# Gender Differences in The Association of Individual And Neighborhood Socio-Economic Factors With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium


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# Gender Differences in The Association of Individual And Neighborhood Socio-Economic Factors With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium

**Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**

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**Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics, Socioeconomic Factors, Population-based

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**Abstract** (word count: 246; max. 300)

**Objective:** To analyze gender differences in the relationship of individual and neighborhood social factors with present type 2 diabetes mellitus (T2DM).

**Design:** Five cross-sectional studies.

**Setting:** Studies were conducted in five regions of Germany from 1997-2006.

**Participants:** The sample consisted of 8,870 individuals in 226 neighborhoods.

**Primary and secondary outcome measures:** Prevalent T2DM.

**Results:** In the multi-level regression analysis, we found that the gradient in the association of social status and T2DM was stronger in women (odds ratio (OR) low versus high social status: 2.18 (95% confidence intervals (CI): 1.34-3.55)) than men (OR low versus high: 1.48 (95% CI: 1.01-2.17)). A statistically significant interaction was estimated between gender and social status: Men with low social status had the highest chance of T2DM in comparison to high social status women (OR: 4.37 (95% CI: 2.65-7.21)). For women, being not employed as compared to being employed constituted an increased chance of T2DM (OR of T2DM in unemployed: 1.83 (95% CI: 1.18-2.85); OR in retired: 1.77 (95% CI: 1.04-3.02); OR in others: 1.73 (95% CI: 1.06-2.83). Neighborhood unemployment rate was associated with T2DM prevalence in men (OR highest versus lowest tertile: 1.46 (95% CI: 1.14-1.88)). Regional variation in the T2DM prevalence was more pronounced in women. Variation was explained by explanatory variables in men, but not in women.

**Conclusions:** Being a man of low social status yielded a markedly increased chance of T2DM; however, in general, the prevalence of T2DM in women was more affected by social determinants.

## Article Summary

### Article focus

- The aim of this study is to examine disparities in the association of individual and neighborhood social determinants with prevalent T2DM by gender in a pooled analysis of five population-based regional studies.

### Key messages

- The association between the socio-economic status and T2DM is stronger in women than in men, particularly the individual employment status is an important determinant of T2DM in women.
- Spatial variation in T2DM is more pronounced in women, as already observed for obesity.
- Neighborhood unemployment rate is only associated with T2DM in men.

### Strength and limitations of this study

- Data of five population-based representative studies linking data on the prevalence of T2DM to small areas and regions were applied.
- This study adds knowledge to the research on the interaction of gender, social determinants on different levels and health.
- Limitations are as follows: The cross-sectional design does not allow causal conclusions; T2DM was based on a self-reported physician's diagnosis; Administrative definitions of neighborhoods could result in exposure misclassification and underestimation of neighborhood effects; Problem of residential selection.

**List of Abbreviations**

| | |
|---|---|
| CARLA | Cardiovascular Disease, Living and Ageing in Halle Study |
| CI | Confidence Interval |
| DHS | Dortmund Health Study |
| DIAB-CORE | Diabetes Collaborative Research of Epidemiologic Studies |
| HNR | Heinz Nixdorf Recall Study |
| KORA S4 | Cooperative Health Research in the Region of Augsburg Survey 4 |
| MOR | Median Odds Ratio |
| OR | Odds Ratio |
| SD | Standard Deviation |
| SE | Standard Error |
| SHIP | Study of Health in Pomerania |
| T2DM | Type 2 Diabetes Mellitus |
| $V_A$ | Area-Level Variance |

**Introduction**

Gender differences in health inequality vary by the studied health outcome, the measure of social status and the stage of life course [1-4]. Studies concerning type 2 diabetes mellitus (T2DM) mainly found a stronger relationship between the socio-economic status and T2DM in women than in men [5-10]. Beyond an individual's social status, the residential environment is a potential source of social and material deprivation that affects health [11-13]. As part of the Diabetes Collaborative Research of Epidemiologic Studies (DIAB-CORE) in Germany, Schipf et al. reported regional disparities in the age-standardized prevalence of T2DM [14]. In two recent studies, we found that the prevalence of T2DM varied across regions in Germany, even after adjustment for individual characteristics. These variations could in part be explained by neighborhood unemployment rate within cities or by regional deprivation [15, 16].

Gender differences may arise out of different exposures to social, psychosocial and behavioral determinants of health and characteristics of the residential environment ("differential exposure hypothesis") [3, 17]. Another explanation might be a different vulnerability to health determinants, characteristics of the residential environment and reaction to material, behavioral and psychosocial conditions of men and women ("differential vulnerability hypothesis") [3, 17]. Differences in men's and women's perception of residential environment and social status may be as well a source of disparities. Stafford et al. examined gender differences in the relationship between self-rated health and the neighborhood context. The residential environment had a larger impact on the health of women [17].

The aim of this study was (1) to investigate if the association of individual and neighborhood social determinants with prevalent T2DM differs for men and women in a pooled analysis of five population-based regional studies; (2) to examine the extent to which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany; and (3), to assess the pattern of gender differences across regions in a study-stratified analysis.

**Methods**

Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage cluster or stratified random sampling) and response proportions (56%-69%). All participants gave written informed consent. Within the five studies, similar instruments, questionnaires and medical measurements were applied to collect data. Study designs have been described elsewhere in more detail [18-22].

In brief, data on 11,688 subjects aged 45-74 years were provided. 2,281 individuals living in rural areas of KORA and SHIP were excluded from the sample because of missing data on the neighborhood level. Study participants were assigned to neighborhoods via addresses of residence at baseline (eight subjects could not be linked). The neighborhoods were defined by administrative units: statistical administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning regions (summary of city districts) in KORA and postal code areas in SHIP. The 9,399 study participants of the sample resided in 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of participants with missing information on the individual characteristics (missing information on social status or employment status n=520), the final sample consisted of 8,870 individuals in 226 neighborhoods.

Based on the definition of the DIAB-CORE Consortium [23], a T2DM case was defined as self-reported physician-diagnosed T2DM or self-reported diabetes treatment (insulin, oral anti-diabetic agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded from the analyses to avoid inclusion of possible cases of type 1 diabetes.

Social status was based on a summary score of the net household income and educational attainment derived from a modified version of the Winkler-Index of Socioeconomic Status and divided into three groups (high; medium; or low) [24]. We differentiated between four employment status groups:

employed, retired and unemployed individuals as well as persons with other forms of employment, for example housewives. Among the marital status of the study participants, it was only known whether one lived with or without a partner. The dichotomized lifestyle variables smoking status (current smoker; former or never smoker), physical exercise (exercise; no exercise), measured body mass index (BMI) (<30 kg/m²; >=30 kg/m²) and alcohol consumption (no or moderate intake: women: <=20 grams per day; men: <=40 grams per day; high intake: women: >20 grams per day; men: >40 grams per day) were summarized in an index of health-related behavior. Exercising included any exercise irrespective of frequency and duration. The lifestyle index was categorized: most healthy (no risk factor), healthy (one risk factor), less healthy (two risk factors), unhealthy (three risk factors) and most unhealthy (four risk factors). All variables were constructed following DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of comparability.

Individual level data were combined with data on neighborhood unemployment rate for the median year of the data collection period of each study, obtained from the statistical offices of each considered city. Neighborhood unemployment rate was calculated as the number of unemployed residents in relation to the working-age population (15-64 years of age) and was used to define the socio-economic status of neighborhoods, since it is considered to be a strong predictor of health outcomes [21, 25, 26]. Equally-sized tertiles of study-specific neighborhood unemployment rate were used for further analysis.

Crude and age-adjusted prevalence of T2DM (derived from a logistic regression) and corresponding 95% confidence intervals (CI) were calculated by gender and socio-economic variables. A series of mixed effects logistic regression models was fitted. The models were adjusted for age, gender (if not stratified), social status, employment status, lifestyle and neighborhood unemployment rate. Gender-stratified regressions were modeled and regional and between-neighborhood variation in the prevalence of T2DM of men and women calculated. In addition, we estimated models including terms for gender and the socio-economic variables (social status, employment status and neighborhood unemployment rate) as main effects and an interaction term for the effect of the socio-economic variable by gender taking the whole sample. The results were presented as odds ratios (OR) with corresponding 95% CI.

Our data set had the following hierarchical structure: individuals (level 1), nested within neighborhoods (level 2), which were nested in study regions (level 3). Random effects were included to capture regional (between-study) and between-neighborhood variation reported as median odds ratios (MOR). The latter represents a transformation of the area-level variation ($V_A$) on an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and lowest-risk-area. The MOR was calculated on the level of neighborhoods and study regions with the following equation: $MOR = exp\left(\sqrt{(2 * V_A)} * 0.6745\right)$, where 0.6745 is the 75th centile of the cumulative distribution function of the normal distribution with mean zero and variance one [27, 28].

Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small number of cases, the social status variable had to be applied as a continuous measure in this sub-analysis (ranging between two points, highest social status, and 14 points, lowest social status). For this purpose, inverse-variance weighting was used to estimate fixed and random effects summary estimates and displayed in forest plots [29]. Q-statistic and $I^2$ index were applied to assess heterogeneity and the extent of heterogeneity between study results respectively [30]. Analyses were performed in STATA/ SE 11.0.

**Results**

In total, 8,870 subjects residing in 226 neighborhoods in five German regions were included in our analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95% CI 9.2-10.9) (significance derived from 95% CI). This pattern was observed in all five regional studies. Demographic, social and lifestyle characteristics are reported in table 2. Women were more often of low and medium social status and not employed than men, except in SHIP. Men, in contrast, had more often an unhealthy life style. A higher proportion of women than men reported living without a partner.

*Social status:* The age-adjusted prevalence of T2DM was statistically significantly lower in women and men of high social status (4.7% (95% CI: 3.9-5.7) versus 9.7% (95% CI: 8.2-11-4) in low social status women; 6.9% (95% CI: 5.9-8.1) versus 14.1% (95% CI: 11.8-16.7) in low social status men) (table 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all social status groups. The social gradient in the chance of T2DM was stronger in women (OR in low versus high social status: 2.18 (95% CI: 1.34-3.55); OR in medium versus high social status: 1.85 (95% CI: 1.19-2.87)) than men (OR in low versus high social status: 1.48 (95% CI: 1.01-2.17); OR in medium versus high social status: 1.04 (95% CI: 0.81-1.32)) (table 4).

The interaction terms of the social status categories and gender were statistically significant in the fully adjusted regression model (gender*low social status: coefficient (coef.): -0.62 (95% CI: -1.18- -0.05); gender*medium social status: coef.: -0.75 (95% CI: -1.22- -0.27)). For women, the OR of T2DM was 2.86 (95% CI: 1.83-4.51) in the low versus high social status group and 2.20 (95% CI: 1.44-3.37)) in the medium versus high social status group (figure 1). Compared to women of high social status, high social status men had an OR of 2.83 (95% CI: 1.83-4.38) and medium and low status men an OR of 2.96 (95% CI: 1.94-4.50) and 4.37 (2.65-7.21), respectively.

Regarding gender differences in health inequalities across regions, the effect estimates of the five studies were tested to be homogenous (figure 2, online supplement). A low social status was associated with a higher chance of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate. In women, an increase of one point on the social status score (decrease in social status) was associated with an increase of 13% (pooled OR: 1.13 (95% CI: 1.06-1.21); $I^2$=14.0%; p=0.325) in the chance of having T2DM. This association was smaller in men (pooled OR: 1.05 (95% CI: 1.00-1.10); $I^2$=0.0%; p=0.543), although the differences between genders were not significant. This was observed in all studies, except CARLA.

*Employment status:* Employed men (7.3% (95% CI: 6.2-8.7)) had a statistically significantly lower age-adjusted T2DM prevalence than retired men (10.2% (95% CI: 8.8-11.7)) (table 3). In the gender-stratified regression analysis, significant associations between employment status and T2DM were only found in women (OR in unemployed versus employed: 1.83 (95% CI: 1.18-2.85); OR in retired versus employed: 1.77 (95% CI: 1.04-3.02); OR in others versus employed: 1.73 (95% CI: 1.06-2.83)) (table 4).

The interaction terms between the categories unemployed as well as retired and gender were statistically significant in the fully adjusted model (gender*unemployed: coef.: -0.72 (95% CI: -1.14- -0.31); gender*retired: coef.: -0.78 (95% CI: -1.43- -0.12)). Being unemployed, retired or a housewife constituted an increased chance of T2DM in women (OR in unemployed: 2.07 (95% CI: 1.38-3.11); OR in retired: 1.90 (95% CI: 1.13-3.18); OR in others: 1.67 (95% CI: 1.06-2.65)) (results not shown). Compared to employed women, employed, unemployed and retired men showed an elevated chance of having T2DM (OR in employed: 2.70 (1.86-3.91); OR in unemployed: 2.71 (95% CI: 1.82-4.04); OR in retired: 2.35 (95% CI: 1.44-3.83); OR others: 4.84 (95% CI: 1.74-13.47)).

*Neighborhood unemployment rate:* Women and men residing in neighborhoods with a high unemployment rate had a significantly higher prevalence of T2DM (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)) than women and men in areas with low unemployment rate (5.6% (95% CI: 4.8-6.6), respectively 7.4% (95% CI: 6.4-8.6)). Neighborhood unemployment rate was statistically significantly associated with the prevalence of T2DM in men (OR of highest versus lowest tertile: 1.46 (95% CI: 1.14-1.88)), while such an association was not observed in women (table 4). The interaction terms between neighborhood unemployment rate and gender were not statistically significant.

Regional (between-study) variation and between-neighborhood variation in the prevalence of T2DM was larger in women than men. The prevalence of T2DM in men varied only between study regions (model without covariates: MOR: 1.21; $V_A$: 0.04; SE: 0.04), which was fully explained by social status, employment status, lifestyle and neighborhood unemployment rate. The T2DM prevalence in women showed large variation across neighborhoods (model without covariates: MOR: 1.47; $V_A$: 0.16; SE: 0.10) and study regions (MOR: 1.31; $V_A$: 0.08; SE: 0.07), which was not dissolved by the considered explanatory variables (fully adjusted model, between-neighborhood variation: MOR: 1.42; $V_A$: 0.14; SE: 0.09, between-study variation: MOR: 1.32; $V_A$: 0.08; SE: 0.07).

