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Long-Term Care Around the Globe

Diabetes-Associated Factors as Predictors of Nursing Home Admission and Costs in the Elderly Across Europe

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ABSTRACT

Keywords:

Nursing home
institutionalization
diabetes
elderly
complications
functional impairment

Objective: To identify the main factors associated with the use of nursing home facilities and to calculate their costs among older people with diabetes in Europe.

Methods: The sample included 48,464 individuals aged 50 years and older in 12 European countries participating in the Survey of Health, Aging, and Retirement in Europe study from 2004 to 2010. Cost data were obtained from the Organization for Economic Cooperation and Development and the World Bank. Logit regressions were used to assess the impact of diabetes, comorbidities, and functional status on the frequency of nursing home admission. Etiologic fractions were calculated to obtain the nursing home costs attributable to diabetes and its clinical and functional complications.

Results: Diabetes is a predictor for institutionalization. When adjusted for clinical and functional complications, impairment of physical function [mild: odds ratio (OR) 3.27; 95% confidence interval (CI) 2.60–4.19; moderate: OR 8.48, 95% CI 6.02–13.09; severe: OR 12.53, 95% CI 8.03–19.98] and cognition (OR 2.00, 95% CI 1.60–2.68), as well as stroke (OR 2.08, 95% CI 1.61–2.80) showed the strongest association with increased risk of institutionalization. Moreover, this relationship between diabetes, function, and cost was age-dependent, increasing as people get older. Total average nursing home costs incurred by patients with diabetes reached nearly US \$13/capita, ranging between countries from US \$61 to \$0.5. Diabetes-related complications accounted for one-third of these costs (US \$4) and, of these, 78% resulted from functional impairment.

Conclusions: Diabetes is associated with higher risk of institutionalization even after adjusting for complications. Among them, functional impairment explains the major part of the association between diabetes and nursing home admission and leads to increasing costs.

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Traditionally, the social impact of diabetes has been linked to the use of healthcare and social resources. Medical costs for patients with diabetes are up to 3 times higher than for patients without the

disease.¹ According to a recent report by the American Diabetes Association² (ADA), in the United States (US) the costs of diabetes have increased from \$135 billion in 2007 to \$176 billion in 2012 because of an increase in diabetes prevalence. This estimation is in line with another US study, which reports that the average yearly expenditure per capita for an older diabetes patient lies between \$3407 and \$9713.³

Although in low- and middle-income countries diabetes affects the younger populations,^{4,5} in high-income countries, the prevalence of diabetes is more prominent among older people and is rapidly increasing over time.⁶ As the population ages, and there are higher costs per capita with advancing age,⁷ the scenario for the next decades shows an increase in the costs associated to the management of people with diabetes. These increasing costs constitute a new challenge for health systems.^{8,9}

The authors declare no conflicts of interest.

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Use of healthcare resources because of diabetes typically include visits to physicians and nurses, drug treatments, visits to the emergency department, and hospitalization.¹⁰ However, 2 other components usually neglected should be added to the costs of diabetes among older people: functional impairment and institutionalization. Diabetes among older people significantly increases the risk to be dependent^{11,12} and to be institutionalized.¹³ Evidence from the US shows that diabetes is a predictor of nursing home placement among the frail elderly and old people with diabetes are 1.8 times more likely to be institutionalized.¹⁴ Moreover, around 30%–35% of institutionalized older people have diabetes, a condition associated to a higher resource utilization.¹⁵ However, surprisingly little is known about the role of diabetes mellitus as a determinant of nursing home admission in Europe.

In this study, we extend the previous literature by estimating the effect of diabetes and its related clinical and functional complications on the institutionalization of people aged 50 years and older in 12 European countries, using observational data from Survey of Health, Aging and Retirement in Europe (SHARE), a large panel of elderly Europeans. In addition, we provide country-specific estimates of nursing home expenditures that can be attributed to diabetes and its complications, including functional impairment as one of its components. This approach has been previously used in the reports published by the ADA.¹⁶ However, although those studies estimated an etiologic fraction (EF) for each medical condition regardless of the healthcare resource, we calculated results focusing on nursing home use with specific attention for the role of complications and functional impairments.

