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Article

Socioeconomic inequalities in type 2 diabetes in employed individuals, nonworking spouses and pensioners

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ABSTRACT

Type 2 diabetes (T2D) is a rising global epidemic with lower socioeconomic groups being more affected. Considering specific population subgroups to examine prevalence and socioeconomic inequalities in T2D is rare. Moreover, using one indicator to depict socioeconomic inequalities in health is a common practice despite evidence on differences in what different socioeconomic indicators ought to measure. This study has two aims:

1. Examine the prevalence of T2D in employed individuals, nonworking spouses and pensioners.
2. Examine socioeconomic inequalities in T2D in the three population subgroups and determine the explanatory power of income, education and occupation in employed individuals and nonworking spouses.

This study is based on claims data from a statutory health insurance provider in Lower Saxony, Germany. T2D prevalence in the period between 2013 and 2017 was examined in employed individuals, nonworking spouses and pensioners. Multivariate logistic regression analysis was applied to examine socioeconomic inequalities in T2D in the three population subgroups. Explanatory power of the three socioeconomic indicators was determined by deviance analysis.

Results showed that T2D prevalence was four times higher in male nonworking spouses (24.2%) and 2.6 times higher in female nonworking spouses (12.7%) compared to employed men (6.4%) and women (4.7%) respectively, while it accounted for 40% of men and 36% of women in pensioners. T2D inequalities emerged for all three socioeconomic indicators and were observed in the three subgroups. School education had the highest explanatory power in employed men and women and male nonworking spouses.

Nonworking spouses are an important target group in T2D prevention interventions. The three socioeconomic indicators have independent effects and differ in their explanatory power where low school education appears to be a major risk factor. It can be discussed that health literacy and the associated health behavior play a role in mediating the association between school education and T2D.

Introduction

Type 2 Diabetes Mellitus (T2D) is one of the most prevalent diseases and leading causes of years of life lived with disease worldwide (James et al., 2018). There has been a rising trend in T2D prevalence turning it into a growing global epidemic. As recently estimated by the International Diabetes Federation, the number of people diagnosed worldwide will increase from 463 million in 2019 to 700 million in 2045 leading to a 51% increase in 26 years (International Diabetes Federation, 2019, p. 4). Germany has also reported a rising trend in the prevalence of T2D, where age-standardized prevalence raised from 11% and 12% in 2005 to 15% and 16% in 2014 for men and women respectively (Muschik et al., 2017). However, the relatively high prevalence of T2D is not distributed equally among different socioeconomic groups. Socioeconomic inequalities exist in T2D, with individuals from lower socioeconomic status (SES) groups being more affected (Agardh, Allebeck, Hallqvist, Moradi, & Sidorchuk, 2011). Not only are there socioeconomic variations in the prevalence of T2D, but also in disease management, chronic complications (Kim et al., 2018) and mortality (Rawshani et al., 2016) in T2D patients, making SES an important field of investigation for this

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disease especially when aiming to reduce morbidity and the associated public health burden.

Even though the three indicators education, occupation and income reflect the SES of individuals, they are often used interchangeably when investigating social inequalities in health (Brown, Nevitte, Szeto, & Nandi, 2015; Espelt et al., 2013; Mutyambizi, Booysen, Stokes, Pavlova, & Groot, 2019). Using only one of the indicators as a measure of SES is not rare and can be explained by either lack of information on the three indicators, such as in mortality studies in the UK that are based on information from death certificates (Townsend, Davidson, & M., 1992), or due to sample size limitations that might worsen with more stratified analyses. However, evidence suggests that even when correlated, each of these three indicators measures different aspects of life and thus influence health differently, following different causal mechanisms (Geyer, Hemström, Peter, & Vågerö, 2006; Geyer & Peter, 2000; Lahelma, Martikainen, Laaksonen, & Aittomaki, 2004). This was also supported by recent findings. For example, one study found independent effects of parental education, social class, social status and income on educational attainment (Erikson, 2016), while another one reported independent or "specific" effects of income, occupation, education and class on mortality (Torssander & Erikson, 2010). Moreover, Geyer et al. (2006) investigated effects of the three SES measures on health-related outcomes (all-cause mortality, myocardial infarction, type 2-diabetes) and concluded that there were differences in effect sizes, which also differed among the examined outcomes. Thus, considering all three indicators as measures of SES is essential for obtaining a comprehensive picture of socioeconomic inequalities in T2D. Moreover, determining the explanatory power of the three SES measures in T2D is essential for directing preventive interventions and identifying target groups.