Individuals living without a partner showed statistically significantly higher prevalence then individuals who lived with a partner irrespective of gender. In women and men, an unhealthy life style was statistically significantly associated with a higher T2DM prevalence (table 3). In the gender-stratified regression models, the adjustment for life style reduced the social gradient in the prevalence of T2DM in both women and men (results not shown). The association between life style and the prevalence of T2DM was stronger in women than men (e.g. OR of unhealthy lifestyle versus most healthy lifestyle in women: 5.06 (95% CI: 3.06-8.37); OR of unhealthy lifestyle versus most healthy lifestyle in men 2.84 (95% CI: 1.85-4.35)).



**Discussion**

This study assessed gender differences in the association of individual and neighborhood social factors with prevalent T2DM, using data from five regional population-based studies in Germany. Women and men with a low social status had a higher prevalence of T2DM, however men with a low social status had the highest chance of T2DM as compared to all other gender-social class subgroups. We found that the gradient in the prevalence of T2DM across social status groups was clearly stronger in women than men. This pattern was consistent across all regions but one (CARLA) and with prior studies [5-10]. Robbins et al. reported a significant association between social status and T2DM among Caucasian and African American women but an inconsistent relationship in men, using data from the Third National Health and Nutrition Examination Survey [10].

In our study, the individual employment status only had an impact on the chance of T2DM in women. Being unemployed, retired or a housewife yielded a higher chance of T2DM. Publications on the effects of paid employment on women's health discuss two contrasting theories for this finding: a health promoting function of employment due to role accumulation in contrast to the monotony, isolation, low status and self-esteem of housewives; and a health damaging effect due to role strains, e.g. stress due to multiple roles, and heavy job demands [31, 32]. Arber et al. found that paid work was beneficial for women without children or women over 40 years of age with children in Britain. Younger women with children experienced higher levels of illnesses and substantial strains from holding multiple roles [31]. Repetti et al. argues that the social support provided by colleagues has beneficial effects on women's health and helps buffering stress [32].

Regional and between-neighborhood variation in the prevalence of T2DM was larger in women than in men. We found that neighborhood unemployment rate played an important role in explaining regional health differences in men but not in women. Hence, we conclude that the residential environment is more important for the onset of T2DM in women than men. Previous work on regional variation in self-rated health and BMI also found larger regional variation in women [17, 33, 34].

The gender-specific pattern in the association between socio-economic status and the prevalence of T2DM need to be further explored, since the pathways are still unknown [10]. Macintyre et al. noted that socio-economic determinants vary in their meaning for men and women, since both genders are socialized in different ways with diverging social roles and coping strategies against stress; they hold different occupational positions in the labor market and have dissimilar access to material and psycho-social resources [35]. In our study, overall women were less likely to be of high social status, were less often employed, lived more often alone but were more often engaged in a favorable lifestyle than men.

To gain more insight in mechanisms of social inequalities on health, the analysis of population subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms operate identically in different population groups [17]. This work adds knowledge to the research on the interaction of gender, social determinants and health. So far, only few studies examined this interaction with regard to T2DM and no prior study considered socio-economic characteristics of the neighborhood. Data sources providing representative population-based data on the prevalence of T2DM with a linkage to small areas and regions are still rare.

Some limitations of this work should be acknowledged. We analyzed cross-sectional data analyses with limited causal conclusions. We could not use occupation as an indicator of social status in our analysis since the assessment was not comparable between studies. The prevalence of T2DM was based on a self-reported T2DM physician's diagnosis only. However, Okura et al. found a high accuracy between self-reports and medical records for diabetes and other chronic diseases [36]. Another potential limitation is the selection by response (response proportions: 56%-69%), which might have affected our results.

We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not capture the immediate residential environment of our study participants. This could lead to exposure misclassification and underestimation of neighborhood effects [37]. The applied administrative definition of neighborhoods differed between studies and neighborhoods were diverse according to their area and population size. Another challenge in the research of neighborhood impact on health is the residential selection. Individuals may be selected into neighborhoods due to their individual characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [38, 39]. Finally, we had no information on the residential history of the studies' participants, which could result in an underestimation of neighborhood effects on health [40].

In conclusion, our study identified different relationships of individual and neighborhood unemployment rate with the prevalence of T2DM for women and men. While being a man of low social status yielded the highest chance of T2DM, the social gradient in the prevalence of T2DM was clearly larger in women. Regional variance in the T2DM prevalence was larger in women than men. Whereas the major proportion of the variance in the T2DM prevalence remained unexplained in women, the regional variance in men was low and completely explained by individual and contextual socio-economic variables.

Table 1: Characteristics of The Five Studies (CARLA, DHS, KORA, HNR, and SHIP studies, 1997-2006)[a]

| | CARLA | DHS | KORA | HNR | SHIP |
|---|---|---|---|---|---|
| Federal State (Region) | Saxony-Anhalt (east) | North Rhine-Westphalia (west) | Bavaria (south) | North Rhine-Westphalia (west) | Mecklenburg-West Pomerania (northeast) |
| Sampling | stratified random sampling | stratified random sampling | two-stage cluster sampling | stratified random sampling | two-stage cluster sampling |
| Cities | Halle (Saale) | Dortmund | Augsburg | Bochum, Essen, Mülheim | Greifswald, Stralsund |
| Neighborhoods (n) | 43 city districts | 62 statistical administrative units | 17 planning regions | 108 statistical administrative units | 6 clusters of city districts |
| Corresponding year | 2003 | 2003 | 2000 | 2000/ 2001 | 1999 (2003) |
| Total population (neighborhood range) | 238,078 (18 - 19,210) | 587,607 (476 - 25,686) | 252,725 (2,730 - 37,246) | 1,142,112 (262 - 32,466) | 115,962 (5,230 - 31,154) |
| Unemployment rate (%; neighborhood range) | 14.1 (3.9 - 22.5) | 15.3 (5.0 - 27.7) | 4.8 (1.9 - 7.6) | 7.5 (1.7 - 13.5) | 13.1 (9.9 - 14.9) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

Table 2: Demographic, Social And Lifestyle Characteristics of Men And Women in The Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006)[a]

| | CARLA | | DHS | | KORA | | HNR | | SHIP | |
|---|---|---|---|---|---|---|---|---|---|---|
| Study period | 12/2002-01/2006 | | 09/2003-06/2004 | | 10/1999-04/2001 | | 12/2000-06/2003 | | 10/1997-03/2001 | |
| Number of neighborhoods (range of residing participants) | 37 (3-139) | | 60 (1-42) | | 17 (13-141) | | 106 (1-140) | | 6 (95-396) | |
| | Men | Women | Men | Women | Men | women | men | women | men | women |
| Participants aged 45-74 with full information (n) | 719 | 638 | 414 | 411 | 532 | 494 | 2,257 | 2,175 | 615 | 615 |
| Crude diabetes prevalence (%) (95% CI) | 12.9 (10.6-15.6) | 12.1 (9.6-14.9) | 11.8 (8.9-15.3) | 7.8 (5.4-10.8) | 6.95 (4.9-9.5) | 5.5 (3.6-7.9) | 8.9 (7.8-10.2) | 5.9 (5.0-7.0) | 11.7 (9.3-14.5) | 9.6 (7.4-12.2) |
| Mean age (SD) | 61.0 (8.0) | 60.4 (7.8) | 60.9 (8.4) | 59.7 (8.5) | 58.9 (8.6) | 58.8 (8.4) | 59.5 (7.8) | 59.4 (7.8) | 60.3 (8.3) | 58.8 (8.3) |
| Social status (%) | | | | | | | | | | |
| Low | 7.4 | 13.0 | 11.1 | 23.8 | 5.8 | 16.4 | 6.2 | 19.7 | 12.2 | 26.0 |
| medium | 61.3 | 65.1 | 46.1 | 46.2 | 48.5 | 54.1 | 53.0 | 55.9 | 67.3 | 63.1 |
| High | 31.3 | 21.9 | 42.8 | 29.9 | 45.7 | 29.6 | 40.9 | 24.4 | 20.5 | 10.9 |
| Employment status (%) | | | | | | | | | | |
| Employed | 34.9 | 30.6 | 38.7 | 34.8 | 50.4 | 35.0 | 46.4 | 31.9 | 33.3 | 35.1 |
| Unemployed | 48.1 | 52.0 | 51.9 | 33.8 | 42.9 | 39.3 | 47.6 | 37.4 | 54.0 | 49.6 |
| Retired | 15.2 | 12.4 | 7.3 | 6.1 | 6.4 | 8.9 | 5.7 | 7.5 | 12.4 | 14.5 |
| Others | 1.8 | 5.0 | 2.2 | 25.3 | 0.4 | 16.8 | 0.3 | 23.3 | 0.3 | 0.8 |
| Marital status (%) | | | | | | | | | | |
| Living with a partner | 89.0 | 73.4 | 86.7 | 71.5 | 82.5 | 67.2 | 90.2 | 74.7 | 88.3 | 68.8 |
| Living without a partner | 11.0 | 26.7 | 13.3 | 28.5 | 17.5 | 32.8 | 9.8 | 25.3 | 11.7 | 31.2 |
| Lifestyle Index[b] (%) | | | | | | | | | | |
| most healthy lifestyle | 9.6 | 20.1 | 12.8 | 19.5 | 16.2 | 26.1 | 15.1 | 18.7 | 6.5 | 22.6 |
| healthy lifestyle | 24.5 | 40.4 | 32.6 | 38.2 | 37.8 | 39.5 | 39.2 | 44.1 | 34.6 | 38.5 |
| less healthy lifestyle | 41.5 | 29.8 | 37.2 | 33.6 | 32.3 | 28.3 | 33.6 | 28.5 | 38.5 | 29.6 |
| unhealthy lifestyle | 22.4 | 9.6 | 15.0 | 7.5 | 10.7 | 5.3 | 9.2 | 5.3 | 18.7 | 8.3 |
| most unhealthy lifestyle | 2.0 | 0.2 | 1.5 | 0.7 | 1.9 | 0.2 | 1.0 | / | 1.3 | 0.7 |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

[b] dichotomized lifestyle variables: smoking status (current smoker; former or never smoker), physical exercise (exercise; no exercise), measured body mass index (BMI) (<30 kg/m²; >=30 kg/m²) and alcohol consumption (no or moderate intake: women: <=20 grams per day; men: <=40 grams per day; high intake: women: >20 grams per day; men: >40 grams per day)

Table 3: Gender-Stratified Crude And Age-Adjusted Prevalence of Type 2 Diabetes by Individual And Neighborhood Socio-Demographic Variables With Data From Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006) [a, b]

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude Prevalence | | | | Adjusted Prevalence | | Crude Prevalence | | | | Adjusted Prevalence | |
| **Individual Characteristics** | **No.** | **T2DM Cases** | **%** | **95% CI** | **%** | **95% CI** | **No.** | **T2DM Cases** | **%** | **95% CI** | **%** | **95% CI** |
| **Social status** | | | | | | | | | | | | |
| low | 345 | 56 | 16.2 | 12.5-20.6 | 14.1 | 11.8-16.7 | 851 | 104 | 12.2 | 10.1-14.6 | 9.7 | 8.2-11.4 |
| middle | 2499 | 267 | 10.7 | 9.5-12.0 | 9.7 | 8.7-10.8 | 2475 | 194 | 7.8 | 6.8-9.0 | 6.6 | 5.8-7.5 |
| high | 1693 | 129 | 7.6 | 6.4-9.0 | 6.9 | 5.9-8.1 | 1007 | 26 | 2.6 | 1.7-3.8 | 4.7 | 3.9-5.7 |
| **Employment status** | | | | | | | | | | | | |
| employed | 1931 | 126 | 6.5 | 5.5-7.7 | 7.3 | 6.2-8.7 | 1420 | 39 | 2.8 | 2.0-3.7 | 5.5 | 4.6-6.7 |
| unemployed | 2196 | 289 | 13.2 | 11.8-14.7 | 10.3 | 8.0-13.2 | 1783 | 213 | 12.0 | 10.5-13.5 | 7.9 | 6.0-10.2 |
| retired | 378 | 32 | 8.5 | 5.9-11.7 | 10.2 | 8.8-11.7 | 399 | 26 | 6.5 | 4.3-9.4 | 7.8 | 6.6-9.1 |
| others | 32 | 5 | 15.6 | 5.3-32.8 | 8.7 | 6.4-11.6 | 731 | 46 | 6.3 | 4.6-8.3 | 6.6 | 5.0-8.6 |
| **Marital status** | | | | | | | | | | | | |
| Living with a partner | 4016 | 387 | 9.6 | 8.7-10.6 | 8.7 | 7.9-9.5 | 3141 | 199 | 6.3 | 5.5-7.2 | 6.2 | 5.5-7.0 |
| Living without a partner | 521 | 65 | 12.5 | 9.8-15.6 | 11.5 | 9.7-13.4 | 1192 | 125 | 10.5 | 8.8-12.4 | 8.3 | 7.1-9.6 |
| **Life style** | | | | | | | | | | | | |
| most healthy | 589 | 32 | 5.4 | 3.8-7.6 | 4.3 | 3.3-5.5 | 882 | 31 | 3.5 | 2.4-5.0 | 3.6 | 2.8-4.7 |
| healthy | 1610 | 123 | 7.6 | 6.4-9.1 | 7.1 | 6.1-8.2 | 1806 | 126 | 7.0 | 5.8-8.3 | 6.1 | 5.2-7.0 |
| less healthy | 1619 | 189 | 11.7 | 10.2-13.3 | 10.1 | 8.9-11.4 | 1270 | 112 | 8.8 | 7.3-10.5 | 8.7 | 7.5-10.0 |
| unhealthy | 602 | 98 | 16.3 | 13.4-19.5 | 15.3 | 13.0-17.9 | 284 | 44 | 15.5 | 11.5-20.2 | 13.3 | 11.0-15.9 |
| most unhealthy | 60 | 6 | 10.0 | 3.8-20.5 | 9.7 | 4.7-19.2 | 9 | 1 | 11.1 | 2.8-48.3 | 8.4 | 3.9-16.9 |
| **Neighborhood Characteristic** | | | | | | | | | | | | |
| **Unemployment rate** | | | | | | | | | | | | |
| low | 1519 | 125 | 8.2 | 6.9-9.7 | 7.4 | 6.4-8.6 | 1384 | 85 | 6.1 | 4.9-7.5 | 5.6 | 4.8-6.6 |
| mid | 1578 | 143 | 9.1 | 7.7-10.6 | 8.6 | 7.5-9.9 | 1527 | 120 | 7.9 | 6.6-9.3 | 6.5 | 5.6-7.6 |
| high | 1440 | 184 | 12.8 | 11.1-14.6 | 10.9 | 9.6-12.3 | 1422 | 119 | 8.4 | 7.0-9.9 | 8.3 | 7.2-9.5 |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)
[b] Age-adjusted prevalence are derived from logistic regression models in the whole sample