Methods

Study Population

Data for this study were obtained from the SHARE study. SHARE is a longitudinal study that includes information about health, socioeconomic status, and family networks of a representative sample of 86,290 individuals aged 50 years and over from 19 European countries and Israel. We limited our study to 12 of those countries, namely Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, The Netherlands, Spain, Sweden, and Switzerland and excluded Estonia, Hungary, Ireland, Israel, Poland, Portugal, and Slovenia because of their small sample size. We pooled data from 3 different waves: wave 1 (2004), wave 2 (2006–2007), and wave 4 (2010), excluding data from Wave 3 since it included information on individuals' childhood health and, hence, such data was not useful for our analysis. Persons in a nursing home are included when one of their family members is in the sample or when they were already included in previous waves.

Data regarding total expenditure for nursing homes per country were taken from the Organization for Economic Cooperation and Development (OECD) data and statistics databases for the survey years (2004, 2006, 2007, and 2010). We 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 were not available for Italy, Sweden, and Greece, therefore, these countries were only included in the first part of our analyses.

Finally, to improve the cross-country comparability of the results, information on gross domestic product for every country and year included in this study was taken from the World Bank. Monetary values are in current US dollars 2010 and adjusted by purchasing power parity index.

Statistical Analyses

We used logit regression models to determine the impact of having diabetes on the likelihood of being admitted to a nursing home either

temporarily or permanently. As we used a panel dataset, we estimated random-effects models with clustered standard errors at the individual level to take into account within individual autocorrelation.^{17–19} First, univariate analyses were performed between the dependent variable and each of the independent variables. Only the variables that were significant (P value of <0.1) in the univariate analysis were included in the multivariate regressions.

Model 1 adjusted for demographic characteristics (age,^{20–25} sex,^{20,21,24,26} marital status,^{21–27} education,^{22,27} number of children,²³ and employment status^{25,28}), socioeconomic status (household income^{22,28}), chronic conditions not related to diabetes, time and country dummies. In this model some diseases, such as cerebrovascular conditions as well as functional impairment, were not included because of their relationship with diabetes. If these complications had been counted in, the gross effect of diabetes would not be measured. Model 2 included clinical complications of diabetes, to evaluate the net impact of diabetes on institutionalization. Models 3 and 4 added functional complications, informal care, and smoking habits. Informal care was considered as a social support variable that might be a confounder in our analysis. Only smoking habits were included in the third and fourth regression as health behaviors because of their expected large confounding effect. Smokers have a tendency to die earlier, therefore, have less risk of being institutionalized.

We performed several sensitivity analyses. First, to measure the effect of complications related with diabetes on the outcome, interactions between diabetes and health conditions were included (model 4). Second, because one of the aims of this analysis is to study cross-country differences, regression models 1, 3, and 4 detailed in this section were run by country, rather than using country as a dummy variable. Third, we also ran the analysis by splitting the sample into age groups.

Estimating Nursing Home Costs Attributed to Diabetes and its Clinical and Functional Complications

We estimated the costs of nursing home attributable to diabetes as follows. First, we derived the adjusted relative risks according to the procedure explained by Norton et al in 2014 and 2013^{29,30} from the coefficients estimated in the logit model to calculate the EF for each of the clinical and functional complications associated with diabetes.¹⁶ By doing so, we were able to estimate the excess of nursing home care by people with diabetes that would be avoided if an individual did not have diabetes (or one of its complications).^{2,16} The general formula to calculate the EF was as follows:

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

where EF_d is the EF of healthcare resource use, nursing home use in our study, for each condition d distinguished; P_d represents condition specific prevalence; and RR_d denotes the relative risk of condition d as derived from the regression models. Relative risks were calculated from the ORs using the correction proposed by Norton et al²⁹ (2014); Norton et al (2013)³⁰; and Kleinman and Norton (2009).³¹

Costs in this study were divided into 2 subcategories^{2,16}: (1) gross cost attributable to diabetes (2) and net cost, making a distinction between costs attributed to diabetes and those related to its comorbidities and functional complications.

The former costs can be estimated using the following formula,

$$C_{Dj}^{NH} = EF_D \times C_j^{NH} \quad (2)$$

where C_{Dj}^{NH} denotes the total nursing home costs generated by people with diabetes, EF_D is the EF for diabetes based on model 1,

Fig. 1. Flow chart of diabetes and clinical and functional complications leading to nursing home placement.

and C^{NH} represents the total expenditure on nursing home care for the overall sample and by country j .

