcomes, suggesting that men have higher mortality rates (Gregg et al., 2007; Kivimäki et al., 2018), whereas women show to be more likely to he admitted to hospital (Schneider et al., 2016). Such disparities between males and females could be due to variations in diabetes severity (Kautzky-Willer et al., 2016; Kivimäki et al., 2018) with respect to lifestyles and diabetes-related complications.

Broadly, several implications can be obtained from the above findings. First, differences in the effect of diabetes with regards to comorbidity and clinical and functional complications should be widely studied due to their role in rising cost of diabetes. Second, special attention should be paid to people in advancing age and with low socioeconomic status, confirming the empirical results reported by previous authors (Reisig et al., 2007; Fleetcroft et al., 2017). Further analyses could aim to disentangle the reverse pathway between socioeconomic status and morbidity to get rid of endogeneity issues that could be present in the associations analysed in the current paper. Measurement and understanding of socioeconomic inequalities in health and health care are critical for achieving higher equity in health care (Sortso et al., 2016; 2017).

Hence, the consistency of our findings across countries included in SHARE would be of great relevance for governments and policymakers to be aware of diabetes burden on health outcomes among older adults, especially on hospital admission, as nearly 35–40% of diabetes-related costs are associated with the management of vascular complications and hospital admission (Clarke et al., 2010). Moreover, comorbidity should not be neglected when assessing diabetes impact, as we have shown that clinical complications play a key role lowering potential bias, but functional impairment should not be excluded either: being limited in the activities of daily living increases diabetes-related costs of care by three folds compared with costs of those who are independent in old people (Sinclair et al., 2015). Without controlling for diabetes-related conditions and functional impairment as we are doing in the current analysis, the estimated coefficients could be imprecise due to endogeneity, as those obtained in model A, which excludes those variables.

However, some limitations should also be mentioned. Firstly, data on clinical conditions, such as diabetes, is self-reported by respondents, possibly leading to recall bias and the results could either over or underestimate the real impact of diabetes and other self-reported covariates on both outcomes. However, data from health conditions collected using self-reported information is reliable according to the existing literature (Goebeler et al., 2007; Dal Grande et al., 2012). Secondly, some authors (Norlund et al., 2001; Rodríguez-Sánchez and Cantarero-Prieto, 2017) have already reported that, when evaluating the effect of diabetes, researchers should consider the role of endogeneity. Nevertheless, we did not have more detailed information about diabetes (family history or time since diagnosis) in SHARE dataset, which could be implemented in further research using additional data. Thus, what we have done is using other health factors which could be related to the development of diabetes, such as having overweight or obesity, smoking habits and a set of clinical and functional complications, which have been described before. Thirdly, quality of the data collected is assured, controlling for potential differences between countries. Response rates between countries in SHARE data range from 40.3% in Belgium to 97.6% in France during wave 1 (Bergmann et al., 2017). Moreover, the quality of the data collection is guaranteed across countries through what has been called the “Train-a-trainer” program. Within this program, interviewers are explained the importance of working the sample completely to reduce non-response rates and the importance of the representativeness in the random sample. In many countries, incentives schemes were applied to ensure interviewers´ motivation, who were even paid for lower non-response rates. Furthermore, to reduce any potential bias from the data collection process, at the beginning of the development of the SHARE data, a sampling weight was designed and applied to every subsequent collection of data. By doing so, oversampling of some populations or countries would be minimized, although it is true that in many European countries there either exist no national sampling frame or access to a national sampling frame.

Achieving lower inequalities in diabetes among old people are likely to require complex interventions as they might require integrated care between the different healthcare providers and professionals. An appropriate provision of medical advice and attention, such as diabetes management, could also help to reduce inequalities in terms of quality of care and also decrease preventable hospitalizations (Bachmann et al., 2003; Espelt et al., 2011; Fleetcroft et al., 2017).