In addition to the importance of considering all three SES indicators when examining socioeconomic inequalities in health, it is also important to distinguish between population subgroups due to possible differences in their demography, lifestyle and exposure to risk factors. Research suggests that different population subgroups have varying risk levels of morbidity and mortality. For example, a study showed that nonworking spouses have higher risks for T2D prevalence compared to employed individuals (Muschik, Jaunzeme, & Geyer, 2015). Moreover, adverse health outcomes such as heart disease and mortality have been shown to be associated with unemployment (Marmot, Theorell, & Siegrist, 2002; Roelfs, Shor, Davidson, & Schwartz, 2011). Differences in the risk of morbidity among different population subgroups may also be due to associated social roles guiding their behaviors. Many studies found a relationship to exist between social roles and health behavior (Hibbard & Pope, 1993; Kuntsche, Astudillo, & Gmel, 2016; McMunn, Bartley, Hardy, & Kuh, 2006; Mize, 2017) with most of them implying a positive association. While nonworking spouses do not have the occupational role and that of "breadwinning" for example, pensioners might face a big change in social roles with some intensifying while others diminishing (Vidovićová, 2018). Since T2D is a disease that is strongly influenced by lifestyle and health-related behavior that, as mentioned, are also affected by social roles, considering population subgroups separately when examining its prevalence and social inequalities is essential. This will help to identify important target groups and starting points for planning T2D preventive interventions. However, studies examining the prevalence and socioeconomic inequalities in T2D among different population subgroups are scant.

This study aims to examine the prevalence of and SES inequalities in T2D while adjusting for the interplay between the different indicators. This study will particularly add to the literature by identifying the explanatory power of the three SES indicators and by stratifying the analyses for three population subgroups. Precisely, this study will:

1. Examine the period prevalence of T2D in three population subgroups of employed individuals, nonworking spouses and pensioners in the time period 2013 to 2017.
2. Consider socioeconomic inequalities in T2D in the three mentioned population subgroups and to determine the explanatory power of income, education and occupation in employed individuals and nonworking spouses.

Methods

Data

While having the choice between statutory and private health insurance providers for individuals above a certain income threshold, the national health insurance system in Germany mandates that all citizens are health-insured. Approximately, 90% of the German population is covered by statutory health insurance with insurance premiums that depend on the level of income (Statistisches Bundesamt, 2016). This study is based on claims data covering the period 2013–2017 of individuals aged 18 and above from the "Allgemeine Ortskrankenkasse Niedersachsen (AOKN)" which is a federal statutory health insurance provider in the state of Lower Saxony, Germany. The AOKN insures around one third of the citizens in Lower Saxony, but has a varying socioeconomic distribution from the population in Germany, with an overrepresentation of lower socioeconomic groups (Jaunzeme, Eberhard, & Geyer, 2013). The data provided by AOKN are primarily collected for accounting purposes. They include anonymized demographic and socioeconomic information, in- and outpatient diagnoses as well as all prescribed medications and in- and outpatient treatments during the insurance period. The insurance population is divided into subgroups according to certain characteristics such as age and working status. This study was performed with three subgroups of the AOKN insurance provider: employed individuals, nonworking spouses and pensioners. In our data, *employed individuals* are defined as individuals in paid employment who are also liable for social insurance. The subgroup *nonworking spouses* includes nonworking spouses of employed individuals. They are insured within the same statutory health insurance provider as their employed spouses and are legally exempted from paying insurance fees. *Pensioners* are individuals who have reached the age of retirement or individuals with early retirement due to health-related reasons. In our data, about 90% of the pensioners are aged 63 years or older.

Definition of T2D cases

Diagnoses in AOKN are coded according to the International Classification of Diseases, version 10 (ICD-10). In ICD-10, diabetes is assigned the codes: E10 – E14 depending on the type. T2D should be assigned the code E11. Due to inaccuracies in coding from the side of the physicians or double coding (different diabetes codes for the same patient), defining T2D cases was performed after having made a number of decisions. First, individuals with E11 diagnoses being most frequently coded (among all diabetes diagnoses throughout the insurance period) were defined as T2D cases. Second, since almost 90% of diabetes cases are type 2 (International Diabetes Federation, 2019, p. 4), the undefined diabetes diagnoses E14 were considered T2D diagnoses when they were the most frequently coded. Third, since type 1 diabetes (E10) always involves insulin-intake, individuals with E10 coded most frequently but without any insulin prescription throughout the whole insurance period were considered T2D cases. T2D cases that had diabetes diagnoses coded in only one quarter in the whole observation period but were insured for longer than one quarter were not considered as eligible cases.

SES indicators

SES was operationalized by means of the three socioeconomic indicators: education, occupation and income. ***Education*** was classified according to the highest achieved level of school education. It was classified in three levels: low (up to 9 years of schooling or no school

diploma), middle (10 years of schooling) and high (12 or 13 years of schooling). Individuals with no school diploma were added to the low school education group since they only represented 2% of the study population. ***Income*** was classified according to the annual average income in Germany (AGI) as reported by the German Federal Statistical Office, accounting for the varying income levels over time. It was classified in three groups: <40% of the AGI (referred to as low in this study), 40% to <80% of the AGI (middle), and ≥80% of the AGI (high). ***Occupation*** was classified according to Blossfeld (Blossfeld, 1987) which developed an occupation classification system. This system originally included 12 groups in which occupations of similar professional sectors, school or vocational training and professional activities are grouped together. In this study, the 12 occupational groups of Blossfeld were summarized into the four groups: unskilled manuals, skilled manuals, specialists and highly qualified based on qualification level and task complexity.