To evaluate the net costs attributable to diabetes complications, the following formula was used to run the analysis only for the subsample with diabetes:

$$C_{dj}^{NH} = EF_d \times C_{Dj}^{NH} \quad (3)$$

where C_{dj}^{NH} denotes the total nursing home costs attributed to condition d , EF_d is the EF for condition, or complication d and C_{Dj}^{NH} represents the total expenditure on nursing home care incurred by people with diabetes for the overall sample and by country j . Two countries, Denmark and Switzerland, were also excluded from this analysis because of data failures, in addition to the European nations that were dropped due to the lack of available information on nursing home expenditures.

Disease specific prevalence within the sample and by country is provided in Appendix Table 1 (available online).

Variables of Interest

Appendix Table 2 (available online) presents all variables included in our analysis.

Nursing home, our dependent variable, took value 1 if the respondent had been in a nursing home overnight in the last 12 months, either temporarily or permanently, and 0 otherwise. 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 (Figure 1).

The main independent variables were diabetes as well as the complications that might be related to it. SHARE included self-reported information about individual chronic conditions and functional impairment diagnosed by a doctor. In this analysis, we used 6 dichotomous indicators of chronic medical conditions; they are myocardial infarction, stroke, lung disease, cancer, ulcer, and being cognitively impaired, in addition to diabetes.

Diagnoses (model 2 and model 3) and their interaction with diabetes (model 4) were part of the regression model. Furthermore, SHARE contains responses to the Katz activities of daily living (ADL) index, which evaluates functional status as the person's ability to carry out 6 activities of daily living independently³² (bathing, dressing, toileting, transferring, continence, and feeding). Functional impairment was divided into 4 categories: (1) no impairment if individuals reported no limitation; (2) mild functional impairment when respondents declared being limited in 1 or 2 ADLs; (3) moderate functional impairment if participants described being limited in 3–5 ADLs;

and (4) severe functional impairment when the person reported having difficulties in all ADLs. Dummy variables for the different severity levels of functional impairment were included (model 3), with no limitations being the reference group, as well as their interaction with diabetes (model 4).

Results

Sample Characteristics

Characteristics of the study population according to institutionalization status are shown in Table 1. Furthermore, the table shows a comparison of means test between the 2 groups.

The prevalence of diabetes between those allocated to a nursing home and those who were not differed with 18.49% in the former group to 11.49% in the latter. The results suggest further socioeconomic and health differences between the 2 populations. Those who were admitted to nursing homes were 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 were more common in people who have not been institutionalized.

Worse health status was observed in those respondents who answered yes to the nursing home use question. The same trend was observed for the diseases on their own as well as for the interactions between diabetes and its complications.

Diabetes and Its Complications as Predictors of Nursing Home Use

Table 2 shows the results for the overall sample from the 3 regression models. Model 1 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 (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) and marital status other than being married (OR 1.36) significantly increase the risk of being transferred to a nursing home.

When clinical (Table 2, model 2) and functional complications (Table 2, model 3) 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