Table 4: Gender-Stratified Multi-Level Logistic Regression of Type 2 Diabetes by Individual Social Factors and Neighborhood Unemployment Rate [a, b, c]

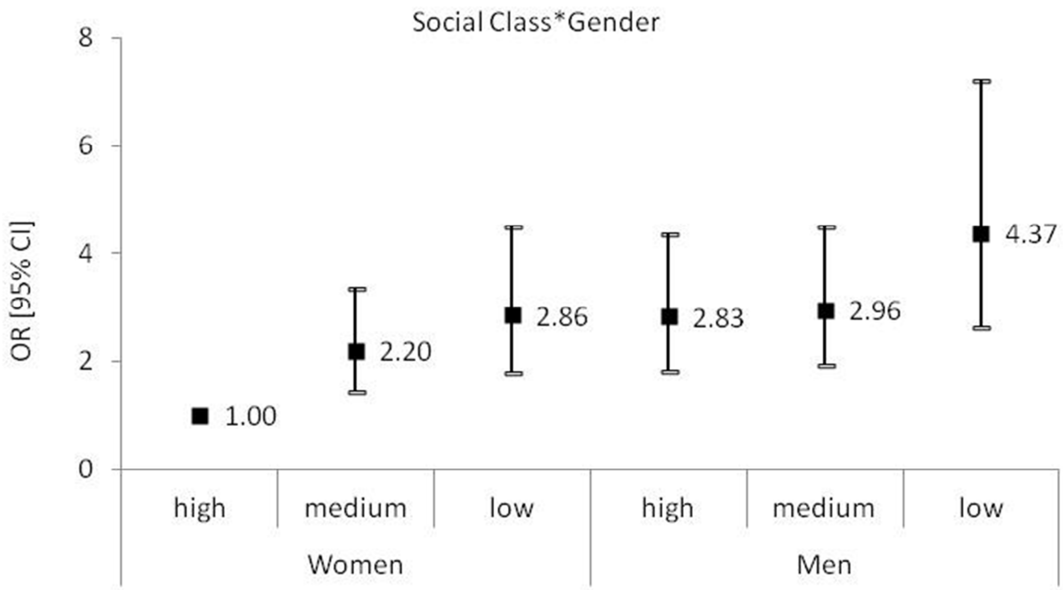
| | Men OR (95% CI) | Women OR (95% CI) |
|---|---|---|
| **Age (cont.)** | 1.05 (1.03-1.07) | 1.06 (1.03-1.08) |
| **Social status (Reference: high social status)** | | |
| medium social status | 1.04 (0.81-1.32) | 1.85 (1.19-2.87) |
| low social status | 1.48 (1.01-2.17) | 2.18 (1.34-3.55) |
| **Employment status (Reference: employed)** | | |
| unemployed | 1.06 (0.75-1.49) | 1.83 (1.18-2.85) |
| retired | 0.92 (0.60-1.41) | 1.77 (1.04-3.02) |
| others | 1.85 (0.69-4.96) | 1.73 (1.06-2.83) |
| **Marital status (Reference: living with a partner)** | | |
| Living without a partner | 1.21 (0.90-1.62) | 1.18 (0.91-1.53) |
| **Lifestyle Index (Ref.: most healthy lifestyle)** | | |
| healthy lifestyle | 1.35 (0.90-2.02) | 2.06 (1.37-3.11) |
| less healthy lifestyle | 2.03 (1.37-3.00) | 2.68 (1.76-4.07) |
| unhealthy lifestyle | 2.84 (1.85-4.35) | 5.06 (3.06-8.37) |
| most unhealthy lifestyle | 1.81 (0.72-4.57) | 5.13 (0.57-46.48) |
| **Neighborhood Characteristic** | | |
| **Unemployment rate (Reference: low unemployment rate)** | | |
| medium unemployment rate | 1.08 (0.83-1.39) | 1.30 (0.92-1.83) |
| high unemployment rate | 1.46 (1.14-1.88) | 1.08 (0.75-1.54) |
| **Level 2: Neighborhoods n** | 219 | 223 |
| VA | 0.00 (0.12) | 0.32 (0.15) |
| Median Odds Ratio | 1.00 | 1.35 |
| **Level 3: Study Regions n** | 5 | 5 |
| VA | 0.00 (0.07) | 0.28 (0.12) |
| Median Odds Ratio | 1.00 | 1.30 |

[a] Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

[b] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[c] men: n=4,537, women: n=4,333

Figure 1: Logistic Regression of Type 2 Diabetes With Interaction of Social Status*Gender [a, b, c ,d]




[a] Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

[b] Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

[c] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[d] n=8,870

**Declaration of Competing Interests**

Nothing to declare.

### Data sharing statement

No additional data available.

**Patient consent**

Obtained.

**Contribution**

The authors G.M., K.B. (DHS), S.H., K.H.G. (CARLA), S.M., N.P. (HNR), S.S., H.V. (SHIP), W.M., and C.M. (KORA) researched data. G.M. developed the study conception, performed the statistical analyses and drafted the manuscript. K.B. contributed to the study conception, statistical analyses and data interpretation. W.R. and T.T. contributed to the pooling of data. All authors critically reviewed the manuscript and contributed to the interpretation of the results.

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**Online Supplemental Material**

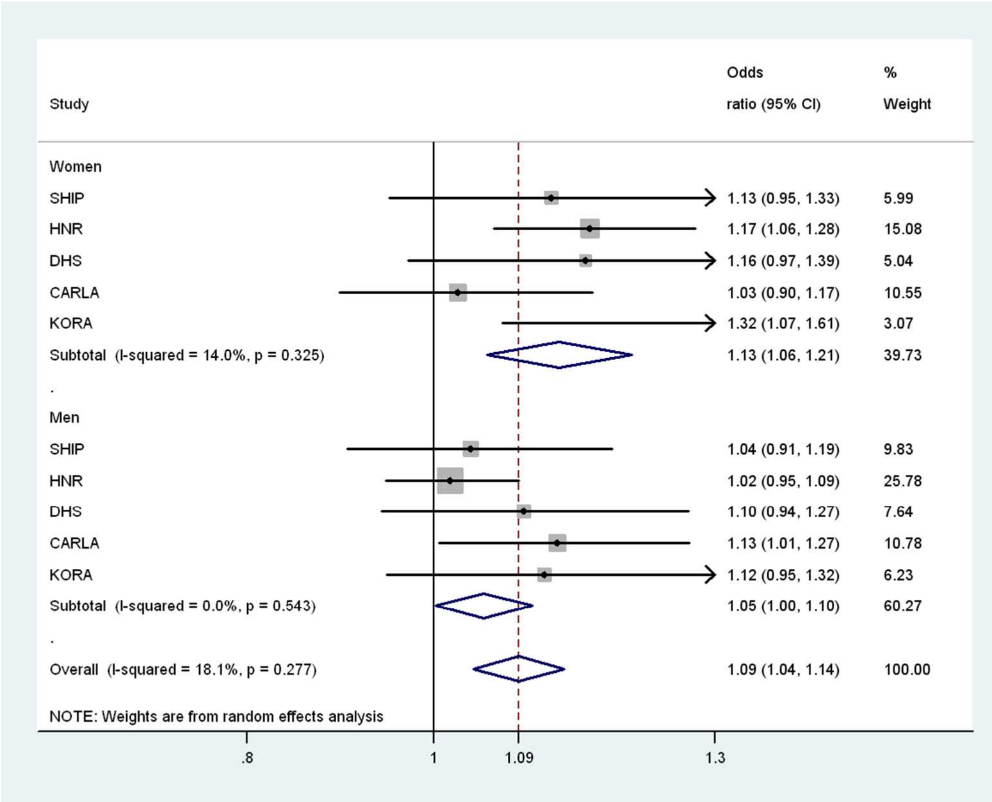
Figure 2: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes for the Social Status Score (Range: 2-14 Points) for Women and Men [a, b, c, d]

[a] Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

[b] Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

[c] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[d] Heterogeneity tested via Q-statistic and $I^2$-index

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6-7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6-7 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 8 |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6-7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7-8 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 7 |
| | | (*c*) Explain how missing data were addressed | 6 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | - |
| | | (*e*) Describe any sensitivity analyses | 8 |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 6/8 |
| | | (b) Give reasons for non-participation at each stage | 6 |
| | | (c) Consider use of a flow diagram | - |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 8/15 (table 2) |
| | | (b) Indicate number of participants with missing data for each variable of interest | 6 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 15 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 8-10/17 (table 3) |
| | | (*b*) Report category boundaries when continuous variables were categorized | 6 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | - |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 10 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 11-12 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 13 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 12 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 12 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 25 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

# Gender Differences in The Association of Individual Social Class And Neighborhood Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium

| | |
|---|---|
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| <b>Primary Subject Heading</b>: | Epidemiology |
| Secondary Subject Heading: | Diabetes and endocrinology, Epidemiology, Public health |
| Keywords: | General diabetes < DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, PUBLIC HEALTH |

**Gender Differences in The Association of Individual Social Class And Neighborhood Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium**

**Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**

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**Abstract** (word count: 256; max. 300)

**Objective:** To analyze gender differences in the relationship of individual social class, employment status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).

**Design:** Five cross-sectional studies.

**Setting:** Studies were conducted in five regions of Germany from 1997-2006.

**Participants:** The sample consisted of 8,870 individuals residing in 226 neighborhoods in five urban regions.

**Primary and secondary outcome measures:** Prevalent T2DM.

**Results:** We found significant multiplicative interactions between gender and the individual variables social class and employment status (being unemployed, retired). Social class was statistically significant associated with T2DM in men and women, whereby this association was stronger in women (low versus high social class: odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34)) than men (low versus high social class: OR 1.75 (95% CI: 1.20-2.54)). Significant associations of employment status and T2DM were only found in women (unemployed versus employed: OR 1.73 (95% CI: 1.02-2.92); retired versus employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed: OR 1.64 (95% CI: 1.01-2.67)). Neighborhood unemployment rate was associated with T2DM in men (highest versus lowest tertile: OR 1.52 (95% CI: 1.18-1.96)). Between-study and between-neighborhood variation in the T2DM prevalence was more pronounced in women. The considered covariates helped to explain statistically the variation in the T2DM prevalence among men, but not among women.

**Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the association was more pronounced in women. Employment status only affected T2DM in women. Neighborhood unemployment rate is an important predictor of T2DM in men, but not in women.

**Article Summary**

**Article focus**

- The aim of this study was to examine disparities in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM by gender in a pooled analysis of five population-based regional studies.

**Key messages**

- Social class was statistically significantly associated with T2DM among women and men, however, the association was stronger in women than men; particularly the individual employment status is an important determinant of T2DM in women.
- Between-study and between-neighborhood variance in T2DM was more pronounced in women, as already observed for obesity.
- Neighborhood unemployment rate is only associated with T2DM in men after the adjustment for individual variables.

**Strength and limitations of this study**

- Data of five population-based representative studies linking data on the prevalence of T2DM to small areas and regions were applied.
- This study adds knowledge to the research on the interaction of gender, social determinants on different levels and health.
- Limitations were as follows: The cross-sectional design does not allow causal conclusions; T2DM was based on a self-reported physician's diagnosis; Administrative definitions of neighborhoods could result in exposure misclassification and underestimation of neighborhood effects; Problem of residential selection.

**List of Abbreviations**

| | |
|---|---|
| CARLA | Cardiovascular Disease, Living and Ageing in Halle Study |
| CI | Confidence Interval |
| DHS | Dortmund Health Study |
| DIAB-CORE | Diabetes Collaborative Research of Epidemiologic Studies |
| HNR | Heinz Nixdorf Recall Study |
| KORA S4 | Cooperative Health Research in the Region of Augsburg Survey 4 |
| MOR | Median Odds Ratio |
| OR | Odds Ratio |
| SD | Standard Deviation |
| SE | Standard Error |
| SHIP | Study of Health in Pomerania |
| T2DM | Type 2 Diabetes Mellitus |
| $V_A$ | Area-Level Variance |

**Introduction**

Gender differences in health inequality vary by the studied health outcome, the measure of social status and the stage of life course [1-3]. A systematic review of 23 case-control and cohort studies on socio-economic differences in the incidence of type 2 diabetes mellitus (T2DM) concluded that inequality in the risk of T2DM was stronger in women than men [4]. For instance, Smith at al. examined the association between the life-course socio-economic position and T2DM in the Framingham Offspring Study and detected a significant association among women but not among men [5]. Similar results were shown by Imkampe et al. [6].