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TABLES

Table 1: Summary Statistics for the whole sample and by diabetes status[8]

VARIABLES	**Whole sample (N = 173,208)**	**People with diabetes (N = 21,584)**	**People without diabetes (N = 151,624)**	**Comparison of means** p-value
Hospital use				
Hospital admission	14.52	21.97	13.42	0.000***
Number of times admitted to hospital, if admitted (SD)	1.67 (1.51)	1.82 (1.63)	1.63 (1.48)	0.000***
Length of stay per hospital stay, if admitted (SD)	7.34 (11.96)	8.55 (14.00)	7.05 (11.39)	0.000***
Death				
Dead	5.17	8.14	4.73	0.000***
Age at death, if dead (SD)	79.47 (9.94)	78.78 (9.19)	79.65 (10.11)	0.000***
Diabetes	12.88	-	-	
Age (SD)	66.67 (9.82)	69.56 (9.24)	66.25 (9.83)	0.000***
Female	57.29	53.75	57.82	0.000***
Married	70.26	66.89	70.75	0.000***
Employment status				0.000***
Retired	56.61	67.25	55.03	
Employed	26.19	12.97	28.14	
Disabled	3.23	5.21	2.93	
Education				0.012**
No education	4.21	6.95	3.80	
Low secondary education	17.65	18.63	17.50	
Upper secondary education	31.08	27.78	31.57	
Non-tertiary education	4.25	3.73	4.33	
Short tertiary education	20.25	13.81	21.20	
Bachelor	0.74	0.50	0.78	
Household income (SD)	29,904.54 (50,833.32)	24,460.71 (39,517.04)	30,709.27 (52,250.81)	0.000***
Body Mass Index (BMI) categories				0.000***
Underweight	1.15	0.47	1.26	

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[8] Means are presented as percentages, unless indicated otherwise.

VARIABLES	**Whole sample (N = 173,208)**	**People with diabetes (N = 21,584)**	**People without diabetes (N = 151,624)**	**Comparison of means** p-value
Normal weight	36.26	19.60	38.72	
Overweight	41.81	41.13	41.91	
Obesity	20.78	38.80	18.11	
Current smoker	15.31	12.64	15.70	0.000***
Chronic conditions				
Chronic lung disease	5.69	8.40	5.29	0.000***
Gastric ulcer	4.58	5.65	4.42	0.000***
Cancer	4.76	5.68	4.63	0.000***
Hypertension	38.79	61.92	35.37	0.000***
Cholesterol	23.40	40.19	20.92	0.000***
Heart problems	13.67	24.02	12.14	0.000***
Stroke	3.70	7.01	3.21	0.000***
Functional impairment				0.000***
No ADL impairment	89.28	80.14	90.63	
Mild ADL impairment	8.91	15.77	7.90	
Moderate ADL impairment	1.15	2.66	0.92	
Severe ADL impairment	0.65	1.42	0.54	
Countries				0.000***
Austria	6.99	6.64	7.04	
Germany	6.63	6.81	6.60	
Sweden	6.84	5.43	7.05	
The Netherlands	5.12	3.97	5.29	
Spain	8.28	10.97	7.89	
Italy	7.75	7.80	7.74	
France	8.56	7.59	8.93	
Denmark	6.90	3.88	6.27	
Greece	3.77	3.25	3.84	
Switzerland	5.26	2.94	5.61	
Belgium	9.62	8.09	9.85	
Czech Republic	7.63	11.05	7.13	

VARIABLES	**Whole sample (N = 173,208)**	**People with diabetes (N = 21,584)**	**People without diabetes (N = 151,624)**	**Comparison of means** p-value
Poland	2.17	2.29	2.16	
Portugal	1.23	2.01	1.12	
Slovenia	3.57	3.80	3.53	
Estonia	7.79	8.03	7.75	
Waves				0.000***
Wave 1 (year 2004)	11.44	8.51	11.86	
Wave 2 (year 2006/07)	16.87	15.19	17.12	
Wave 4 (year 2010)	24.89	24.98	24.88	
Wave 5 (year 2013)	30.62	32.56	30.34	
Wave 6 (year 2015)	16.18	18.76	15.80	

Note: Sample of respondents aged 50 – 105.4. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Two-part model: results of the effect of diabetes from the fixed-effects logit model for having been admitted to hospital in the last twelve months and the GLM models for the number of times being admitted to hospital and the average length of stay per hospitalization