Table 1
Sample Characteristics and Comparison of Means Test Between Groups

Variables	Admitted to Nursing Home (N = 441)			No Nursing Home (N = 63386)			Comparison of Means P Value
	Mean (SD)	Min	Max	Mean (SD)	Min	Max	
Age	75.18 (11.91)	50.1	100.1	65.08 (10.33)	50	104.3	.000***
Female (%)	62.32	0	1	56.03	0	1	.012**
High or middle education (%)	38.64	0	1	52.33	0	1	.000***
Married (%)	50.58	0	1	75.42	0	1	.000***
Low household income (%)	36.53	0	1	33.33	0	1	.077*
High household income (%)	30.67	0	1	33.35	0	1	.121
Retired (%)	69.06	0	1	52.01	0	1	.000***
Homemaker (%)	10.43	0	1	11.65	0	1	.99
Household size	1.73 (0.93)	1	7	2.23 (1.03)	1	14	.000***
Number of children	2.07 (1.58)	0	11	2.23 (1.46)	0	17	.095*
Number of grandchildren	3.73 (3.49)	0	20	2.87 (3.26)	0	25	.000***
Children in household (%)	23.96	0	1	37.91	0	1	.000***
Children in less than 5 km (%)	23.20	0	1	22.08	0	1	.11
Diabetes (%)	18.49	0	1	11.49	0	1	.000***
Myocardial infarction (%)	24.15	0	1	12.94	0	1	.000***
Stroke (%)	19.44	0	1	3.85	0	1	.000***
Chronic lung disease (%)	8.70	0	1	5.66	0	1	.002***
Cancer (%)	7.97	0	1	4.91	0	1	.012***
Ulcer (%)	6.04	0	1	5.52	0	1	.780
Cognitive impairment (%)	18.63	0	1	6.61	0	1	.000***
Mild functional impairment (%)	29.38	0	1	8.84	0	1	.000***
Moderate functional impairment (%)	12.71	0	1	1.17	0	1	.000***
Severe functional impairment (%)	11.75	0	1	0.63	0	1	.000***
Current smoker (%)	12.68	0	1	19.16	0	1	.000***
Ever smoked (%)	39.69	0	1	46.50	0	1	.003***
Informal care (%)	43.82	0	1	17.74	0	1	.000***
Austria (%)	6.94	0	1	6.38	0	1	.558
Germany (%)	6.10	0	1	5.69	0	1	.964
Sweden (%)	9.69	0	1	6.14	0	1	.219
The Netherlands (%)	9.33	0	1	6.65	0	1	.044**
Spain (%)	5.14	0	1	6.53	0	1	.059*
Italy (%)	6.22	0	1	7.30	0	1	.935
France (%)	8.73	0	1	9.38	0	1	.586
Denmark (%)	6.82	0	1	5.20	0	1	.300
Greece (%)	7.89	0	1	4.91	0	1	.000***
Switzerland (%)	3.59	0	1	4.95	0	1	.098*
Belgium (%)	11.60	0	1	9.72	0	1	.079*
Czech Republic (%)	7.18	0	1	7.09	0	1	.790
Wave 1 (%)	35.41	0	1	24.49	0	1	.000***
Wave 2 (%)	26.79	0	1	29.16	0	1	.080*
Wave 4 (%)	37.80	0	1	46.35	0	1	.003***

*** $P < .01$; ** $P < .05$; * $P < .10$.

Means of dichotomous variables are expressed as percentages.

nursing home placement are the several levels of functional impairment, with severe functional impairment having the highest OR (OR 12.53).

Marginal effects of the regressors on the probability of nursing home use are displayed in [Appendix Table 3](#) (available online).

Sensitivity Analysis

[Table 2](#) also shows the ORs from the interactions model (model 4). 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.

Finally, results by country are shown in [Appendix Tables 4 and 5](#) (available online). Looking at models 1 and 3, diabetes is only significant in 3 countries: Sweden, The Netherlands, and Spain. Results regarding other diseases and complications vary quite a lot across countries, as do interactions. When the sample is divided by age groups [[Appendix Table 6](#) (available online)], diabetes brings on a significantly higher risk of nursing home admission for those older than age 65 years. Diabetes coefficients are greater in for those older than age 80 years (OR 1.84 in model 1) than in those between ages 66 and 80 years (OR 1.71 in model 1). When clinical and functional

complications are included, diabetes remains a significant predictor only in the oldest subsample (OR 1.45 in model 3).

The Costs of Diabetes and Its Complications

[Table 3](#) shows the results for the adjusted relative risks and the EFs. Results for nursing home costs are shown in [Figure 2](#). Information about total nursing home costs per capita per country and year can be found in [Appendix Table 7](#) (available online).

Total average costs per capita incurred by people with diabetes for nursing home care within the SHARE sample and during the 3 waves reached \$12.66, with one-third of them attributed to complications. The complications associated with diabetes that generate the greatest burden to national nursing home expenditures are functional impairment (\$3.16 in total) and stroke (\$0.45). Costs range from \$61 per capita in The Netherlands to \$0.35 in Czech Republic. In Spain, the costs attributed to diabetes complications are the highest (\$25 per capita attributed to clinical and functional complications).

[Figure 2](#) also reports costs as a percentage of country gross domestic product. Spain shows the largest percentages in which the main drivers of increasing costs are several degrees of functional impairment.