Tanaka et.al [7] found associations among both men and women: With an increasing level of wealth the authors presented an increasing odds of T2DM in men and women in an older population aged 50+, but the association was more pronounced in women. Differentiating by ethnicity, Robbins et al. reported a significant association between SES and T2DM among Caucasian and African American women but an inconsistent relationship in Caucasian and African American men [8]. Tang et al. [9] and Ross et al. [10] found as well weak association between measures of social status and T2DM in men.

Contrasting results were found by Kumari et al. [11] and Maty et al. [12]. The first study presented a stronger inverse relationship between the civil service employment grade and the incidence of T2DM in men, applying data of the Whitehall study II. The latter work reported higher T2DM risks for blue-collar men than women in comparison to white-collar employees.

Beyond an individual's social class, socio-economic characteristics of the neighborhood affect health [13-15]. As part of the Diabetes Collaborative Research of Epidemiologic Studies (DIAB-CORE) in Germany, Schipf et al. reported regional disparities in the age-standardized prevalence of T2DM [16]. In two recent studies, we found that the prevalence of T2DM varied across regions in Germany, even after adjustment for individual characteristics. These variations could in part be explained statistically by neighborhood unemployment rate within cities or by regional deprivation [17 18].

Gender differences may arise out of different exposures to social, psychosocial and behavioral determinants of health ("differential exposure hypothesis"). Another explanation might be a different vulnerability to health determinants, characteristics of the neighborhood and reaction to material, behavioral and psychosocial conditions of men and women ("differential vulnerability hypothesis") [2 19]. Differences in men's and women's perception of the neighborhood context and social status may be as well a source of health disparities [19]. Stafford et al. examined gender differences in the relationship between self-rated health and the neighborhood context and found a larger impact of the neighborhood context on the health of women [19].

The aim of this study was (1) to investigate if the association of individual social class, individual employment status and neighborhood unemployment rate with prevalent T2DM differs for men and women in a pooled analysis of five population-based regional studies; and (2) to examine the extent to which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a sub-analysis, we performed study-specific calculations of the relationship between T2DM and social class in men and women.

**Methods**

Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage cluster or stratified random sampling) and response proportions (56%-69%). The studies were approved by local ethics committees and informed written consent was obtained from the study participants. Within the five studies, similar instruments, questionnaires and medical measurements were applied to collect data. Study designs have been described elsewhere in more detail [20-24].

In brief, data on 11,688 subjects aged 45-74 years were provided. 2,281 individuals living in rural areas of KORA and SHIP were excluded from the sample, because these subject could not be assigned to spatial units below the level of municipalities; so, that our study was limited to urban areas. Study participants were assigned to neighborhoods via addresses of residence at baseline (eight subjects could not be linked). The neighborhoods were defined by administrative units: statistical administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning regions (summary of city districts) in KORA and postal code areas in SHIP. The 9,399 study participants of the sample resided in 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of participants with missing information on individual characteristics (n=529), the final sample consisted of 8,870 residents in 226 neighborhoods.

Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded from the analyses to avoid inclusion of possible cases of type 1 diabetes.

Social class was measured with a summary score of income and education. Its' operationalization was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on individual educational and professional attainment, net household income and the occupational position of the main earner of a household. The three dimensions are transformed to an ordinal scale ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information on occupational status was not available for our analysis, the index was solely based on education and income, ranging between 2 and 14 points. The index was divided into three groups: high social class, medium social class and low social class. Study participants were classified in four employment status groups: employed, retired and unemployed individuals as well as persons with other forms of employment, including participants in vocational retraining, housewives and housemen.

Neighborhood unemployment rate was applied as a proxy for the socio-economic status of the neighborhoods. Neighborhood unemployment rate was calculated as the number of unemployed residents in relation to the working-age population (15-64 years of age), obtained from the statistical offices of each considered city. The median year of the data collection period of each study was used as the reference year. A number of studies applied unemployment rate as a measure of deprivation and it was proven to be a strong predictor of health outcomes [22 27-29]. Campbell et al. highlighted that unemployment rate is a simple and good indicator for social and material deprivation, which is regularly updated and easily accessible [30]. For our analysis, equally-sized tertiles of study-specific neighborhood unemployment rate were used to detect a potential dose-response relationship.

The variable marital status summarized information whether a study participant lived with or without a partner. Moreover, life style variables including smoking status (current smoker; former smoker; never smoker), physical exercise (exercise; no exercise), body mass index (BMI) (<30 kg/m²; >=30 kg/m²) and alcohol consumption (no or moderate intake: women: <=20 grams per day; men: <=40 grams per day; high intake: women: >20 grams per day; men: >40 grams per day) were considered. Exercising included any exercise irrespective of frequency and duration. All variables were constructed following DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of comparability.

**Statistical Analysis**

Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual variables and neighborhood unemployment rate.

Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods (level 2), which were nested in study regions (level 3). To account for this data structure in our statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed effects logistic regression models. First, we tested for interactions between gender and individual social class, employment status and neighborhood unemployment rate. To do so, we estimated regression models including terms for gender and social class, employment status or neighborhood unemployment rate as main effects and an interaction term for the effect of social class, employment status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables age, marital status and the remaining social variables (social class/ employment status/ neighborhood unemployment rate) depending on the variable of interest. Life style factors, including smoking, alcohol consumption, BMI and physical activity were evaluated as potential mediators in the relationship between T2DM and individual social class, employment status or neighborhood unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.

Random effects were included to capture between-study and between-neighborhood variance reported as median odds ratios (MOR). The latter represents a transformation of the area-level variation ($V_A$) on an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and lowest-risk-area. The MOR was calculated on the level of neighborhoods and study regions with the following equation: $MOR = exp\left(\sqrt{(2 * V_A)} * 0.6745\right)$, where 0.6745 is the 75th centile of the cumulative distribution function of the normal distribution with mean zero and variance one [31 32].

Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small number of cases, the social class variable had to be applied as a continuous measure in this sub-analysis (ranging between two points, highest social class, and 14 points, lowest social class). For this purpose, inverse-variance weighting was used to estimate fixed and random effects summary estimates and displayed in forest plots [33]. Q-statistic and $I^2$ index were applied to assess heterogeneity and the extent of heterogeneity between study results respectively [34]. Analyses were performed in STATA/ SE 11.0.

**Results**

In total, 8,870 subjects residing in 226 neighborhoods in five urban regions were included in our analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95% CI 9.2-10.9) (significance derived from 95% CI). This pattern was observed in all five regional studies. Socio-demographic characteristics are reported in table 2. Women belonged more often to the low or medium social class and a higher proportion was not employed compared to men, except in SHIP. A higher proportion of women than men reported to live without a partner.

The age-adjusted prevalence of T2DM was statistically significantly lower in high social class women and men than in the low social class (4.7% (95% CI: 3.9-5.7) respectively 9.7% (95% CI: 8.2-11-4) in women; 6.9% (95% CI: 5.9-8.1) respectively 14.1% (95% CI: 11.8-16.7) in men) (table 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all social classes. Employed men had a statistically significantly lower age-adjusted T2DM prevalence with 7.3% (95% CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods, the highest age-adjusted prevalence of T2DM was found in women and men living in neighborhoods with a high unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)). Individuals living without a partner showed statistically significantly higher prevalence then individuals who lived with a partner irrespective of gender. Being physical inactive or having a BMI of 30 or above was statistically significantly associated with a higher T2DM prevalence in men and women.

In the fully adjusted multivariable analyses, the interaction terms of social class and gender were statistically significant. Among the employment status, we found significant multiplicative interactions between unemployed individuals and gender as well as between retired individuals and gender. The interaction terms between neighborhood unemployment rate and gender were not statistically significant.

The results of the gender-stratified multivariable regression analysis are presented in table 4. Among women and men, we found a statistically significant association of social class and T2DM. The social gradient in the odds of T2DM was reduced when the models were adjusted for age and the confounding variables. This reduction was particularly large in women. Overall, the association between social class and T2DM was stronger in women (low versus high social class: OR 2.68 (95% CI: 1.66-4.34); medium versus high social class: OR 2.02 (95% CI: 1.31-3.13)) than men (low versus high social class: OR 1.75 (95% CI: 1.20-2.54); medium versus high social class: OR 1.13 (95% CI: 0.89-1.43)) (model 3, table 4). Significant associations of employment status and T2DM were only found in women: In reference to employed women, unemployed women, retired women and women with other employment status had a 1.73, (95% CI: 1.02-2.92), a 1.77 (95% CI: 1.10-2.84) respectively a 1.64 (95% CI: 1.01-2.67)) higher odds to have T2DM. The significant elevated odds of T2DM in retired men were dissolved by adjustment for age. Women residing in neighborhoods with a medium level of unemployment showed a significant elevated odds to have T2DM (OR 1.45 (95% CI: 1.03-2.04), model 2), which was dissolved when the model was adjusted by confounding variables. In contrast, men residing in neighborhoods with a high level of unemployment showed a 52% (95% CI: 1.18-1.96) higher odds to have T2DM than men in low unemployment neighborhoods in the confounder-adjusted model 3. T2DM was no longer associated with marital status after adjustment by confounding variables in model 3 (living without versus living with a partner: OR 1.17 (95% CI: 0.90-1.51) in women, OR 1.19 (95% CI: 0.88-1.59) in men).

In model 4, the life style factors BMI, physical activity and smoking (only men) were introduced in the model. These life style factors were previously evaluated to be associated with social class, employment status (not associated with physical exercise in women) and neighborhood unemployment rate as well with the presence of type 2 diabetes (smoking only in men). In men and women, we observed effect modifications among individual social class, employment status and neighborhood unemployment rate when introducing these life style factors into the analysis. Especially, the association between social class and T2DM was strongly reduced in women mainly accounted by the BMI.

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. The prevalence of T2DM in men varied only between study regions (model 1: MOR: 1.21; $V_A$: 0.04; SE: 0.04), which was fully explained statistically by age, social class, employment status, neighborhood unemployment rate, marital status and life style factors. The T2DM prevalence in women showed large variation across neighborhoods (model 1: MOR: 1.47; $V_A$: 0.16; SE: 0.10) and study regions (model 1: MOR: 1.31; $V_A$: 0.08; SE: 0.07), which was not dissolved by the considered explanatory variables (model 4, between-neighborhood variation: MOR: 1.42; $V_A$: 0.13; SE: 0.10, between-study variation: MOR: 1.27; $V_A$: 0.06; SE: 0.06).

Regarding gender differences in health inequalities across regions, the effect estimates of the five studies were tested to be homogenous (figure 1). A low social class was associated with a higher odds of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate. In women, an increase of one point on the social class score (decrease in social class) was associated with an increase of 13% (pooled OR: 1.13 (95% CI: 1.06-1.21); $I^2$=14.0%; p=0.325) in the odds of having T2DM. This association was smaller in men (pooled OR: 1.05 (95% CI: 1.00-1.10); $I^2$=0.0%; p=0.543), although the differences between genders were not significant. This was observed in all studies, except CARLA.

## Discussion

This study assessed gender differences in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM, using data from five regional population-based studies in Germany. Women and men belonging to the low social class had a higher prevalence of T2DM. We found that the gradient in the prevalence of T2DM across social classes was clearly stronger in women than men. This pattern was consistent across all regions but CARLA and in line with results of prior studies presenting only associations in women [6 9 10], or in men and women but more pronounced in women [7 8].

In our study, the individual employment status was only associated with T2DM in women. Being unemployed, retired or a housewife yielded higher odds of T2DM. However, since we were not able to consider occupational position in our analyses, the interpretation of these findings is limited. In the literature, two contrasting theories are discussed for the effects of paid employment on women's health. Employment can have a health promoting function due to role accumulation in contrast to the monotony, isolation, low status and self-esteem of housewives. A health damaging effect could arise due to role strains, e.g. stress due to multiple roles, and heavy job demands [35 36].

Men residing in neighborhoods with a high level of unemployment rate were more likely to have T2DM than men in better-off neighborhoods. These effects remained even after adjustment for confounding and mediator variables, whereas associations between neighborhood unemployment rate and T2DM in women were dissolved by the introduction of confounding variables. These deviating effects of neighborhood unemployment rate between men and women may be explained by the fact that men were more often engaged in employment and, hence, depend more on the regional labor market and its employment opportunities than women. Potential underlying mechanisms in the relationship between neighborhood unemployment and T2DM include neighborhood resources such as the availability of grocery stores offering healthy food and recreational facilities [15], the adoption and maintenance of risky health behavior and psychosocial factors such as chronic stress [13 37].

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. We found that individual social class, employment status and neighborhood unemployment rate played an important role in explaining statistically regional differences in the prevalence of T2DM in men. A large fraction of the detected variation in the prevalence of T2DM on the level of neighborhoods and regions remained statistically unexplained in women, suggesting that there were characteristics on the individual, neighborhood and regional level that determine the presence of T2DM and which were not considered in our analysis. Previous work on regional variation in self-rated health and BMI also found larger regional variation in women [19 38 39].

The gender-specific pattern in the association between social class and the prevalence of T2DM need to be further explored, since the pathways are still unknown [8]. Macintyre et al. noted that socio-economic determinants vary in their meaning for men and women, since both genders are socialized in different ways with diverging social roles and coping strategies against stress; they hold different occupational positions in the labor market and have dissimilar access to material and psycho-social resources [40]. In our study, overall women were less likely to be in the high social class and were less often employed.

To gain more insight in mechanisms of social inequalities on health, the analysis of population subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms operate identically in different population groups [19]. This work adds knowledge to the research on the interaction of gender, social determinants and health. So far, only few studies examined this interaction with regard to T2DM and to our knowledge no study considered neighborhood unemployment rate in regard to that, so far. Data sources providing representative population-based data on the prevalence of T2DM with a linkage to small areas and regions are still rare.

Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited causal conclusions. We could not use occupation as an indicator of social class in our analysis since the assessment was not comparable between studies. The prevalence of T2DM was based on a self-reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative [42]. Another potential limitation is the selection by response (response proportions: 56%-69%), which might have affected our results. The exclusion of participants from the initial sample due to missing information on individual characteristics (mainly due to missing information on net household income) could have led to an underestimation of the social gradient in T2DM, because these subjects were on average older, more often female, out of employment and with a lower educational status. However, a sensitivity analysis showed similar results applying education as measure of social class.