ALTERNATIVE SAMPLES BY SOCIODEMOGRAPHIC CHARACTERISTICS	**Average Marginal Effects on the probability of having been admitted to hospital Model A**	**Coefficient on the number of times having been admitted to hospital Model A**	**Coefficient on the mean length of hospital admission stay Model A**	**Average Marginal Effects on the probability of having been admitted to hospital Model D**	**Coefficient on the number of times having been admitted to hospital Model D**	**Coefficient on the mean length of hospital admission stay Model D**
Whole Sample (N(obs) = 173,208; N(individuals) =73,301)	0.00993***	0.0766***	0.115***	0.00870**	0.0579***	0.0912***
	(0.00331)	(0.0153)	(0.0272)	(0.00397)	(0.0152)	(0.0269)
Gender						
Female (N(obs) = 99,194; N(individuals) =40,765)	0.0115**	0.0778***	0.0335	0.00987*	0.0596***	0.0104
	(0.00500)	(0.0208)	(0.0369)	(0.00543)	(0.0210)	(0.0369)
Male (N(obs) = 74,014; N(individuals) =32,536)	0.00758*	0.0752***	0.213***	0.00665	0.0544**	0.190***
	(0.00412)	(0.0227)	(0.0397)	(0.00574)	(0.0221)	(0.0390)
Chow-test p-value for significant differences between genders	0.019**			0.030**		
Age group						
Age 50 - 65 (N(obs) = 83,390; N(individuals) =41,964)	0.0483**	0.107***	0.118**	0.0339	0.0874***	0.122**
	(0.0230)	(0.0284)	(0.0534)	(0.0227)	(0.0281)	(0.0553)
Age 65 - 80 (N(obs) = 71,146; N(individuals) =36,038)	0.000666	0.0552***	0.136***	0.000214	0.0350*	0.0936***
	(0.000849)	(0.0212)	(0.0353)	(0.00123)	(0.0208)	(0.0341)
Age 80+ (N(obs) = 18,672; N(individuals) =10,436)	0.00115	0.0697*	0.0515	0.00143	0.0532	0.0214
	(0.00146)	(0.0359)	(0.0671)	(0.00347)	(0.0366)	(0.0656)
Chow-test p-value for significant differences between age groups	0.002***				0.087*	
Education group						
Low edu. (N(obs) = 38,142; N(individuals) =16,240)	0.0172*	0.0847***	0.0994*	0.0124	0.0588*	0.0809
	(0.0102)	(0.0304)	(0.0563)	(0.00986)	(0.0305)	(0.0564)
Medium edu. (N(obs) = 61,231; N(individuals) =26,264)	0.0132*	0.0853***	0.100**	0.0113	0.0666**	0.0781**
	(0.00734)	(0.0274)	(0.0399)	(0.00856)	(0.0271)	(0.0398)
High edu. (N(obs) = 35,983; N(individuals) =15,134)	0.00649	0.0526	0.210***	0.00363	0.0286	0.167**
	(0.00613)	(0.0407)	(0.0808)	(0.00542)	(0.0390)	(0.0737)
Chow-test p-value for significant differences between education groups	0.033**			0.054*		
Household income group						
Low inc. (N(obs) = 60,075; N(individuals) =37,988)	0.00276	0.0600**	0.114***	0.00156	0.0395	0.105***
	(0.00196)	(0.0245)	(0.0406)	(0.00207)	(0.0241)	(0.0406)
Medium inc. (N(obs) = 58,620; N(individuals) =36,851)	0.0454**	0.0692***	0.0899**	0.0498**	0.0540**	0.0647
	(0.0210)	(0.0246)	(0.0445)	(0.0230)	(0.0247)	(0.0440)
High inc. (N(obs) = 59,757; N(individuals) =34,156)	-0.00659	0.112***	0.147**	-0.0115	0.0888***	0.109*
	(0.00751)	(0.0316)	(0.0599)	(0.00988)	(0.0315)	(0.0625)
Chow-test p-value for significant	0.008***			0.016**		