Table 2
Results From the Logit Regressions Regarding Nursing Home Admission for the Overall Sample

Variables	OR Model 1	OR Model 2	OR Model 3	OR Model 4
Diabetes	1.55*** (1.22–1.97)	1.45*** (1.14–1.85)	1.24* (0.98–1.62)	1.10 (0.66–1.83)
Diabetes and chronic lung disease				0.76 (0.34–1.69)
Diabetes and cancer				0.72 (0.30–1.70)
Diabetes and ulcer				0.96 (0.44–2.10)
Diabetes and cognitive impairment				0.67 (0.34–1.32)
Diabetes and myocardial infarction				1.05 (0.62–1.77)
Diabetes and stroke				1.04 (0.55–1.98)
Diabetes and mild functional impairment				1.00 (0.54–1.86)
Diabetes and moderate functional impairment				1.10 (0.46–2.61)
Diabetes and severe functional impairment				1.82 (0.68–4.87)
Diabetes and ever smoked				1.50 (0.89–2.51)
Diabetes and informal care				0.95 (0.56–1.60)
Age	1.07*** (1.06–1.09)	1.07** (1.05–1.08)	1.04*** (1.03–1.06)	1.04*** (1.03–1.05)
Female	0.96 (0.78–1.18)	0.98 (0.80–1.21)	0.92 (0.74–1.16)	0.93 (0.74–1.16)
High or middle education	0.88 (0.70–1.10)	0.89 (0.71–1.11)	0.97 (0.77–1.23)	0.96 (0.76–1.22)
Married	0.53*** (0.42–0.66)	0.53*** (0.42–0.66)	0.58*** (0.46–0.74)	0.57*** (0.45–0.73)
Low household income	0.81* (0.63–1.04)	0.80* (0.62–1.03)	0.81* (0.65–1.08)	0.81* (0.62–1.04)
Retired	0.80* (0.64–1.02)	0.80* (0.63–1.01)	0.92 (0.70–1.14)	0.92 (0.72–1.17)
Household size	0.98 (0.84–1.15)	0.97 (0.83–1.14)	0.93 (0.77–1.09)	0.93 (0.78–1.11)
Number of children	1.01 (0.91–1.12)	1.01 (0.91–1.12)	1.00 (0.90–1.11)	0.99 (0.90–1.10)
Number of grandchildren	0.96* (0.92–1.01)	0.96* (0.92–1.00)	0.96* (0.92–1.00)	0.96* (0.92–1.00)
Children in household	0.81 (0.62–1.05)	0.81 (0.62–1.05)	0.77* (0.58–1.01)	0.77* (0.59–1.01)
Chronic lung disease	1.26 (0.90–1.77)	1.19 (0.85–1.67)	0.96 (0.68–1.37)	1.02 (0.68–1.52)
Cancer	1.42** (1.01–2.00)	1.34* (0.95–1.89)	1.27 (0.92–1.84)	1.35 (0.92–1.99)
Cognitive impairment	2.65*** (2.07–3.37)	2.48*** (1.94–3.16)	2.00*** (1.60–2.68)	2.16*** (1.63–2.86)
Myocardial infarction		1.14 (0.90–1.44)	0.98 (0.77–1.25)	0.96 (0.73–1.28)
Stroke		3.50*** (2.72–4.49)	2.08*** (1.61–2.80)	2.05*** (1.48–2.82)
Mild functional impairment			3.27*** (2.60–4.19)	3.28*** (2.53–4.25)
Moderate functional impairment			8.48*** (6.02–13.09)	8.41*** (5.42–13.04)
Severe functional impairment			12.53*** (8.03–19.98)	10.59*** (6.27–17.91)
Current smoker			0.88 (0.63–1.22)	0.89 (0.64–1.23)
Ever smoked			1.04 (0.81–1.31)	0.96 (0.74–1.25)
Informal care			1.38*** (1.09–1.68)	1.40*** (1.10–1.77)
Observations	90,589	90,589	90,589	90,589
Log pseudolikelihood	–2609.98	–2571.28	–2456.44	–2453.33
Prob > χ^2 interactions				0.8301
Country effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes

95% confidence interval in parentheses: *** $P < .01$, ** $P < .05$, * $P < .1$.