Socioeconomic information in claims data is reported to the statutory health insurance providers by employers who are legally bound to provide information on income, occupation and education annually. This implies that the data lacks SES information for nonworking individuals, with the exception of income for pensioners. In scientific research, assigning SES information from one spouse to another or to family members sharing the same household has been a common practice (Geyer, Peter, & Nielsen, 2004; Gliksman et al., 1995; Lidfeldt, Li, Hu, Manson, & Kawachi, 2007). Even though this practice may not be the best solution due to not taking individual differences into account, it has been supported by the argument of homogamy. Homogamy suggests that individuals who become partners tend to have similar social and educational backgrounds (Blackwell & Lichter, 2004). Regardless of SES, it has also been suggested that spouses share socioenvironmental factors and thus similar health risks and health-related behaviors (Di Castelnuovo, Quacquaruccio, Donati, de Gaetano, & Iacoviello, 2009; Leong, Rahme, & Dasgupta, 2014). The consequences of transferring SES of employed individuals to their spouses in T2D have been examined in an earlier study using the same type of data as in our study. It was shown that employed individuals and their spouses have largely similar occupational education gradients in T2D, and the results were replicable for men and women at two different time points (2005 and 2011) (Muschik et al., 2015). Even though that analysis was done using only occupational education, the results are in favor of this practice in our population. Thus, socioeconomic information of employed individuals was assigned to their nonworking spouses in this study to allow for a socioeconomically stratified comparison between the examined subgroups.

Statistical analysis

Due to differences in insurance durations, the mid-interval population essential for period prevalence calculations was calculated by taking into account the duration of observation of each individual, weighting the denominator according to person-years. Since this study is based on longitudinal data, five-years period prevalence was examined for the latest period available: 2013–2017. Analyses were stratified by population subgroups, education, occupation and income and were examined separately for men and women.

Logistic regression analysis was applied to examine the effect of socioeconomic indicators on the prevalence of T2D. Six logistic regression models were applied as follows: model 1 was done on employed men, model 2 on employed women, model 3 on male nonworking spouses, model 4 on female nonworking spouses, model 5 on male pensioners and model 6 on female pensioners. The three socioeconomic variables education, occupational position and income were simultaneously included in models 1 to 4 since they did not highly correlate with each other ($r = 0.01$ for education and income, $r = 0.14$ for income and occupation and $r = 0.37$ for education and occupation). Models 5 and 6 did not include the variables occupation and education since they are not available for pensioners. Individual mid-interval age and observational duration (total number of days insured in the observation period) were controlled for in all models. It was important to control for the latter since the longer a person is observed, the higher the probability that diabetes will be diagnosed.

In order to identify the explanatory power of the socioeconomic indicators in each of the examined subgroups, deviance analysis was applied. This involved applying stepwise regression analyses by omitting one SES variable at a time per population subgroup and gender in order to determine the extent to which each one of the three SES indicators affects the goodness of fit of the comprehensive models. The Pseudo R^2s of all stepwise models were then compared with the pseudo R^2 of the model that includes all three SES indicators per group considered. The SES variable, that when omitted, resulted in the greatest difference in R^2 compared to the comprehensive model was considered to have the strongest explanatory power. This analysis was not performed for pensioners since only income was examined for this group.

Results

The study population consisted of 2,300,217 insured individuals. Socioeconomic information was transferred from employed individuals to their nonworking spouses in 88,366 individuals for school education, 147,953 individuals for occupation and 144,218 individuals for income. About 90% of the transfers concerned women. Among employed individuals, 58.8% were men, while the majority of nonworking spouses and pensioners were women (88% and 58.3% respectively). Frequencies for population characteristics including age, sex and SES are presented in Table 1.

Prevalence of T2D

In the three observed groups, T2D in the period between 2013 and 2017 was most prevalent among pensioners, followed by the subgroups nonworking spouses and employed individuals with higher proportions among men in all groups. While 6.4% of employed men and 4.7% of employed women were prevalent T2D cases, this was the case for almost a quarter of male nonworking spouses and 12.2% of female nonworking spouses. T2D prevalence was considerably higher among pensioners, with 40% of men and 35.8% of women being affected (Fig. 1).

Income

In employed individuals, a gradient was not observed in T2D prevalence across the different income levels (Fig. 2). However, after controlling for age, education and occupation, an effect was observed in both genders in the high-compared to the low-income groups. The odds for a T2D prevalent case in the observed period were 18% lower for men and 10% lower for women in the high income compared to low income group (Table 2).

In male nonworking spouses, the gradient observed in Fig. 2 for the decreasing T2D prevalence with increasing income emerged even after controlling for age and other socioeconomic indicators (Table 2). This was however not the case for women where the odds ratios indicated a 36% higher risk of T2D when their spouses were in the middle as compared to the low income group and almost no difference in the T2D risk emerged when their spouses were in the high compared to the low income group (OR = 0.99).

Among pensioners, a lower risk for T2D prevalence could only be observed in the high compared to the low income group in both men and women with 12% and 18% lower risk respectively (Fig. 2 & Table 2).

Occupation

In employed men, occupation did not appear to have a great effect on the risk of T2D prevalence even after controlling for age and other

Table 1
Population characteristics stratified by gender and population subgroup.