ALTERNATIVE SAMPLES BY SOCIODEMOGRAPHIC CHARACTERISTICS	**Average Marginal Effects on the probability of having been admitted to hospital Model A**	**Coefficient on the number of times having been admitted to hospital Model A**	**Coefficient on the mean length of hospital admission stay Model A**	**Average Marginal Effects on the probability of having been admitted to hospital Model D**	**Coefficient on the number of times having been admitted to hospital Model D**	**Coefficient on the mean length of hospital admission stay Model D**
differences between household income groups						
European country group						
Central & Eastern Europe (N(obs) = 23,542; N(individuals) =10,745)	0.00584	0.0662*	0.137**	0.00468	0.0484	0.124**
	(0.00522)	(0.0382)	(0.0626)	(0.00530)	(0.0379)	(0.0587)
Northern Europe (N(obs) = 36,132; N(individuals) =15,163)	0.00390	0.0448	0.0752	0.000713	0.0253	0.0890
	(0.00381)	(0.0349)	(0.0799)	(0.00287)	(0.0343)	(0.0803)
Southern Europe (N(obs) = 37,023; N(individuals) =16,301)	0.0337*	0.103***	0.0564	0.0374	0.0715**	0.00363
	(0.0185)	(0.0333)	(0.0534)	(0.0231)	(0.0329)	(0.0541)
Western Europe (N(obs) = 74,252; N(individuals) =29,384)	0.00713*	0.0790***	0.149***	0.00664	0.0684***	0.124***
	(0.00426)	(0.0234)	(0.0419)	(0.00542)	(0.0231)	(0.0421)
Chow-test p-value for significant differences between household income groups	0.045**			0.061*		

Standard errors[9] in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Reference categories: No diabetes, other marital status different from married, unemployed or homemaker, no education, normal weight, no functional impairment, wave 1, Germany.
Model A adjusted for the interaction between sociodemographic characteristics at their baseline values (age, gender, marital and employment status and education level) and healthy lifestyle factors (having underweight, overweight or obesity, and being a current smoker) and time dummies; and having diabetes, as well as time and country dummies. In Model B, we also control for non-related diabetes clinical complications, such as chronic lung disease and gastric ulcer. Diabetes-related conditions were included in model C (cancer, cardiovascular risk factors (hypertension and cholesterol), and cardiovascular diseases (heart problems and stroke). Moreover, in Model D the three categories referring to functional impairment (mild, moderate and severe impairment) were added.

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[9] Clustering standard errors implies that we are assuming independence across clusters (which would be survey respondents in our case), but correlations within clusters (Heij et al., 2004). Moreover, clustering standard errors will lead to larger confidence intervals and, thus, fewer variables being statistically significant in the regression models. For example, for one regressor, clustering standard errors will increase the default standard error (that is, without clustering) by $\sqrt{1\rho_x\rho_\varepsilon(\bar{N}-1)}$, where ρ_x is the within-cluster (within-individuals) correlation of the regressor, ρ_ε is the within-cluster (within-individuals) error correlation and N is the average cluster size.

Table 3: Two-part model: results of the effect of diabetes from the random-effects logit model for having died between SHARE waves and the GLM models for age at death of the deceased