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 nondiabetes-related complications (chronic lung disease, cancer and cognitive impairment). Model 2 adds to the previous model diabetes-related clinical complications: myocardial infarction 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.

Across countries, the main drivers of costs attributed to diabetes vary in some way as shown [Figure 2](#). For most countries, functional impairment seems to be the main determinant of increasing nursing home costs attributed to diabetes. After functional impairment, stroke is the complication with the highest burden on institutionalization costs, especially in France, Belgium, and Czech Republic.

Discussion

We assessed the main drivers of nursing home entry among a representative sample of the European population aged 50 years and older, focusing on diabetes and its related complications. Furthermore, taking the values obtained from the logit regressions, we estimated expenditures on people with diabetes who are institutionalized.

Our results confirm that diabetes is a predictor of nursing home admission. Diabetes increases the risk of institutionalization in the overall sample with an OR ranked second for size of its odds. This relationship between institutionalization and diabetes has been documented in previous studies.^{9,23,24,33,34} However, when clinical and functional complications are included in the regression, diabetes is still significant; its coefficient decreases to an OR of 1.240. Hence, the

effect of diabetes is mediated by its clinical and functional complications. Remarkably, the major factor explaining this association is functional impairment.

None of the interactions between diabetes and clinical and functional complications are statistically significant in the overall sample, contrary to what has been found in previous studies.^{32,35,36} 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 does in Spain. In the adjusted model, diabetes remains a significant predictor of nursing home admission in only 3 countries. Spain reports the highest increasing risk of institutionalization because of diabetes.

Total nursing home cost per capita attributable to diabetes was \$12.66 in the sample during the time period analyzed in this study. The particular condition with the largest contribution was mild severity of functional impairment (\$1.78 per capita). This was quite larger than the complication with the second highest costs, stroke, which accounts for \$0.76 per capita. The same pattern was seen when the estimation was run by country.

Previous researchers have already analyzed the factors associated with nursing home admission among older people after adjusting for

Table 3
ORs, Adjusted RRs, and EFs for Diabetes and Diabetes Nonrelated and Related Clinical and Functional Complications

Variables	OR* Model 1	RR [†] Model 1	EF [‡] Model 1	OR* Model 3	RR [†] Model 3	EF [‡] Model 3	OR* Model 1 Austria	RR [†] Model 1 Austria	EF [‡] Model 1 Austria	OR* Model 1 Austria	RR [†] Model 1 Austria	EF [‡] 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
Myocardial infarction	—	—	—	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* Model 1 Germany	RR [†] Model 1 Germany	EF [‡] Model 1 Germany	OR* Model 3 Germany	RR [†] Model 3 Germany	EF [‡] Model 3 Germany	OR* Model 1 Netherlands	RR [†] Model 1 Netherlands	EF [‡] Model 1 Netherlands	OR* Model 1 Netherlands	RR [†] Model 1 Netherlands	EF [‡] 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
Myocardial infarction	—	—	—	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	—	—	—	—	—	—	—	—	—	—	—	—
Variables	OR* Model 1 Spain	RR [†] Model 1 Spain	EF [‡] Model 1 Spain	OR* Model 3 Spain	RR [†] Model 3 Spain	EF [‡] Model 3 Spain	OR* Model 1 France	RR [†] Model 1 France	EF [‡] Model 1 France	OR* Model 1 France	RR [†] Model 1 France	EF [‡] 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
Myocardial infarction	—	—	—	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* Model 1 Belgium	RR [†] Model 1 Belgium	EF [‡] Model 1 Belgium	OR* Model 3 Belgium	RR [†] Model 3 Belgium	EF [‡] Model 3 Belgium	OR* Model 1 Czech Republic	RR [†] Model 1 Czech Republic	EF [‡] Model 1 Czech Republic	OR* Model 1 Czech Republic	RR [†] Model 1 Czech Republic	EF [‡] 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
Myocardial infarction	—	—	—	0.05	0.040	−0.0799	—	—	—	0.36	1.35	0.05
Stroke	—	—	—	4,1785.38	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	—	—	—	2,774.87	9.43	0.0720	—	—	—	—	—	—
Severe functional impairment	—	—	—	11,227.4	12.29	0.0253	—	—	—	4.01	24.23	0.057

OR, odds ratio; RR, relative risk.