	Employed		Nonworking spouses		Pensioners[a]	
	Men	Women	Men	Women	Men	Women
N	790.996	554.845	21,657	159.292	322.927	450.500
Age*	38.71 (12.9)	39.03 (13.02)	51.92 (14.08)	45.66 (13.30)	70.91 (11.98)	74.18 (12.55)
Education n(%)						
Low	228,253 (28.86)	102,927 (18.55)	3346 (15.45)	43,190 (27.11)		
Middle	213,699 (27.02)	196,333 (35.39)	2979 (13.76)	28,041 (17.60)		
High	84,053 (10.63)	98,227 (17.70)	1779 (8.21)	9031 (5.67)		
Missing	264,991 (33.50)	157,358 (28.36)	13,553 (62.58)	79,030 (49.61)		
Occupation n(%)						
Unskilled	143,349 (18.12)	113,001 (20.37)	6384 (29.48)	40,593 (25.48)		
Skilled	414,298 (52.38)	156,954 (28.29)	4713 (21.76)	61,711 (38.74)		
Specialists	147,984 (18.71)	231,649 (41.75)	3207 (14.81)	22,406 (14.07)		
Highly qualified	58,821 (7.44)	44,632 (8.04)	1064 (4.91)	7875 (4.94)		
Missing	26,544 (3.36)	8609 (1.55)	6289 (29.04)	26,707 (16.77)		
Income n(%)						
Low	62,068 (7.85)	95,979 (17.30)	4609 (21.28)	21,120 (13.26)	74,143 (22.96)	208,602 (46.30)
Middle	169,668 (21.45)	213,583 (38.49)	5454 (25.18)	35,144 (22.06)	154,935 (47.98)	185,137 (41.10)
High	382,362 (48.34)	148,967 (26.85)	3828 (17.68)	74,063 (46.50)	81,086 (25.11)	40,318 (8.95)
Missing	176,898 (22.36)	96,316 (17.36)	7766 (35.86)	28,965 (18.18)	12,763 (3.95)	16,443 (3.65)

* Mid-interval age mean (SD).
[a] No information available on education and occupation of pensioners.

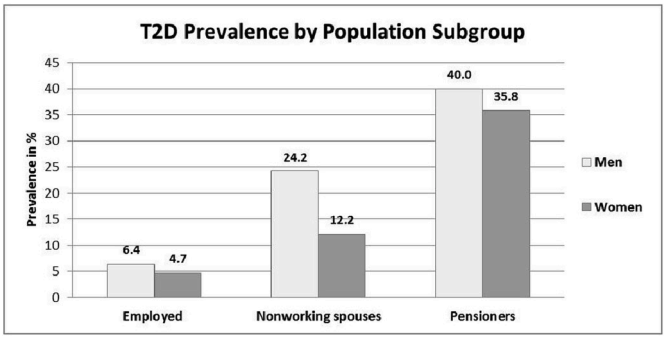

Fig. 1. Crude T2D prevalence proportions by population subgroup and gender.

socioeconomic indicators. This was not the case for employed women, where very clear gradients were observed with lower T2D prevalence with higher occupational positions: highly qualified women had a 22% lower chance to develop T2D compared to unskilled. In the subgroup nonworking spouses, the effect of occupation was more pronounced especially in women, with a 39% lower risk of T2D prevalence in the group whose spouses are highly qualified compared to unskilled (Fig. 3 & Table 2).

Education

Among the three socioeconomic indicators examined, the level of school education appeared to have the most pronounced odds ratios for T2D prevalence in the period between 2013 and 2017. A clear gradient could be observed for men and women in both employed individuals and nonworking spouses, which could also be unanimously validated through the results of the logistic regression analysis after controlling for age, duration of observation, occupation and income. In employed men, high school education was associated with 28% decreased risk of having T2D compared to low school education. The effect of education was even more pronounced in women: employed women in the middle and high education groups were 20% and 35% less likely to have T2D respectively compared to employed women in the low education group. In nonworking spouses, the risk of having T2D was 38% lower for men and 23% lower for women if their spouses were in the high compared to the low education group (Fig. 4 & Table 2).

Explanatory power of SES indicators

The comparison of the Pseudo R^2s indicated that school education resulted in the most variance deterioration compared to the comprehensive model for the groups: employed men and women and male nonworking spouses. The models in which education was omitted had the lowest goodness of fit, indicating that school education had the biggest share (among the examined variables) in explaining the variance