ALTERNATIVE SAMPLES BY SOCIODEMOGRAPHIC CHARACTERISTICS	**Average Marginal Effects on the odds of having died Model A**	**Coefficient on the age at death Model A**	**Average Marginal Effects on the odds of having died Model D**	**Coefficient on the age at death Model D**
Whole Sample	0.0277***	-0.00506	0.0230***	0.0297
(N(obs) = 142,378; N(individuals) =69,595)	(0.00265)	(0.0967)	(0.00256)	(0.0977)
Gender				
Female (N(obs) = 78,810; N(individuals) =38,525)	0.0189***	0.0947	0.0164***	0.119
	(0.00252)	(0.133)	(0.00254)	(0.132)
Male (N(obs) = 63,658; N(individuals) =31,070)	0.0324***	-0.0774	0.0269***	-0.0297
	(0.00339)	(0.133)	(0.00337)	(0.135)
Chow-test p-value for significant differences between genders	0.000***		0.004***	
Age group				
Age 50 - 65 (N(obs) = 83,390; N(individuals) =41,964)	0.0179***	0.0906	0.0163***	0.102
	(0.00300)	(0.227)	(0.00302)	(0.227)
Age 65 - 80 (N(obs) = 71,146; N(individuals) =36,038)	0.0359***	-0.0492	0.0280***	0.0197
	(0.00436)	(0.126)	(0.00411)	(0.128)
Age 80+ (N(obs) = 18,672; N(individuals) =10,436)	0.0557***	0.0684	0.0464***	0.0965
	(0.0112)	(0.146)	(0.0111)	(0.147)
Chow-test p-value for significant differences between age groups	0.038**		0.047**	
Education group				
Low edu. (N(obs) = 38,142; N(individuals) =16,240)	0.0218***	0.0795	0.0156***	0.116
	(0.00446)	(0.181)	(0.00448)	(0.183)
Medium edu. (N(obs) = 61,231; N(individuals) =26,264)	0.0197***	0.222	0.0173	0.230
	(0.00324)	(0.199)	(0.002)	(0.203)
High edu. (N(obs) = 35,983; N(individuals) =15,134)	0.0139***	-0.0238	0.0127***	-0.0141
	(0.0032)	(0.193)	(0.0027)	(0.309)
Chow-test p-value for significant differences between education groups	0.053*		0.061*	
Household income group				
Low inc. (N(obs) = 54,178; N(individuals) =31,964)	0.0326***	-0.0347	0.0273***	-0.0210
	(0.00487)	(0.123)	(0.00478)	(0.126)
Medium inc. (N(obs) = 58,620; N(individuals) =36,851)	0.0372***	0.195	0.0316***	0.278*
	(0.00429)	(0.145)	(0.00412)	(0.148)
High inc. (N(obs) = 59,757; N(individuals) =34,156)	0.0143***	-0.394*	0.0106***	-0.387*
	(0.00331)	(0.206)	(0.00318)	(0.203)
Chow-test p-value for significant differences between household income groups	0.000***		0.000***	
European country group				
Central & Eastern Europe	0.0270***	-0.00709	0.0225***	0.156

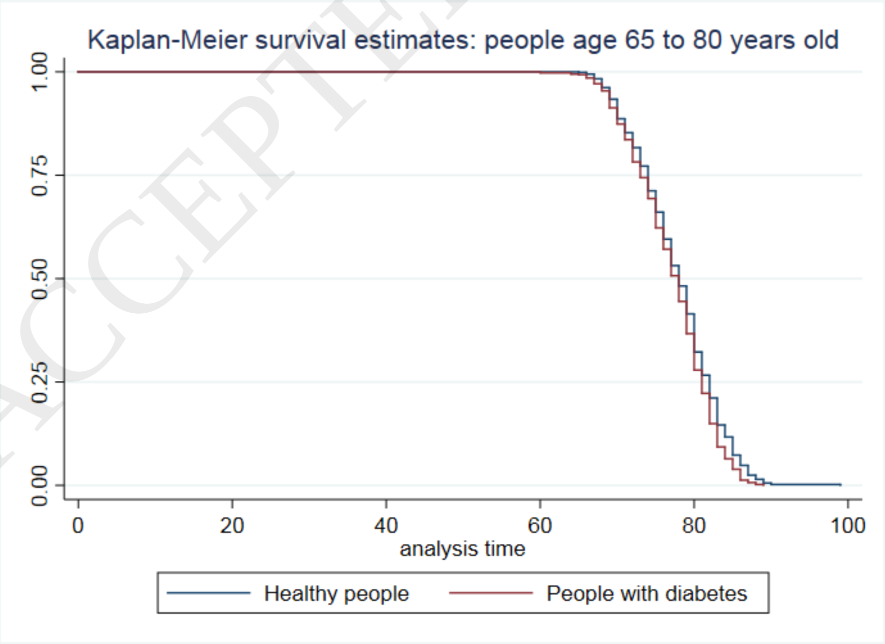
ALTERNATIVE SAMPLES BY SOCIODEMOGRAPHIC CHARACTERISTICS	Average Marginal Effects on the odds of having died Model A	Coefficient on the age at death Model A	Average Marginal Effects on the odds of having died Model D	Coefficient on the age at death Model D
(N(obs) = 23,542; N(individuals) =10,745)	(0.00614)	(0.186)	(0.00590)	(0.197)
Northern Europe (N(obs) = 36,132; N(individuals) =15,163)	0.0289*** (0.00663)	0.0239 (0.193)	0.0234*** (0.00644)	0.0206 (0.191)
Southern Europe (N(obs) = 37,023; N(individuals) =16,301)	0.0448*** (0.00637)	-0.115 (0.170)	0.0366*** (0.00610)	-0.103 (0.168)
Western Europe (N(obs) = 74,252; N(individuals) =29,384)	0.0187*** (0.00379)	0.146 (0.188)	0.0161*** (0.00371)	0.183 (0.191)
Chow-test p-value for significant differences between household income groups	0.002***		0.013**	