We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not capture the immediate neighborhood of residence of our study participants. This could lead to exposure misclassification and underestimation of neighborhood effects [43]. The applied administrative definition of neighborhoods differed between studies and neighborhoods were diverse according to their area and population size. Another challenge in the research of neighborhood impact on health is the residential selection. Individuals may be selected into neighborhoods due to their individual characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [44 45]. Finally, we had no information on the residential history of the study participants, which could result in an underestimation of neighborhood effects on health [46].

In conclusion, our study identified different relationships of individual social class, employment status and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men and women, the prevalence of T2DM was inversely related to social class. This social gradient was stronger in women. Regional variance in the T2DM prevalence was larger in women than men. Whereas the major proportion of the variance in the T2DM prevalence remained statistically unexplained in women, the regional variance in men was low and completely explained by the considered variables.

Table 1: Characteristics of The Five Studies (CARLA, DHS, KORA, HNR, and SHIP studies, Germany, 1997-2006)[a]

| | CARLA | DHS | KORA | HNR | SHIP |
|---|---|---|---|---|---|
| Federal State (Region) | Saxony-Anhalt (east) | North Rhine-Westphalia (west) | Bavaria (south) | North Rhine-Westphalia (west) | Mecklenburg-West Pomerania (northeast) |
| Sampling | stratified random sampling | stratified random sampling | two-stage cluster sampling | stratified random sampling | two-stage cluster sampling |
| Cities | Halle (Saale) | Dortmund | Augsburg | Bochum, Essen, Mülheim | Greifswald, Stralsund |
| Neighborhoods (n) | 43 city districts | 62 statistical administrative units | 17 planning regions | 108 statistical administrative units | 6 clusters of city districts |
| Corresponding year | 2003 | 2003 | 2000 | 2000/ 2001 | 1999 (2003) |
| Total population (neighborhood range) | 238,078 (18 - 19,210) | 587,607 (476 - 25,686) | 252,725 (2,730 - 37,246) | 1,142,112 (262 - 32,466) | 115,962 (5,230 - 31,154) |
| Unemployment rate (%; neighborhood range) | 14.1 (3.9 - 22.5) | 15.3 (5.0 - 27.7) | 4.8 (1.9 - 7.6) | 7.5 (1.7 - 13.5) | 13.1 (9.9 - 14.9) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

Table 2: Socio-demographic Characteristics of Men And Women in The Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006)[a]

| Study | CARLA | | DHS | | KORA | | HNR | | SHIP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | men | women | men | women | men | women | men | women | men | women |
| **Study period** | 12/2002-01/2006 | | 09/2003-06/2004 | | 10/1999-04/2001 | | 12/2000-06/2003 | | 10/1997-03/2001 | |
| **Participants 45-74 with full information** | 719 | 638 | 414 | 411 | 532 | 494 | 2,257 | 2,175 | 615 | 615 |
| **Number of neighborhoods (range of residing participants)** | 37 (3-139) | | 60 (1-42) | | 17 (13-141) | | 106 (1-140) | | 6 (95-396) | |
| **Crude diabetes prevalence (%) (95% CI)** | 12.9 (10.6-15.6) | 12.1 (9.6-14.9) | 11.8 (8.9-15.3) | 7.8 (5.4-10.8) | 7.0 (4.9-9.5) | 5.5 (3.6-7.9) | 8.9 (7.8-10.2) | 5.9 (5.0-7.0) | 11.7 (9.3-14.5) | 9.6 (7.4-12.2) |
| **Mean age (SD)** | 61.0 (8.0) | 60.4 (7.8) | 60.9 (8.4) | 59.7 (8.5) | 58.9 (8.6) | 58.8 (8.4) | 59.53 (7.8) | 59.4 (7.81) | 60.3 (8.3) | 58.8 (8.3) |
| **Social class % (n)** | | | | | | | | | | |
| lower | 7.4 (53) | 13.0 (83) | 11.1 (46) | 23.8 (98) | 5.8 (31) | 16.4 (81) | 6.2 (140) | 19.7 (429) | 12.2 (75) | 26.0 (160) |
| middle | 61.3 (441) | 65.1 (415) | 46.1 (191) | 46.2 (190) | 48.5 (258) | 54.1 (267) | 53.0 (1195) | 55.9 (1215) | 67.3 (414) | 63.1 (388) |
| higher | 31.3 (225) | 21.9 (140) | 42.8 (177) | 29.9 (123) | 45.7 (243) | 29.6 (146) | 40.9 (922) | 24.4 (531) | 20.5 (126) | 10.9 (67) |
| **Employment status % (n)** | | | | | | | | | | |
| employed | 34.9 (251) | 30.6 (195) | 38.7 (160) | 34.8 (143) | 50.4 (268) | 35.0 (173) | 46.4 (1047) | 31.9 (693) | 33.3 (205) | 35.1 (216) |
| retired | 48.1 (346) | 52.0 (332) | 51.9 (215) | 33.8 (139) | 42.9 (228) | 39.3 (194) | 47.6 (1075) | 37.4 (813) | 54.0 (332) | 49.6 (305) |
| unemployed | 15.2 (109) | 12.4 (79) | 7.3 (30) | 6.1 (25) | 6.4 (34) | 8.9 (44) | 5.7 (129) | 7.5 (162) | 12.4 (76) | 14.5 (89) |
| others | 1.8 (13) | 5.0 (32) | 2.2 (9) | 25.3 (104) | 0.4 (2) | 16.8 (83) | 0.3 (6) | 23.3 (507) | 0.3 (2) | 0.8 (5) |
| **Marital status (%)** | | | | | | | | | | |
| living with a partner | 89.0 (640) | 73.4 (468) | 86.7 (359) | 71.5 (294) | 82.5 (439) | 67.2 (332) | 90.2 (2035) | 74.7 (1624) | 88.3 (543) | 68.8 (423) |
| living without a partner | 11.0 (79) | 26.7 (170) | 13.3 (55) | 28.5 (117) | 17.5 (93) | 32.8 (162) | 9.8 (222) | 25.3 (551) | 11.7 (72) | 31.2 (192) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

Table 3: Gender-Stratified Crude And Age-Adjusted Prevalence of Type 2 Diabetes Mellitus by Individual Variables And Neighborhood Unemployment Rate With Data From Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006) [a, b]

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude Prevalence | | | | Age-adjusted Prevalence | | Crude Prevalence | | | | Age-adjusted Prevalence | |
| | No. | T2D Cases | % | 95% CI | % | 95% CI | No. | T2D Cases | % | 95% CI | % | 95% CI |
| **Social class** | | | | | | | | | | | | |
| low | 345 | 56 | 16.2 | 12.5-20.6 | 14.1 | 11.8-16.7 | 851 | 104 | 12.2 | 10.1-14.6 | 9.7 | 8.2-11.4 |
| middle | 2499 | 267 | 10.7 | 9.5-12.0 | 9.7 | 8.7-10.8 | 2475 | 194 | 7.8 | 6.8-9.0 | 6.6 | 5.8-7.5 |
| high | 1693 | 129 | 7.6 | 6.4-9.0 | 6.9 | 5.9-8.1 | 1007 | 26 | 2.6 | 1.7-3.8 | 4.7 | 3.9-5.7 |
| **Employment status** | | | | | | | | | | | | |
| employed | 1931 | 126 | 6.5 | 5.5-7.7 | 7.3 | 6.2-8.7 | 1420 | 39 | 2.8 | 2.0-3.7 | 5.5 | 4.6-6.7 |
| unemployed | 2196 | 289 | 13.2 | 11.8-14.7 | 10.3 | 8.0-13.2 | 1783 | 213 | 12.0 | 10.5-13.5 | 7.9 | 6.0-10.2 |
| retired | 378 | 32 | 8.5 | 5.9-11.7 | 10.2 | 8.8-11.7 | 399 | 26 | 6.5 | 4.3-9.4 | 7.8 | 6.6-9.1 |
| others | 32 | 5 | 15.6 | 5.3-3.3 | 8.7 | 6.4-11.6 | 731 | 46 | 6.3 | 4.6-8.3 | 6.6 | 5.0-8.6 |
| **Marital status** | | | | | | | | | | | | |
| Living with a partner | 4016 | 387 | 9.6 | 8.7-10.6 | 8.7 | 7.9-9.5 | 3141 | 199 | 6.3 | 5.5-7.2 | 6.2 | 5.5-7.0 |
| Living without a partner | 521 | 65 | 12.5 | 9.8-15.6 | 11.5 | 9.7-13.4 | 1192 | 125 | 10.5 | 8.8-12.4 | 8.3 | 7.1-9.6 |
| **Physical exercise** | | | | | | | | | | | | |
| physical exercise | 2473 | 193 | 7.8 | 6.8-8.9 | 7.4 | 6.6-8.4 | 2262 | 136 | 6.0 | 5.1-7.1 | 5.5 | 4.8-6.4 |
| no physical exercise | 2007 | 255 | 12.7 | 11.3-14.2 | 10.9 | 9.7-12.1 | 1989 | 178 | 8.9 | 7.7-10.3 | 8.1 | 7.2-9.2 |
| **Smoking** | | | | | | | | | | | | |
| never smoked | 1369 | 112 | 8.2 | 6.8-9.8 | 8.3 | 7.2-9.6 | 2502 | 208 | 8.3 | 7.3-9.5 | 6.5 | 5.7-7.4 |
| ex-smoker | 1962 | 227 | 11.6 | 10.2-13.1 | 9.6 | 8.4-10.8 | 894 | 67 | 7.5 | 5.9-9.4 | 7.5 | 6.4-8.9 |
| crurrent smoker | 1149 | 109 | 9.5 | 7.9-11.3 | 8.6 | 7.3-10.1 | 855 | 39 | 4.6 | 3.3-6.2 | 6.8 | 5.6-8.1 |
| **BMI** | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| < 30 | 3217 | 258 | 8.0 | 7.1-9.0 | 6.5 | 5.8-7.3 | 2993 | 123 | 4.1 | 3.4-4.9 | 4.7 | 4.1-5.4 |
| ≥ 30 | 1263 | 190 | 15.0 | 13.1-17.1 | 15.4 | 13.7-17.2 | 1258 | 191 | 15.2 | 13.2-17.3 | 11.4 | 10.0-13.0 |
| **Alcohol consumption** | | | | | | | | | | | | |
| no or moderate intake | 3967 | 410 | 10.3 | 9.4-11.3 | 9.2 | 8.3-10.1 | 4013 | 303 | 7.6 | 6.8-8.4 | 6.8 | 6.1-7.7 |
| high intake | 513 | 38 | 7.4 | 5.3-10.0 | 7.3 | 5.6-9.6 | 238 | 11 | 4.6 | 2.3-8.1 | 5.5 | 4.0-7.3 |
| **Unemployment rate** | | | | | | | | | | | | |
| low | 1519 | 125 | 8.2 | 6.9-9.7 | 7.4 | 6.4-8.6 | 1384 | 85 | 6.1 | 4.9-7.5 | 5.6 | 4.8-6.6 |
| mid | 1578 | 143 | 9.1 | 7.7-10.6 | 8.6 | 7.5-9.9 | 1527 | 120 | 7.9 | 6.6-9.3 | 6.5 | 5.6-7.6 |
| high | 1440 | 184 | 12.8 | 11.1-14.6 | 10.9 | 9.6-12.3 | 1422 | 119 | 8.4 | 7.0-9.9 | 8.3 | 7.2-9.5 |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)
[b] Age-adjusted prevalence are derived from logistic regression models in the whole sample

Table 4: Gender-Stratified Multi-Level Logistic Regression of Type 2 Diabetes Mellitus by Individual Social Class, Employment Status and Neighborhood Unemployment Rate [a, b, c]

| | | Social class (Reference: high social class) | | Employment status (Reference: employed) | | | Unemployment rate (Reference: low unemployment rate) | |
|---|---|---|---|---|---|---|---|---|
| | | **middle** | **low** | **retired** | **unemployed** | **others** | **middle** | **high** |
| | | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Model 1[d]** | Women | 3.11 (2.04-4.73) | 5.37 (3.44-8.40) | 4.71 (3.31-6.69) | 2.36 (1.41-3.95) | 2.65 (1.69-4.14) | 1.45 (1.03-2.04) | 1.26 (0.89-1.79) |
| | Men | 1.42 (1.13-1.77) | 2.26 (1.61-3.18) | 2.13 (1.71-2.65) | 1.24 (0.82-1.87) | 2.37 (0.89-6.31) | 1.15 (0.89-1.48) | 1.58 (1.24-2.02) |
| **Model 2[e]** | Women | 2.25 (1.46-3.45) | 3.16 (1.99-5.03) | 2.01 (1.26-3.21) | 2.07 (1.23-3.48) | 1.77 (1.10-2.85) | 1.45 (1.03-2.04) | 1.25 (0.88-1.78) |
| | Men | 1.21 (0.96-1.51) | 1.99 (1.41-2.81) | 1.24 (0.90-1.72) | 1.17 (0.77-1.76) | 1.97 (0.73-5.28) | 1.12 (0.86-1.45) | 1.62 (1.26-2.70) |
| **Model 3[f]** | Women | 2.02 (1.31-3.13) | 2.68 (1.66-4.34) | 1.77 (1.10-2.84) | 1.73 (1.02-2.92) | 1.64 (1.01-2.67) | 1.36 (0.96-1.93) | 1.13 (0.79-1.62) |
| | Men | 1.13 (0.89-1.43) | 1.75 (1.20-2.54) | 1.09 (0.77-1.52) | 0.94 (0.61-1.44) | 1.99 (0.74-5.36) | 1.08 (0.83-1.40) | 1.52 (1.18-1.96) |
| **Model 4[g, h]** | Women | 1.55 (0.99-2.41) | 1.76 (1.07-2.90) | 1.66 (1.03-2.68) | 1.74 (1.02-2.98) | 1.64 (1.00-2.70) | 1.21 (0.85-1.73) | 1.03 (0.71-1.48) |
| | Men | 1.03 (0.81-1.31) | 1.49 (1.02-2.20) | 1.02 (0.72-1.44) | 0.91 (0.59-1.40) | 1.71 (0.63-4.66) | 1.06 (0.82-1.37) | 1.45 (1.13-1.86) |