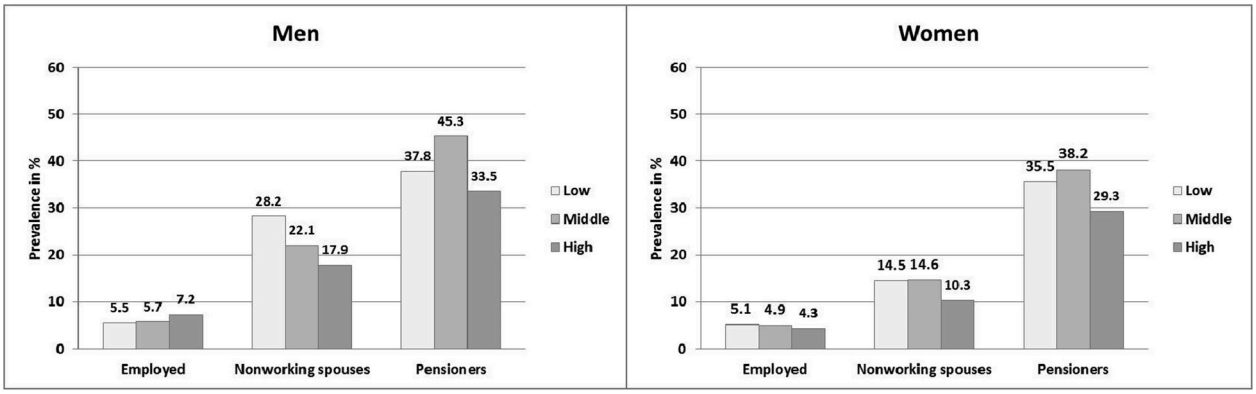

Fig. 2. Crude T2D prevalence proportions by **income** and population subgroup.

Table 2
Odds ratios of T2D prevalence by income, occupation and education as estimated by means of logistic regression.

	Employed						Nonworking Spouses						Pensioners[a]					
	Men n = 448,061			Women n = 342,829			Men n = 6807			Women n = 72,724			Men n = 310,164			Women n = 434,057		
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Income																		
Low	1	–	–	1	–	–	1	–	–	1	–	–	1	–	–	1	–	–
Middle	0.93	0.07	0.86–1.01	0.96	0.16	0.92–1.01	0.96	0.69	0.80–1.16	1.36	<0.001	1.22–1.52	1.05	<0.001	1.03–1.07	1.01	0.30	0.99–1.02
High	0.82	<0.001	0.76–0.88	0.90	<0.001	0.85–0.95	0.84	0.09	0.69–1.03	0.99	0.81	0.90–1.10	0.88	<0.001	0.86–0.90	0.82	<0.001	0.80–0.84
Occupation																		
Unskilled	1	–	–	1	–	–	1	–	–	1	–	–						
Skilled	0.98	0.25	0.94–1.02	0.89	<0.001	0.84–0.93	0.80	<0.05	0.68–0.95	0.84	<0.001	0.79–0.90						
Specialists	0.99	0.85	0.95–1.05	0.80	<0.001	0.76–0.84	0.83	0.05	0.69–1.00	0.76	<0.001	0.69–0.83						
Highly qualified	0.93	<0.05	0.88–0.99	0.78	<0.001	0.72–0.85	0.72	0.05	0.51–1.00	0.61	<0.001	0.52–0.70						
Education																		
Low	1	–	–	1	–	–	1	–	–	1	–	–						
Middle	0.88	<0.001	0.86–0.91	0.80	<0.001	0.77–0.84	0.91	0.26	0.78–1.07	0.81	<0.001	0.76–0.86						
High	0.72	<0.001	0.67–0.76	0.65	<0.001	0.61–0.69	0.62	<0.001	0.49–0.79	0.77	<0.001	0.68–0.88						

Adjusted for mid-interval age and duration of observation in all models. Model 1: employed men, included variables are: income, occupation, education, mid-interval age and duration of observation. Model 2: employed women, included variables are: income, occupation, education, mid-interval age and duration of observation. Model 3: Male nonworking spouses, included variables are: income, occupation, education, mid-interval age and duration of observation. Model 4: female nonworking spouses, included variables are: income, occupation, education, mid-interval age and duration of observation. Model 5: male pensioners, included variables are: income, mid-interval age and duration of observation. Model 6: female pensioners, included variables are income, mid-interval age and duration of observation.

[a] No information available on education and occupation of pensioners.

in the outcome. For the group of female nonworking spouses, the model where income was omitted had the highest pseudo R^2 difference compared with the comprehensive model for this group, but the differences in R^2s between the stepwise and comprehensive models were small (Table 3).

Discussion

Socioeconomic inequalities in T2D

This study provides evidence on socioeconomic inequalities of T2D among different population subgroups. Even though gradients in socioeconomic inequalities were observed for the three indicators, how and the extent to which these indicators were associated with T2D prevalence was not identical. Higher income levels predicted lower T2D prevalence in employed and pensioned men and women as well as male nonworking spouses, but not in female nonworking spouses. For occupation, higher occupational groups were also shown to have lower risks for T2D prevalence in employed as well as nonworking spouses, but the effect was stronger in women in both subgroups. School education had very clear gradients for both examined subgroups (employed and nonworking spouses) with higher education indicating lower T2D prevalence risks. The deviance analyses also showed education to have the highest explanatory power in employed men and women and male nonworking spouses. Moreover, the results showed independent effects of the three SES indicators on the risk of T2D prevalence due to mutually adjusting for them in the regression analyses. This supports the argument that the three indicators exhibit different causal or influential pathways in determining health outcomes (Geyer, 2008; Geyer et al., 2006; Geyer & Peter, 2000; Lahelma et al., 2004).