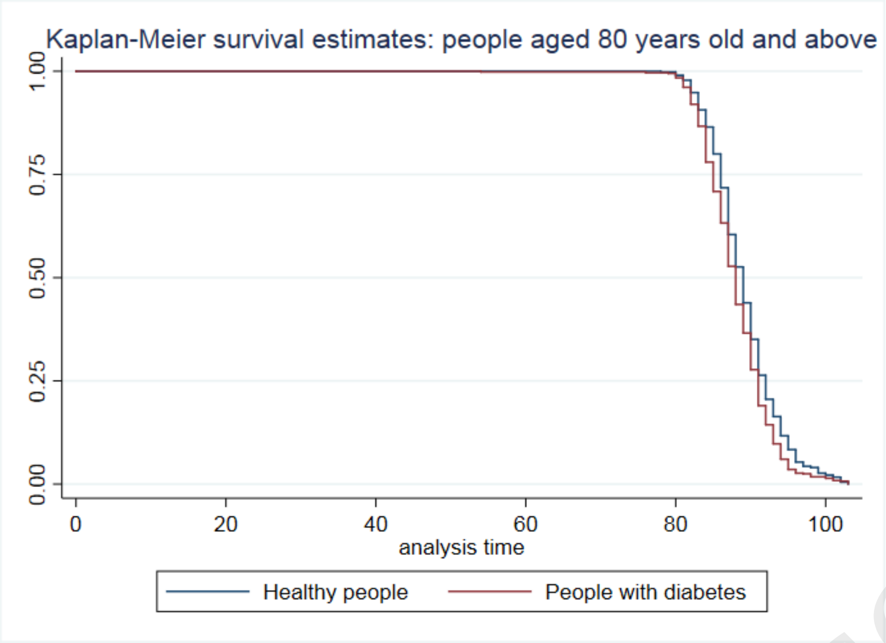
Standard errors in parentheses[9]. *** p<0.01, ** p<0.05, * p<0.1

Reference categories: No diabetes, other marital status different from married, unemployed or homemaker, no education, normal weight, no functional impairment, wave 1, Germany.

Model A adjusted for the interaction between sociodemographic characteristics at their baseline values (age, gender, marital and employment status and education level) and healthy lifestyle factors (having underweight, overweight or obesity, and being a current smoker) and time dummies; and having diabetes, as well as time and country dummies. In Model B, we also control for non-related diabetes clinical complications, such as chronic lung disease and gastric ulcer. Diabetes-related conditions were included in model C (cancer, cardiovascular risk factors (hypertension and cholesterol), and cardiovascular diseases (heart problems and stroke). Moreover, in Model D the three categories referring to functional impairment (mild, moderate and severe impairment) were added.

Figure 1 Kaplan-Meier survival curves for age at death by diabetes status





Healthy people refers to the healthy individuals with no diabetes nor any other chronic disease included in the analysis (chronic lung disease, gastric ulcer, cancer, high blood pressure, cholesterol, heart problems, stroke, mild functional impairment, moderate functional impairment, and severe functional impairment).