[a] Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

[b] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[c] men: n=4,537, women: n=4,333

[d] Model 1: unadjusted

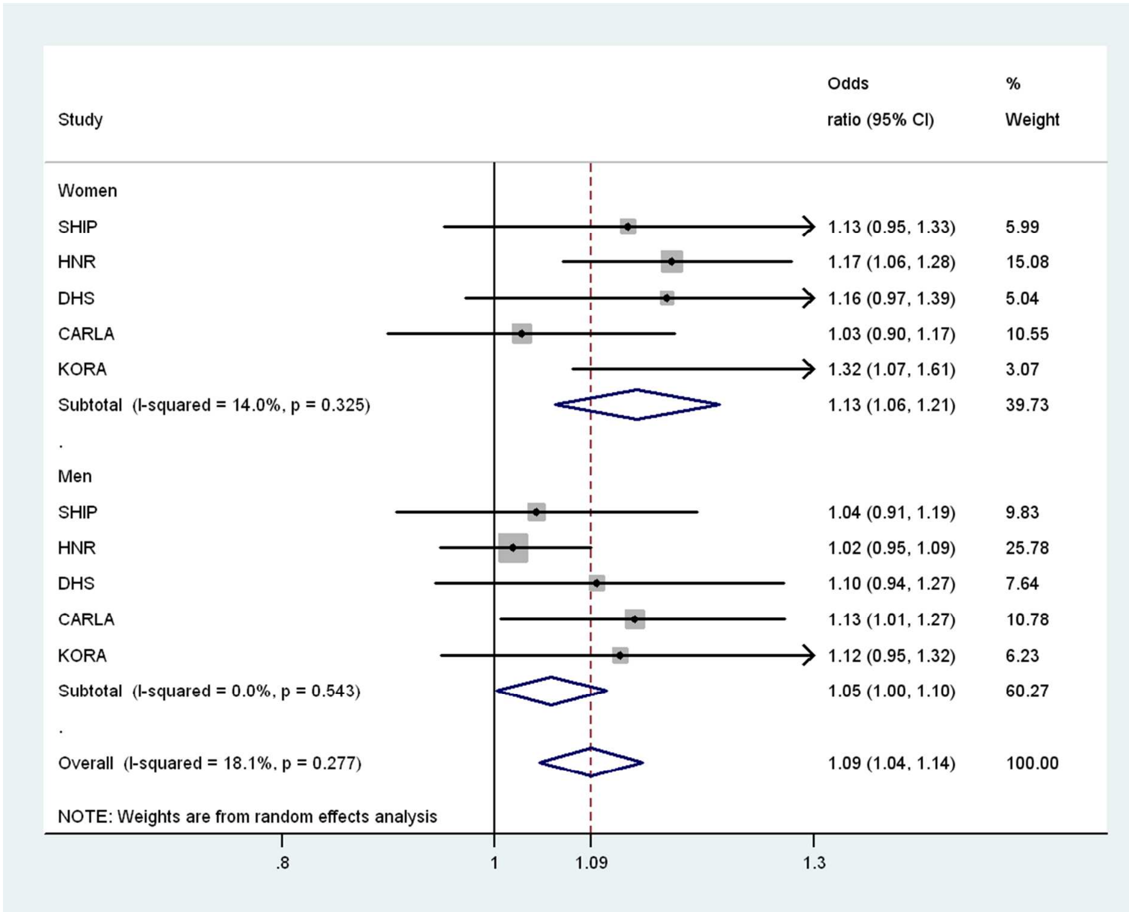
[e] Model 2: adjusted by age

[f] Model 3: adjusted by other confounders: social class, employment status, neighborhood unemployment rate, marital status

[g] Model 4: adjusted by mediators: BMI, physical exercise, smoking (only for men)

[h] Sample size n=8,731 due to 139 missing values on life style factors

Figure 1: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes Mellitus for the Social Class Score (Range: 2-14 Points) in Women and Men [a, b, c, d]




[a] Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

[b] Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

[c] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[d] Heterogeneity tested via Q-statistic and $I^2$-index

**Declaration of Competing Interests**

Nothing to declare.

**Data sharing statement**

There is no additional data available.

**Patient consent**

Obtained.

**Contribution**

The authors G.M., K.B. (DHS), S.H., K.H.G. (CARLA), S.M., N.P. (HNR), S.S., H.V. (SHIP), W.M., and C.M. (KORA) researched data. G.M. developed the study conception, performed the statistical analyses and drafted the manuscript. K.B. contributed to the study conception, statistical analyses and data interpretation. W.R. and T.T. contributed to the pooling of data. All authors critically reviewed the manuscript and contributed to the interpretation of the results.

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# Gender Differences in The Association of Individual Social Class And Neighborhood Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium

**Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**

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**Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics, Socioeconomic Factors, Population-based

Word count: 3632

**Abstract** (word count: 256; max. 300)

**Objective:** To analyze gender differences in the relationship of individual social class, employment status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).

**Design:** Five cross-sectional studies.

**Setting:** Studies were conducted in five regions of Germany from 1997-2006.

**Participants:** The sample consisted of 8,870 individuals residing in 226 neighborhoods in five urban regions.

**Primary and secondary outcome measures:** Prevalent T2DM.

**Results:** We found significant multiplicative interactions between gender and the individual variables social class and employment status (being unemployed, retired). Social class was statistically significant associated with T2DM in men and women, whereby this association was stronger in women (low versus high social class: odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34)) than men (low versus high social class: OR 1.75 (95% CI: 1.20-2.54)). Significant associations of employment status and T2DM were only found in women (unemployed versus employed: OR 1.73 (95% CI: 1.02-2.92); retired versus employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed: OR 1.64 (95% CI: 1.01-2.67)). Neighborhood unemployment rate was associated with T2DM in men (highest versus lowest tertile: OR 1.52 (95% CI: 1.18-1.96)). Between-study and between-neighborhood variation in the T2DM prevalence was more pronounced in women. The considered covariates helped to explain statistically the variation in the T2DM prevalence among men, but not among women.

**Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the association was more pronounced in women. Employment status only affected T2DM in women. Neighborhood unemployment rate is an important predictor of T2DM in men, but not in women.

**Article Summary**

**Article focus**

- The aim of this study was to examine disparities in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM by gender in a pooled analysis of five population-based regional studies.

**Key messages**

- Social class was statistically significantly associated with T2DM among women and men, however, the association was stronger in women than men; particularly the individual employment status is an important determinant of T2DM in women.
- Between-study and between-neighborhood variance in T2DM was more pronounced in women, as already observed for obesity.
- Neighborhood unemployment rate is only associated with T2DM in men after the adjustment for individual variables.

**Strength and limitations of this study**

- Data of five population-based representative studies linking data on the prevalence of T2DM to small areas and regions were applied.
- This study adds knowledge to the research on the interaction of gender, social determinants on different levels and health.
- Limitations were as follows: The cross-sectional design does not allow causal conclusions; T2DM was based on a self-reported physician's diagnosis; Administrative definitions of neighborhoods could result in exposure misclassification and underestimation of neighborhood effects; Problem of residential selection.

**List of Abbreviations**

| | |
|---|---|
| CARLA | Cardiovascular Disease, Living and Ageing in Halle Study |
| CI | Confidence Interval |
| DHS | Dortmund Health Study |
| DIAB-CORE | Diabetes Collaborative Research of Epidemiologic Studies |
| HNR | Heinz Nixdorf Recall Study |
| KORA S4 | Cooperative Health Research in the Region of Augsburg Survey 4 |
| MOR | Median Odds Ratio |
| OR | Odds Ratio |
| SD | Standard Deviation |
| SE | Standard Error |
| SHIP | Study of Health in Pomerania |
| T2DM | Type 2 Diabetes Mellitus |
| $V_A$ | Area-Level Variance |

**Introduction**

Gender differences in health inequality vary by the studied health outcome, the measure of social status and the stage of life course [1-3]. A systematic review of 23 case-control and cohort studies on socio-economic differences in the incidence of type 2 diabetes mellitus (T2DM) concluded that inequality in the risk of T2DM was stronger in women than men [4]. For instance, Smith at al. examined the association between the life-course socio-economic position and T2DM in the Framingham Offspring Study and detected a significant association among women but not among men [5]. Similar results were shown by Imkampe et al. [6].

Tanaka et.al [7] found associations among both men and women: With an increasing level of wealth the authors presented an increasing odds of T2DM in men and women in an older population aged 50+, but the association was more pronounced in women. Differentiating by ethnicity, Robbins et al. reported a significant association between SES and T2DM among Caucasian and African American women but an inconsistent relationship in Caucasian and African American men [8]. Tang et al. [9] and Ross et al. [10] found as well weak association between measures of social status and T2DM in men.

Contrasting results were found by Kumari et al. [11] and Maty et al. [12]. The first study presented a stronger inverse relationship between the civil service employment grade and the incidence of T2DM in men, applying data of the Whitehall study II. The latter work reported higher T2DM risks for blue-collar men than women in comparison to white-collar employees.

Beyond an individual's social class, socio-economic characteristics of the neighborhood affect health [13-15]. As part of the Diabetes Collaborative Research of Epidemiologic Studies (DIAB-CORE) in Germany, Schipf et al. reported regional disparities in the age-standardized prevalence of T2DM [16]. In two recent studies, we found that the prevalence of T2DM varied across regions in Germany, even after adjustment for individual characteristics. These variations could in part be explained statistically by neighborhood unemployment rate within cities or by regional deprivation [17 18].

Gender differences may arise out of different exposures to social, psychosocial and behavioral determinants of health ("differential exposure hypothesis"). Another explanation might be a different vulnerability to health determinants, characteristics of the neighborhood and reaction to material, behavioral and psychosocial conditions of men and women ("differential vulnerability hypothesis") [2 19]. Differences in men's and women's perception of the neighborhood context and social status may be as well a source of health disparities [19]. Stafford et al. examined gender differences in the relationship between self-rated health and the neighborhood context and found a larger impact of the neighborhood context on the health of women [19].

The aim of this study was (1) to investigate if the association of individual social class, individual employment status and neighborhood unemployment rate with prevalent T2DM differs for men and women in a pooled analysis of five population-based regional studies; and (2) to examine the extent to which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a sub-analysis, we performed study-specific calculations of the relationship between T2DM and social class in men and women.

**Methods**

Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage cluster or stratified random sampling) and response proportions (56%-69%). The studies were approved by local ethics committees and informed written consent was obtained from the study participants. Within the five studies, similar instruments, questionnaires and medical measurements were applied to collect data. Study designs have been described elsewhere in more detail [20-24].

In brief, data on 11,688 subjects aged 45-74 years were provided. 2,281 individuals living in rural areas of KORA and SHIP were excluded from the sample, because these subject could not be assigned to spatial units below the level of municipalities; so, that our study was limited to urban areas. Study participants were assigned to neighborhoods via addresses of residence at baseline (eight subjects could not be linked). The neighborhoods were defined by administrative units: statistical administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning regions (summary of city districts) in KORA and postal code areas in SHIP. The 9,399 study participants of the sample resided in 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of participants with missing information on individual characteristics (n=529), the final sample consisted of 8,870 residents in 226 neighborhoods.

Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded from the analyses to avoid inclusion of possible cases of type 1 diabetes.

Social class was measured with a summary score of income and education. Its' operationalization was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on individual educational and professional attainment, net household income and the occupational position of the main earner of a household. The three dimensions are transformed to an ordinal scale ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information on occupational status was not available for our analysis, the index was solely based on education and income, ranging between 2 and 14 points. The index was divided into three groups: high social class, medium social class and low social class. Study participants were classified in four employment status groups: employed, retired and unemployed individuals as well as persons with other forms of employment, including participants in vocational retraining, housewives and housemen.

Neighborhood unemployment rate was applied as a proxy for the socio-economic status of the neighborhoods. Neighborhood unemployment rate was calculated as the number of unemployed residents in relation to the working-age population (15-64 years of age), obtained from the statistical offices of each considered city. The median year of the data collection period of each study was used as the reference year. A number of studies applied unemployment rate as a measure of deprivation and it was proven to be a strong predictor of health outcomes [22 27-29]. Campbell et al. highlighted that unemployment rate is a simple and good indicator for social and material deprivation, which is regularly updated and easily accessible [30]. For our analysis, equally-sized tertiles of study-specific neighborhood unemployment rate were used to detect a potential dose-response relationship.

The variable marital status summarized information whether a study participant lived with or without a partner. Moreover, life style variables including smoking status (current smoker; former smoker; never smoker), physical exercise (exercise; no exercise), body mass index (BMI) (<30 kg/m²; >=30 kg/m²) and alcohol consumption (no or moderate intake: women: <=20 grams per day; men: <=40 grams per day; high intake: women: >20 grams per day; men: >40 grams per day) were considered. Exercising included any exercise irrespective of frequency and duration. All variables were constructed following DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of comparability.

**Statistical Analysis**

Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual variables and neighborhood unemployment rate.

Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods (level 2), which were nested in study regions (level 3). To account for this data structure in our statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed effects logistic regression models. First, we tested for interactions between gender and individual social class, employment status and neighborhood unemployment rate. To do so, we estimated regression models including terms for gender and social class, employment status or neighborhood unemployment rate as main effects and an interaction term for the effect of social class, employment status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables age, marital status and the remaining social variables (social class/ employment status/ neighborhood unemployment rate) depending on the variable of interest. Life style factors, including smoking, alcohol consumption, BMI and physical activity were evaluated as potential mediators in the relationship between T2DM and individual social class, employment status or neighborhood unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.