It has been argued that the three socioeconomic indicators overlap in determining the SES of individuals and thus could be used interchangeably when examining SES inequalities (Lazarsfeld, 1937). This is because the level of education is in many cases a determinant for occupation, which in turn determines income. Thus, the three SES indicators might depict overlapping resources that generally determine the social status of individuals. However, the different SES measures do not necessarily overlap in explaining risks for different outcomes, and each could have a different or specific pathway. This has been validated by the results of this study as well as several other studies that found independent effects of different SES measures on different outcomes (Erikson, 2016; Torssander & Erikson, 2010). Moreover, in this study, the three socioeconomic indicators were only weakly correlated with each other ($r = 0.01$ for education and income, $r = 0.14$ for income and occupation and $r = 0.37$ for education and occupation), which contradicts the argument that they overlap and can be used interchangeably in our population. Nevertheless, studies examining and showing an overlap between different SES measures also exist, but are scarce. In explaining outcomes like children occupational attainment and children earnings for example, it was shown that parental education, income and occupation overlap to a great extent (Erola, Jalonen, & Lehti, 2016; Mood, 2017). While this might be outcome or population specific, it is theoretically and empirically more appropriate to consider all the three SES measures wherever possible. This would allow for an adequate understanding of what aspects of socioeconomic position have an effect on health outcomes, and the way different SES measures influence these outcomes.

Not only could different outcomes be specific on whether SES measures overlap in explaining them, but also the way and the extent to which the three socioeconomic indicators affect health depend on the health or disease-related outcome considered (Geyer, 2008). In other health outcomes like chronic low back pain, job position has been shown to be the single most important socioeconomic indicator in a recent German study (Fliesser, De Witt Huberts, & Wippert, 2018), while another study showed that income had higher effects than education in predicting ambulatory blood pressure (Cundiff, Uchino, Smith, &

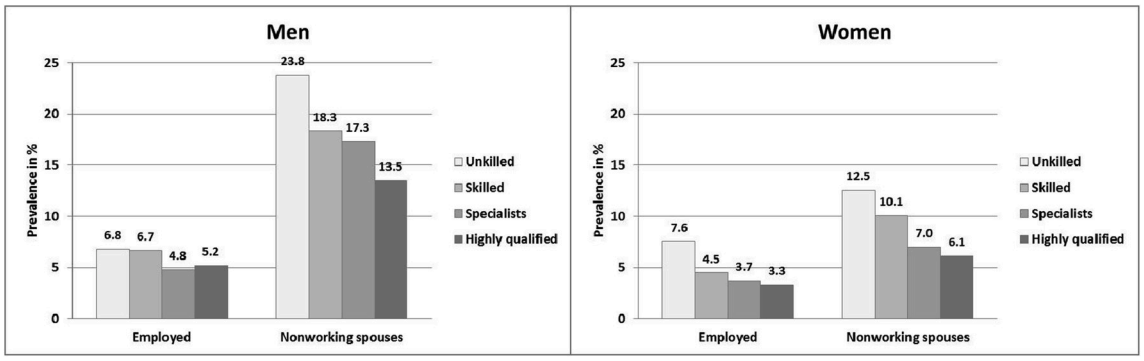

Fig. 3. Crude T2D prevalence proportions by **occupation** and population subgroup.

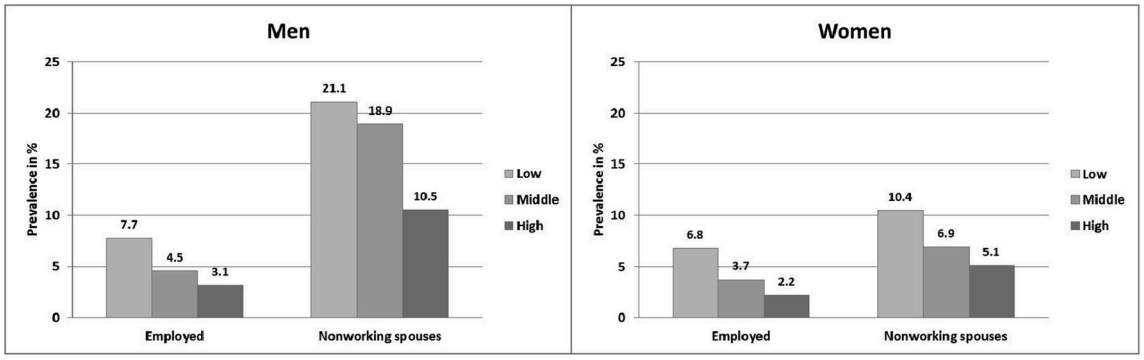

Fig. 4. Crude T2D prevalence proportions by **school education** and population subgroup.

Table 3
Pseudo R2 of logistic regression models in deviance analysis.

Model	Employed		Nonworking spouses	
	Men n = 448,061	**Women** n = 342,829	**Men** n = 6807	**Women** n = 72,724
Comprehensive model	0.1577	0.0970	0.1201	0.1003
Income excluded	0.1573	0.0969	0.1195	0.0982
Occupation excluded	0.1577	0.0962	0.1186	0.0986
Education excluded	0.1568	0.0951	0.1172	0.0990

Adjusted for mid-interval age and duration of observation in all models.