*OR obtained from logit regressions adjusting for age, sex, 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.

[†]Relative risks estimated after running logit regressions using the Stata command *adjrr* (Norton et al 2013).

[‡]EF estimated using formula (1).

Fig. 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 purchasing power parity (PPP) index, current international dollars, followed by percentage of nursing home (NH) costs over gross domestic product (GDP) per capita. 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 (eg, for the whole sample, the costs attributed to mild functional impairment are calculated as follows: $0.1437 \times \$12.66 = \1.82).

functional disability.^{20–27} A recent report showed that the effect of diabetes or stroke on institutionalization disappears after adjusting for functional status,² which is consistent with our results. Furthermore, our expenditure figures may be compared with the estimations provided in the report by ADA (2013).² They concluded that, in the US, 57% of the total costs incurred by people with diabetes are attributed to diabetes. Our estimates concern only nursing home costs and show an even smaller percentage attributable to diabetes at 37.27% of costs; this confirms the relevance of comorbidities when analyzing the economic burden of diabetes.

The methods used to estimate nursing home costs attributable to each disease improved on the methods used by ADA in the 2007 and 2010 diabetes reports^{2,16} because we adjusted for potential bias by including several potential confounders and corrected for disease-specific prevalence in the estimation of relative risk parameters and the EFs. If we had not estimated the adjusted relative risks, our estimation could be overestimating the impact of diabetes and its nonrelated and related clinical and functional complications.

Two main reasons motivated the use of EFs for the calculation of costs. First, EFs allow the researcher to make clearer judgements about causality. Second, they allow considering the “external validity” of the results because EFs force researchers to examine first the relevance of

their results and, then, think about the impact of their results for the society as a whole.³⁷

Some limitations should also be mentioned. First, nursing home residents were not sampled in SHARE. Therefore, only people who moved to a nursing home after the first interview or whose nursing home admission was temporary were included in the survey. Hence, the results that are reported here might underestimate the effect of diabetes and its clinical and functional complications because the nursing home population may be comprised of short-stay patients. Moreover, differences in definitions of nursing home costs and in the organization of the system might impact cross-country differences, as it has been reflected in the large variety of per capita costs. Another limitation is that, although SHARE includes a question about costs and care services, it was not possible to use this information in the present analysis because of 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 were obtained from the Organization for Economic Cooperation and Development for all the countries and years considered, except Sweden, Italy, and Greece. Finally, the self-reported nature of the data, especially about health, together with the missing information regarding some complications (eyesight and renal problems), could potentially bias the results. Nevertheless, this possibility looks

Fig. 2. (continued).

unlikely as the data show strong consistency across waves, and there are several articles confirming the reliability of self-reported health data.^{38,39}

Our study is the first cross-country analysis looking at the burden of diabetes on nursing home use and costs. It is also one of the first to include functional impairment as one of the factors involved in predicting costs associated to diabetes. It is noteworthy that functional impairment does not only help to explain costs; it is the main determinant. Moreover, this relationship between functional status, risk for admission in nursing home, and its associated costs are age-dependent, as they show a clear age gradient. These results are important because policymakers might have had the wrong focus and it might be important to focus on retaining or improving functional status to contain nursing home costs and the possibly related burden on people's quality of life as well as that of their relatives. Diabetes prevalence is increasing and, together with the aging population, its associated costs are predicted to noticeably increase in the coming years. Some general European guidelines have already considered patients with diabetes in nursing homes, but most of them are largely focused on individual's clinical management and not on functional dependency.^{8,40} 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.

Conclusions

Diabetes increases the risk of institutionalization, although the effect of diabetes decreases when clinical and functional complications are included in the regression, thereby reducing its impact on healthcare resources. Moreover, the major factor explaining this association is functional impairment. Overall, total costs per capita incurred by people with diabetes reach \$12.66 in the sample and the time period analyzed in this study, bearing functional impairment the greatest burden of the disease. Two main implications can be drawn from the present analysis: previous studies could overestimate the effect of other comorbidities which have usually been associated with diabetes, and, moreover, policymakers might have had the wrong focus when informing policies and diabetes guidelines, since the main driver of higher costs is functional impairment.

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Supplementary Data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jamda.2016.09.011>.

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