Random effects were included to capture between-study and between-neighborhood variance reported as median odds ratios (MOR). The latter represents a transformation of the area-level variation ($V_A$) on an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and lowest-risk-area. The MOR was calculated on the level of neighborhoods and study regions with the following equation: $MOR = exp\left(\sqrt{(2 * V_A)} * 0.6745\right)$, where 0.6745 is the 75$^{th}$ centile of the cumulative distribution function of the normal distribution with mean zero and variance one [31 32].

Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small number of cases, the social class variable had to be applied as a continuous measure in this sub-analysis (ranging between two points, highest social class, and 14 points, lowest social class). For this purpose, inverse-variance weighting was used to estimate fixed and random effects summary estimates and displayed in forest plots [33]. Q-statistic and $I^2$ index were applied to assess heterogeneity and the extent of heterogeneity between study results respectively [34]. Analyses were performed in STATA/ SE 11.0.

**Results**

In total, 8,870 subjects residing in 226 neighborhoods in five urban regions were included in our analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95% CI 9.2-10.9) (significance derived from 95% CI). This pattern was observed in all five regional studies. Socio-demographic characteristics are reported in table 2. Women belonged more often to the low or medium social class and a higher proportion was not employed compared to men, except in SHIP. A higher proportion of women than men reported to live without a partner.

The age-adjusted prevalence of T2DM was statistically significantly lower in high social class women and men than in the low social class (4.7% (95% CI: 3.9-5.7) respectively 9.7% (95% CI: 8.2-11-4) in women; 6.9% (95% CI: 5.9-8.1) respectively 14.1% (95% CI: 11.8-16.7) in men) (table 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all social classes. Employed men had a statistically significantly lower age-adjusted T2DM prevalence with 7.3% (95% CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods, the highest age-adjusted prevalence of T2DM was found in women and men living in neighborhoods with a high unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)). Individuals living without a partner showed statistically significantly higher prevalence then individuals who lived with a partner irrespective of gender. Being physical inactive or having a BMI of 30 or above was statistically significantly associated with a higher T2DM prevalence in men and women.

In the fully adjusted multivariable analyses, the interaction terms of social class and gender were statistically significant. Among the employment status, we found significant multiplicative interactions between unemployed individuals and gender as well as between retired individuals and gender. The interaction terms between neighborhood unemployment rate and gender were not statistically significant.

The results of the gender-stratified multivariable regression analysis are presented in table 4. Among women and men, we found a statistically significant association of social class and T2DM. The social gradient in the odds of T2DM was reduced when the models were adjusted for age and the confounding variables. This reduction was particularly large in women. Overall, the association between social class and T2DM was stronger in women (low versus high social class: OR 2.68 (95% CI: 1.66-4.34); medium versus high social class: OR 2.02 (95% CI: 1.31-3.13)) than men (low versus high social class: OR 1.75 (95% CI: 1.20-2.54); medium versus high social class: OR 1.13 (95% CI: 0.89-1.43)) (model 3, table 4). Significant associations of employment status and T2DM were only found in women: In reference to employed women, unemployed women, retired women and women with other employment status had a 1.73, (95% CI: 1.02-2.92), a 1.77 (95% CI: 1.10-2.84) respectively a 1.64 (95% CI: 1.01-2.67)) higher odds to have T2DM. The significant elevated odds of T2DM in retired men were dissolved by adjustment for age. Women residing in neighborhoods with a medium level of unemployment showed a significant elevated odds to have T2DM (OR 1.45 (95% CI: 1.03-2.04), model 2), which was dissolved when the model was adjusted by confounding variables. In contrast, men residing in neighborhoods with a high level of unemployment showed a 52% (95% CI: 1.18-1.96) higher odds to have T2DM than men in low unemployment neighborhoods in the confounder-adjusted model 3. T2DM was no longer associated with marital status after adjustment by confounding variables in model 3 (living without versus living with a partner: OR 1.17 (95% CI: 0.90-1.51) in women, OR 1.19 (95% CI: 0.88-1.59) in men).

In model 4, the life style factors BMI, physical activity and smoking (only men) were introduced in the model. These life style factors were previously evaluated to be associated with social class, employment status (not associated with physical exercise in women) and neighborhood unemployment rate as well with the presence of type 2 diabetes (smoking only in men). In men and women, we observed effect modifications among individual social class, employment status and neighborhood unemployment rate when introducing these life style factors into the analysis. Especially, the association between social class and T2DM was strongly reduced in women mainly accounted by the BMI.

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. The prevalence of T2DM in men varied only between study regions (model 1: MOR: 1.21; $V_A$: 0.04; SE: 0.04), which was fully explained statistically by age, social class, employment status, neighborhood unemployment rate, marital status and life style factors. The T2DM prevalence in women showed large variation across neighborhoods (model 1: MOR: 1.47; $V_A$: 0.16; SE: 0.10) and study regions (model 1: MOR: 1.31; $V_A$: 0.08; SE: 0.07), which was not dissolved by the considered explanatory variables (model 4, between-neighborhood variation: MOR: 1.42; $V_A$: 0.13; SE: 0.10, between-study variation: MOR: 1.27; $V_A$: 0.06; SE: 0.06).

Regarding gender differences in health inequalities across regions, the effect estimates of the five studies were tested to be homogenous (figure 1). A low social class was associated with a higher odds of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate. In women, an increase of one point on the social class score (decrease in social class) was associated with an increase of 13% (pooled OR: 1.13 (95% CI: 1.06-1.21); $I^2$=14.0%; p=0.325) in the odds of having T2DM. This association was smaller in men (pooled OR: 1.05 (95% CI: 1.00-1.10); $I^2$=0.0%; p=0.543), although the differences between genders were not significant. This was observed in all studies, except CARLA.

**Discussion**

This study assessed gender differences in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM, using data from five regional population-based studies in Germany. Women and men belonging to the low social class had a higher prevalence of T2DM. We found that the gradient in the prevalence of T2DM across social classes was clearly stronger in women than men. This pattern was consistent across all regions but CARLA and in line with results of prior studies presenting only associations in women [6 9 10], or in men and women but more pronounced in women [7 8].

In our study, the individual employment status was only associated with T2DM in women. Being unemployed, retired or a housewife yielded higher odds of T2DM. However, since we were not able to consider occupational position in our analyses, the interpretation of these findings is limited. In the literature, two contrasting theories are discussed for the effects of paid employment on women's health. Employment can have a health promoting function due to role accumulation in contrast to the monotony, isolation, low status and self-esteem of housewives. A health damaging effect could arise due to role strains, e.g. stress due to multiple roles, and heavy job demands [35 36].

Men residing in neighborhoods with a high level of unemployment rate were more likely to have T2DM than men in better-off neighborhoods. These effects remained even after adjustment for confounding and mediator variables, whereas associations between neighborhood unemployment rate and T2DM in women were dissolved by the introduction of confounding variables. These deviating effects of neighborhood unemployment rate between men and women may be explained by the fact that men were more often engaged in employment and, hence, depend more on the regional labor market and its employment opportunities than women. Potential underlying mechanisms in the relationship between neighborhood unemployment and T2DM include neighborhood resources such as the availability of grocery stores offering healthy food and recreational facilities [15], the adoption and maintenance of risky health behavior and psychosocial factors such as chronic stress [13 37].

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. We found that individual social class, employment status and neighborhood unemployment rate played an important role in explaining statistically regional differences in the prevalence of T2DM in men. A large fraction of the detected variation in the prevalence of T2DM on the level of neighborhoods and regions remained statistically unexplained in women, suggesting that there were characteristics on the individual, neighborhood and regional level that determine the presence of T2DM and which were not considered in our analysis. Previous work on regional variation in self-rated health and BMI also found larger regional variation in women [19 38 39].

The gender-specific pattern in the association between social class and the prevalence of T2DM need to be further explored, since the pathways are still unknown [8]. Macintyre et al. noted that socio-economic determinants vary in their meaning for men and women, since both genders are socialized in different ways with diverging social roles and coping strategies against stress; they hold different occupational positions in the labor market and have dissimilar access to material and psycho-social resources [40]. In our study, overall women were less likely to be in the high social class and were less often employed.

To gain more insight in mechanisms of social inequalities on health, the analysis of population subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms operate identically in different population groups [19]. This work adds knowledge to the research on the interaction of gender, social determinants and health. So far, only few studies examined this interaction with regard to T2DM and to our knowledge no study considered neighborhood unemployment rate in regard to that, so far. Data sources providing representative population-based data on the prevalence of T2DM with a linkage to small areas and regions are still rare.

Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited causal conclusions. We could not use occupation as an indicator of social class in our analysis since the assessment was not comparable between studies. The prevalence of T2DM was based on a self-reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative [42]. Another potential limitation is the selection by response (response proportions: 56%-69%), which might have affected our results. The exclusion of participants from the initial sample due to missing information on individual characteristics (mainly due to missing information on net household income) could have led to an underestimation of the social gradient in T2DM, because these subjects were on average older, more often female, out of employment and with a lower educational status. However, a sensitivity analysis showed similar results applying education as measure of social class. We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not capture the immediate neighborhood of residence of our study participants. This could lead to exposure misclassification and underestimation of neighborhood effects [43]. The applied administrative definition of neighborhoods differed between studies and neighborhoods were diverse according to their area and population size. Another challenge in the research of neighborhood impact on health is the residential selection. Individuals may be selected into neighborhoods due to their individual characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [44 45]. Finally, we had no information on the residential history of the study participants, which could result in an underestimation of neighborhood effects on health [46].

In conclusion, our study identified different relationships of individual social class, employment status and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men and women, the prevalence of T2DM was inversely related to social class. This social gradient was stronger in women. Regional variance in the T2DM prevalence was larger in women than men. Whereas the major proportion of the variance in the T2DM prevalence remained statistically unexplained in women, the regional variance in men was low and completely explained by the considered variables.

Table 1: Characteristics of The Five Studies (CARLA, DHS, KORA, HNR, and SHIP studies, Germany, 1997-2006)[a]

| | CARLA | DHS | KORA | HNR | SHIP |
|---|---|---|---|---|---|
| Federal State (Region) | Saxony-Anhalt (east) | North Rhine-Westphalia (west) | Bavaria (south) | North Rhine-Westphalia (west) | Mecklenburg-West Pomerania (northeast) |
| Sampling | stratified random sampling | stratified random sampling | two-stage cluster sampling | stratified random sampling | two-stage cluster sampling |
| Cities | Halle (Saale) | Dortmund | Augsburg | Bochum, Essen, Mülheim | Greifswald, Stralsund |
| Neighborhoods (n) | 43 city districts | 62 statistical administrative units | 17 planning regions | 108 statistical administrative units | 6 clusters of city districts |
| Corresponding year | 2003 | 2003 | 2000 | 2000/ 2001 | 1999 (2003) |
| Total population (neighborhood range) | 238,078 (18 - 19,210) | 587,607 (476 - 25,686) | 252,725 (2,730 - 37,246) | 1,142,112 (262 - 32,466) | 115,962 (5,230 - 31,154) |
| Unemployment rate (%; neighborhood range) | 14.1 (3.9 - 22.5) | 15.3 (5.0 - 27.7) | 4.8 (1.9 - 7.6) | 7.5 (1.7 - 13.5) | 13.1 (9.9 - 14.9) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

Table 2: Socio-demographic Characteristics of Men And Women in The Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006)[a]

| Study | CARLA | | DHS | | KORA | | HNR | | SHIP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | men | women | men | women | men | women | men | women | men | women |
| **Study period** | 12/2002-01/2006 | | 09/2003-06/2004 | | 10/1999-04/2001 | | 12/2000-06/2003 | | 10/1997-03/2001 | |
| **Participants 45-74 with full information** | 719 | 638 | 414 | 411 | 532 | 494 | 2,257 | 2,175 | 615 | 615 |
| **Number of neighborhoods (range of residing participants)** | 37 (3-139) | | 60 (1-42) | | 17 (13-141) | | 106 (1-140) | | 6 (95-396) | |
| **Crude diabetes prevalence (%) (95% CI)** | 12.9 (10.6-15.6) | 12.1 (9.6-14.9) | 11.8 (8.9-15.3) | 7.8 (5.4-10.8) | 7.0 (4.9-9.5) | 5.5 (3.6-7.9) | 8.9 (7.8-10.2) | 5.9 (5.0-7.0) | 11.7 (9.3-14.5) | 9.6 (7.4-12.2) |
| **Mean age (SD)** | 61.0 (8.0) | 60.4 (7.8) | 60.9 (8.4) | 59.7 (8.5) | 58.9 (8.6) | 58.8 (8.4) | 59.53 (7.8) | 59.4 (7.81) | 60.3 (8.3) | 58.8 (8.3) |
| **Social class % (n)** | | | | | | | | | | |
| lower | 7.4 (53) | 13.0 (83) | 11.1 (46) | 23.8 (98) | 5.8 (31) | 16.4 (81) | 6.2 (140) | 19.7 (429) | 12.2 (75) | 26.0 (160) |
| middle | 61.3 (441) | 65.1 (415) | 46.1 (191) | 46.2 (190) | 48.5 (258) | 54.1 (267) | 53.0 (1195) | 55.9 (1215) | 67.3 (414) | 63.1 (388) |
| higher | 31.3 (225) | 21.9 (140) | 42.8 (177) | 29.9 (123) | 45.7 (243) | 29.6 (146) | 40.9 (922) | 24.4 (531) | 20.5 (126) | 10.9 (67) |
| **Employment status % (n)** | | | | | | | | | | |
| employed | 34.9 (251) | 30.6 (195) | 38.7 (160) | 34.8 (143) | 50.4 (268) | 35.0 (173) | 46.4 (1047) | 31.9 (693) | 33.3 (205) | 35.1 (216) |
| retired | 48.1 (346) | 52.0 (332) | 51.9 (215) | 33.8 (139) | 42.9 (228) | 39.3 (194) | 47.6 (1075) | 37.4 (813) | 54.0 (332) | 49.6 (305) |
| unemployed | 15.2 (109) | 12.4 (79) | 7.3 (30) | 6.1 (25) | 6.4 (34) | 8.9 (44) | 5.7 (129) | 7.5 (162) | 12.4 (76) | 14.5 (89) |
| others | 1.8 (13) | 5.0 (32) | 2.2 (9) | 25.3 (104) | 0.4 (2) | 16.8 (83) | 0.3 (6) | 23.3 (507) | 0.3 (2) | 0.8 (5) |
| **Marital status (%)** | | | | | | | | | | |
| living with a partner | 89.0 (640) | 73.4 (468) | 86.7 (359) | 71.5 (294) | 82.5 (439) | 67.2 (332) | 90.2 (2035) | 74.7 (1624) | 88.3 (543) | 68.8 (423) |
| living without a partner | 11.0 (79) | 26.7 (170) | 13.3 (55) | 28.5 (117) | 17.5 (93) | 32.8 (162) | 9.8 (222) | 25.3 (551) | 11.7 (72) | 31.2 (192) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