Birmingham, 2015). In T2D, the result on the relatively strong predicting effect of education has been replicated in numerous studies (Geyer et al., 2006; Sacerdote et al., 2012; Tamayo, Herder, & Rathmann, 2010). A possible explanation for this strong association is health literacy, which is defined as the ability to obtain and use health-related information in order to take adequate health decisions. T2D is to a high extent associated with lifestyle risk factors such as unhealthy eating, lack of sufficient physical activity and smoking. The role of education is further amplified by the fact that programs involving patient education and self-management have become an integral element of treatment and secondary prevention in diabetic medicine (Davies et al., 2018). Self-management turned out as successful with respect to risks of diabetes-related comorbidity (Htay et al., 2019; Rawshani et al., 2017). Thus, being health literate in terms of being more aware of the risk factors associated with T2D might play a role in mediating the association between education and T2D.

T2D prevalence

The prevalence of T2D in the period 2013–2017 differed greatly between population subgroups. T2D prevalence in male and female nonworking spouses was almost 4 and 2.6 times as high the prevalence of employed men and women. Pensioners, who were in average around 73 years of age (Table 1) had the highest proportions of T2D prevalence. In this group almost one in three women and two out of five in men had T2D in the observed period (Fig. 1).

The prevalence proportions observed in this study were higher than other published prevalence proportions of T2D in Germany (Meisinger et al., 2010; Robert Koch-Institut, 2016). The nationwide population-based German National Health Interview and Examination Survey for Adults (DEGS1) conducted by Robert Koch Institute (RKI) between 2008 and 2012 on adults aged between 18 and 79 years reported an overall diabetes prevalence of 7% for men and 7.4% for women (Robert Koch-Institut, 2016). In addition to the fact that the age range in our data is wider and includes individuals older than 79 years, this study differs from survey-based studies because it is based on claims data. Claims data covers all diagnosed diabetes cases in the studied population including elderly und severely ill individuals who are usually underrepresented in survey-based studies. However, Even in German studies that were based on claims data, the prevalence of T2D appears to be lower than in our study. A study based on data from the German Institute of Medical Documentation and Information (DIMDI) that provides comprehensive routine data from all statutory health insurance providers reported an overall T2D prevalence of 7% for the years 2009 and 2010 (Tamayo, Brinks, Hoyer, Kuβ, & Rathmann, 2016). This might be explained by differences in the definition of T2D cases, by regional differences of rates and socioeconomic distributions as well as different scopes of observation periods. Our study considered a 5-year period with observation times longer than 1 year for most of the included individuals, which enabled examining the cumulative prevalence over 5 years. In fact, comparing prevalence proportions in different studies is challenging even with similar observation periods due to inconsistent methods of prevalence calculation (Spronk et al., 2019) and standardization according to different populations.

Differences in population subgroups

While the higher prevalence of T2D in pensioners compared to other subgroups is not surprising due to the higher age of this group, the higher prevalence of T2D observed in nonworking spouses compared to employed individuals is remarkable (Fig. 1). One explanation is that the group of nonworking spouses has a higher average age than the group of employed individuals (average mid interval age is 38 versus 47 years respectively). This could partially explain the higher T2D prevalence in this group, especially that only a minority of T2D are diagnosed under the age of 45 (Heidemann, Kuhnert, Born, & Scheidt-Nave, 2017). As part of the analysis process in our study, this explanation was empirically checked and it was observed that the strength of the effect of being a nonworking spouse compared to being employed on the risk of T2D prevalence reduced but remained significant after controlling for age (result not shown). Another explanation might be employment status and social roles. Research suggests that having multiple social roles is associated with better health behavior. This has been thoroughly investigated where it was shown that accumulating social roles in early and middle adulthood was associated with better health and health-promoting lifestyles (Black, Murry, Cutrona, & Chen, 2009; Rozario, Morrow-Howell, & Hinterlong, 2004). Being employed adds up to social roles of individuals which, according to the role accumulation theory, have an influence on how individuals structure their daily life in a way that benefits health behavior. Having multiple responsibilities is associated with better social connection and higher self-esteem due to accomplishments that are socially valued, something that has an influence of the physical and mental wellbeing of individuals (Aneshensel, Frerichs, & Clark, 1981; Glass & Fujimoto, 1994; Mize, 2017; Sieber, 1974). This could be a reason why in this study, nonworking spouses had higher T2D prevalence. While the same could be argued for pensioners who face a big change in social roles (Vidovićová, 2018), it is less apposite without taking into consideration pre-pension factors and lifestyle because T2D is a chronic disease that develops over time. Regardless of the role accumulation theory, the association between employment and the risk of T2D has been established in many studies. In a recent meta-analysis that examined the impact of diabetes on employment, it was shown that evidence on the significant negative association between diabetes and employment status is consistent (Pedron, Emmert-Fees; Laxy, & Schwettmann, 2019). However, it can also be discussed that lower employment in individuals with T2D could be due to health impairment associated with the disease. This selection effect, the so-called healthy worker effect (Shah, 2009), could have resulted in showing lower T2D prevalence in employed individuals as compared to nonworking spouses.

Earlier research suggests that lower employment rates associated with diabetes could be also triggered from the side of the employers due to fear of lower productivity and the feeling of responsibility towards diabetic employees, especially those who are insulin-dependent (American Diabetes Association, 2014; Nebiker-Pedrotti et al., 2009). Since diabetes has been shown to be associated with stigma (Lee, Lim, & Koh, 2014; Schabert, Browne, Mosely, & Speight, 2013) and workplace discrimination (Nebiker-Pedrotti et al., 2009), lower employment rates in diabetes could also be triggered from the side of the potential employees with diabetes due to discouragement. However, whether the association between being a nonworking spouse and having a higher risk for T2D is causal remains to be unclear. In addition to the fact that nonworking spouses in this study are married to individuals with lower levels of school education compared to the subgroup employed individuals (see Table 1), this study found that school education is a strong predictor for T2D prevalence in nonworking spouses. This might have contributed to the higher T2D prevalence in nonworking spouses compared to employed individuals. Temporality in the association between school education and T2D is likely since school education is usually completed long before the average age for a T2D diagnosis (Heidemann et al., 2017). Holding on the pre-assumption of household homogamy (Blackwell & Lichter, 2004), a lower school education in our population would be associated with an increased risk of T2D because it could be associated with the presence of important risk factors such as lower health literacy (Qin & Xu, 2016; van der Heide et al., 2013). Thus, it can be suggested that here too, education might play a role in the causal pathway between being a nonworking spouse and having a higher risk for T2D prevalence. However, examining socioeconomic variations in T2D in nonworking spouses using individual SES instead of that of spouses is essential to validate this conclusion.

Limitations

The secondary data nature of this study is associated with some limitations. First, since socioeconomic information of statutory health-insured individuals are obtained from employers who are bound to report them on a yearly basis, socioeconomic information was lacking for nonworking spouses. Therefore, a limitation of this study is the inability to consider individual SES in this subgroup, which might have led to unprecise conclusions. Results on SES inequalities for nonworking spouses follow the pre-assumption of household SES homogamy and should thus be considered with caution. Among pensioners, only information on income was available and the effect of it on T2D prevalence was examined without adjusting for education and occupation. Therefore, comparing the explanatory power and the independent effects of SES indicators for this group is not possible, which also limits the ability to compare it with the two other examined subgroups. Third, undiagnosed T2D cases, the so called “dark figure” in T2D diagnosis, are not captured in this study. Even though the prevalence of undiagnosed T2D cases is decreasing over time in Germany, there still is evidence on their existence (Jacobs & Rathmann, 2020) which might have caused an underestimation of T2D prevalence when examined using routine data. In addition, other population subgroups were not considered in this study due the scope of the paper. Furthermore, AOKN has a varying socioeconomic distribution from the German population. However, this does not affect the generalizability of the results since we stratified by and adjusted for SES.

Conclusion

Socioeconomic inequalities in T2D exist in Germany with Lower SES groups being more affected. Education, occupation and income exhibited independent effects and differences in the extent to which they influence T2D prevalence in employed individuals and nonworking spouses. It is thus recommended that they are not used interchangeably when possible. School education has the strongest explanatory power in employed individuals and male nonworking spouses, thus pointing towards the important role of health literacy for the prevention of T2D. Further research that uses the three SES indicators to examine their explanatory power and independent effects on T2D in pensioners is required. Nonworking spouses are an important target group when considering T2D prevention interventions due to a several times higher prevalence in this group compared to employed individuals.

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Ethical statement

No ethics approval is required for this study. The analyses were performed using a pre-existing claims dataset. Their scientific use is regulated by German law in the German Civil Code “Bürgerliches

Gesetzbuch", and the data protection officer of the Local Statutory Health Insurance of Lower Saxony-AOK Niedersachsen (Germany) has given permission to use them for scientific purposes.

Data availability statement

The data analyzed in this study are not publicly available due to protection of data privacy of the insured individuals by the AOK Niedersachsen (AOKN-Statutory Local Health Insurance of Lower Saxony). The data underlying this study belong to the AOKN. Interested researchers can send data access requests to Dr. Jona Stahmeyer at the AOKN using the following e-mail address: Jona.Stahmeyer@aok.nds.de. The authors did not have any special access privileges.

Declaration of competing interest

None.

CRediT authorship contribution statement

Batoul Safieddine: Conceptualization, Methodology, Formal analysis, Writing - original draft. **Stefanie Sperlich:** Methodology, Writing - review & editing. **Johannes Beller:** Methodology, Writing - review & editing. **Karin Lange:** Supervision. **Jelena Epping:** Writing - review & editing. **Juliane Tetzlaff:** Writing - review & editing. **Fabian Tetzlaff:** Writing - review & editing. **Siegfried Geyer:** Conceptualization, Methodology, Supervision, Writing - review & editing.

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Appendix A. Supplementary data

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