Table 3: Gender-Stratified Crude And Age-Adjusted Prevalence of Type 2 Diabetes Mellitus by Individual Variables And Neighborhood Unemployment Rate With Data From Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006) [a, b]

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude Prevalence | | | | Age-adjusted Prevalence | | Crude Prevalence | | | | Age-adjusted Prevalence | |
| | No. | T2D Cases | % | 95% CI | % | 95% CI | No. | T2D Cases | % | 95% CI | % | 95% CI |
| **Social class** | | | | | | | | | | | | |
| low | 345 | 56 | 16.2 | 12.5-20.6 | 14.1 | 11.8-16.7 | 851 | 104 | 12.2 | 10.1-14.6 | 9.7 | 8.2-11.4 |
| middle | 2499 | 267 | 10.7 | 9.5-12.0 | 9.7 | 8.7-10.8 | 2475 | 194 | 7.8 | 6.8-9.0 | 6.6 | 5.8-7.5 |
| high | 1693 | 129 | 7.6 | 6.4-9.0 | 6.9 | 5.9-8.1 | 1007 | 26 | 2.6 | 1.7-3.8 | 4.7 | 3.9-5.7 |
| **Employment status** | | | | | | | | | | | | |
| employed | 1931 | 126 | 6.5 | 5.5-7.7 | 7.3 | 6.2-8.7 | 1420 | 39 | 2.8 | 2.0-3.7 | 5.5 | 4.6-6.7 |
| unemployed | 2196 | 289 | 13.2 | 11.8-14.7 | 10.3 | 8.0-13.2 | 1783 | 213 | 12.0 | 10.5-13.5 | 7.9 | 6.0-10.2 |
| retired | 378 | 32 | 8.5 | 5.9-11.7 | 10.2 | 8.8-11.7 | 399 | 26 | 6.5 | 4.3-9.4 | 7.8 | 6.6-9.1 |
| others | 32 | 5 | 15.6 | 5.3-3.3 | 8.7 | 6.4-11.6 | 731 | 46 | 6.3 | 4.6-8.3 | 6.6 | 5.0-8.6 |
| **Marital status** | | | | | | | | | | | | |
| Living with a partner | 4016 | 387 | 9.6 | 8.7-10.6 | 8.7 | 7.9-9.5 | 3141 | 199 | 6.3 | 5.5-7.2 | 6.2 | 5.5-7.0 |
| Living without a partner | 521 | 65 | 12.5 | 9.8-15.6 | 11.5 | 9.7-13.4 | 1192 | 125 | 10.5 | 8.8-12.4 | 8.3 | 7.1-9.6 |
| **Physical exercise** | | | | | | | | | | | | |
| physical exercise | 2473 | 193 | 7.8 | 6.8-8.9 | 7.4 | 6.6-8.4 | 2262 | 136 | 6.0 | 5.1-7.1 | 5.5 | 4.8-6.4 |
| no physical exercise | 2007 | 255 | 12.7 | 11.3-14.2 | 10.9 | 9.7-12.1 | 1989 | 178 | 8.9 | 7.7-10.3 | 8.1 | 7.2-9.2 |
| **Smoking** | | | | | | | | | | | | |
| never smoked | 1369 | 112 | 8.2 | 6.8-9.8 | 8.3 | 7.2-9.6 | 2502 | 208 | 8.3 | 7.3-9.5 | 6.5 | 5.7-7.4 |
| ex-smoker | 1962 | 227 | 11.6 | 10.2-13.1 | 9.6 | 8.4-10.8 | 894 | 67 | 7.5 | 5.9-9.4 | 7.5 | 6.4-8.9 |
| crurrent smoker | 1149 | 109 | 9.5 | 7.9-11.3 | 8.6 | 7.3-10.1 | 855 | 39 | 4.6 | 3.3-6.2 | 6.8 | 5.6-8.1 |
| **BMI** | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| < 30 | 3217 | 258 | 8.0 | 7.1-9.0 | 6.5 | 5.8-7.3 | 2993 | 123 | 4.1 | 3.4-4.9 | 4.7 | 4.1-5.4 |
| ≥ 30 | 1263 | 190 | 15.0 | 13.1-17.1 | 15.4 | 13.7-17.2 | 1258 | 191 | 15.2 | 13.2-17.3 | 11.4 | 10.0-13.0 |
| **Alcohol consumption** | | | | | | | | | | | | |
| no or moderate intake | 3967 | 410 | 10.3 | 9.4-11.3 | 9.2 | 8.3-10.1 | 4013 | 303 | 7.6 | 6.8-8.4 | 6.8 | 6.1-7.7 |
| high intake | 513 | 38 | 7.4 | 5.3-10.0 | 7.3 | 5.6-9.6 | 238 | 11 | 4.6 | 2.3-8.1 | 5.5 | 4.0-7.3 |
| **Unemployment rate** | | | | | | | | | | | | |
| low | 1519 | 125 | 8.2 | 6.9-9.7 | 7.4 | 6.4-8.6 | 1384 | 85 | 6.1 | 4.9-7.5 | 5.6 | 4.8-6.6 |
| mid | 1578 | 143 | 9.1 | 7.7-10.6 | 8.6 | 7.5-9.9 | 1527 | 120 | 7.9 | 6.6-9.3 | 6.5 | 5.6-7.6 |
| high | 1440 | 184 | 12.8 | 11.1-14.6 | 10.9 | 9.6-12.3 | 1422 | 119 | 8.4 | 7.0-9.9 | 8.3 | 7.2-9.5 |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)
[b] Age-adjusted prevalence are derived from logistic regression models in the whole sample

Table 4: Gender-Stratified Multi-Level Logistic Regression of Type 2 Diabetes Mellitus by Individual Social Class, Employment Status and Neighborhood Unemployment Rate [a, b, c]

| | | Social class (Reference: high social class) | | Employment status (Reference: employed) | | | Unemployment rate (Reference: low unemployment rate) | |
|---|---|---|---|---|---|---|---|---|
| | | **middle** | **low** | **retired** | **unemployed** | **others** | **middle** | **high** |
| | | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Model 1**[d] | Women | 3.11 (2.04-4.73) | 5.37 (3.44-8.40) | 4.71 (3.31-6.69) | 2.36 (1.41-3.95) | 2.65 (1.69-4.14) | 1.45 (1.03-2.04) | 1.26 (0.89-1.79) |
| | Men | 1.42 (1.13-1.77) | 2.26 (1.61-3.18) | 2.13 (1.71-2.65) | 1.24 (0.82-1.87) | 2.37 (0.89-6.31) | 1.15 (0.89-1.48) | 1.58 (1.24-2.02) |
| **Model 2**[e] | Women | 2.25 (1.46-3.45) | 3.16 (1.99-5.03) | 2.01 (1.26-3.21) | 2.07 (1.23-3.48) | 1.77 (1.10-2.85) | 1.45 (1.03-2.04) | 1.25 (0.88-1.78) |
| | Men | 1.21 (0.96-1.51) | 1.99 (1.41-2.81) | 1.24 (0.90-1.72) | 1.17 (0.77-1.76) | 1.97 (0.73-5.28) | 1.12 (0.86-1.45) | 1.62 (1.26-2.70) |
| **Model 3**[f] | Women | 2.02 (1.31-3.13) | 2.68 (1.66-4.34) | 1.77 (1.10-2.84) | 1.73 (1.02-2.92) | 1.64 (1.01-2.67) | 1.36 (0.96-1.93) | 1.13 (0.79-1.62) |
| | Men | 1.13 (0.89-1.43) | 1.75 (1.20-2.54) | 1.09 (0.77-1.52) | 0.94 (0.61-1.44) | 1.99 (0.74-5.36) | 1.08 (0.83-1.40) | 1.52 (1.18-1.96) |
| **Model 4**[g, h] | Women | 1.55 (0.99-2.41) | 1.76 (1.07-2.90) | 1.66 (1.03-2.68) | 1.74 (1.02-2.98) | 1.64 (1.00-2.70) | 1.21 (0.85-1.73) | 1.03 (0.71-1.48) |
| | Men | 1.03 (0.81-1.31) | 1.49 (1.02-2.20) | 1.02 (0.72-1.44) | 0.91 (0.59-1.40) | 1.71 (0.63-4.66) | 1.06 (0.82-1.37) | 1.45 (1.13-1.86) |

[a] Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

[b] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[c] men: n=4,537, women: n=4,333

[d] Model 1: unadjusted

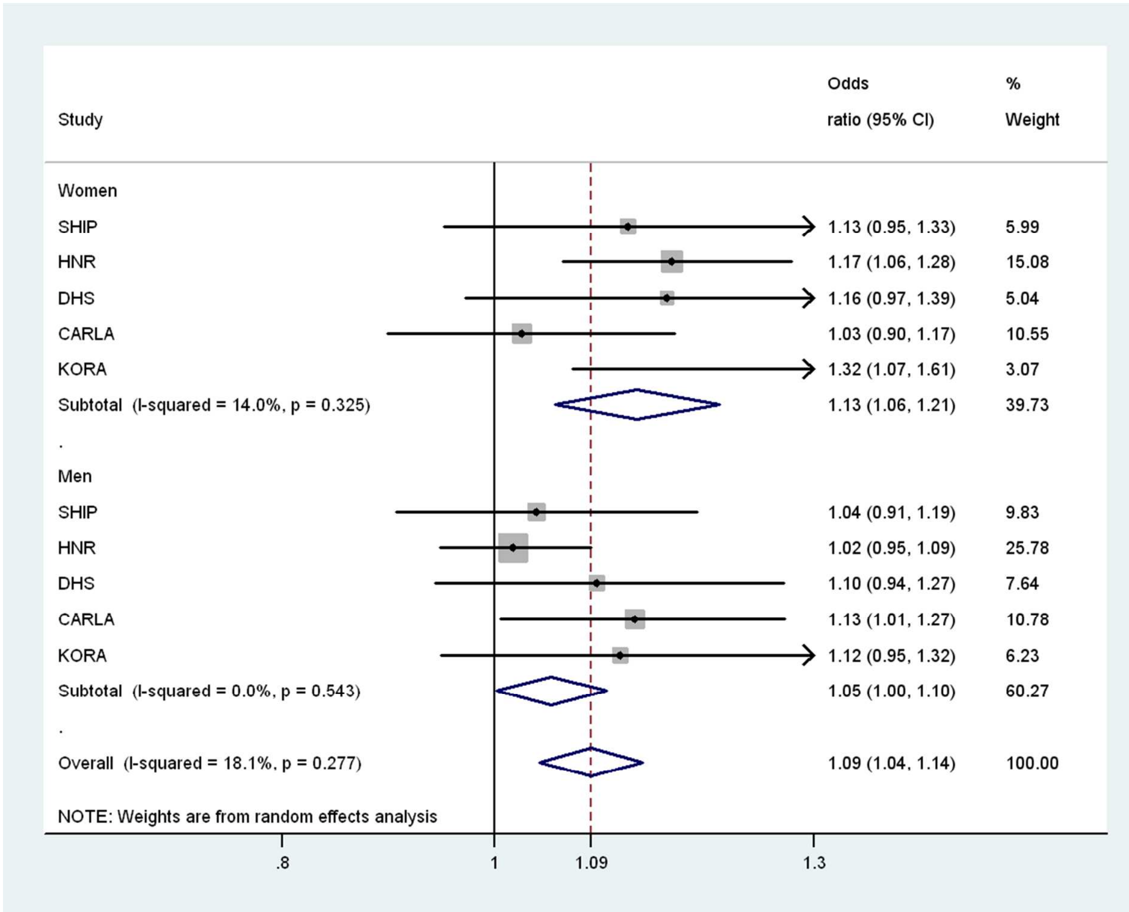
[e] Model 2: adjusted by age

[f] Model 3: adjusted by other confounders: social class, employment status, neighborhood unemployment rate, marital status

[g] Model 4: adjusted by mediators: BMI, physical exercise, smoking (only for men)

[h] Sample size n=8,731 due to 139 missing values on life style factors

Figure 1: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes Mellitus for the Social Class Score (Range: 2-14 Points) in Women and Men [a, b, c, d]




[a] Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

[b] Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

[c] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[d] Heterogeneity tested via Q-statistic and I²-index

**Declaration of Competing Interests**

Nothing to declare.

**Data sharing statement**

There is no additional data available.

**Patient consent**

Obtained.

**Contribution**

The authors G.M., K.B. (DHS), S.H., K.H.G. (CARLA), S.M., N.P. (HNR), S.S., H.V. (SHIP), W.M., and C.M. (KORA) researched data. G.M. developed the study conception, performed the statistical analyses and drafted the manuscript. K.B. contributed to the study conception, statistical analyses and data interpretation. W.R. and T.T. contributed to the pooling of data. All authors critically reviewed the manuscript and contributed to the interpretation of the results.

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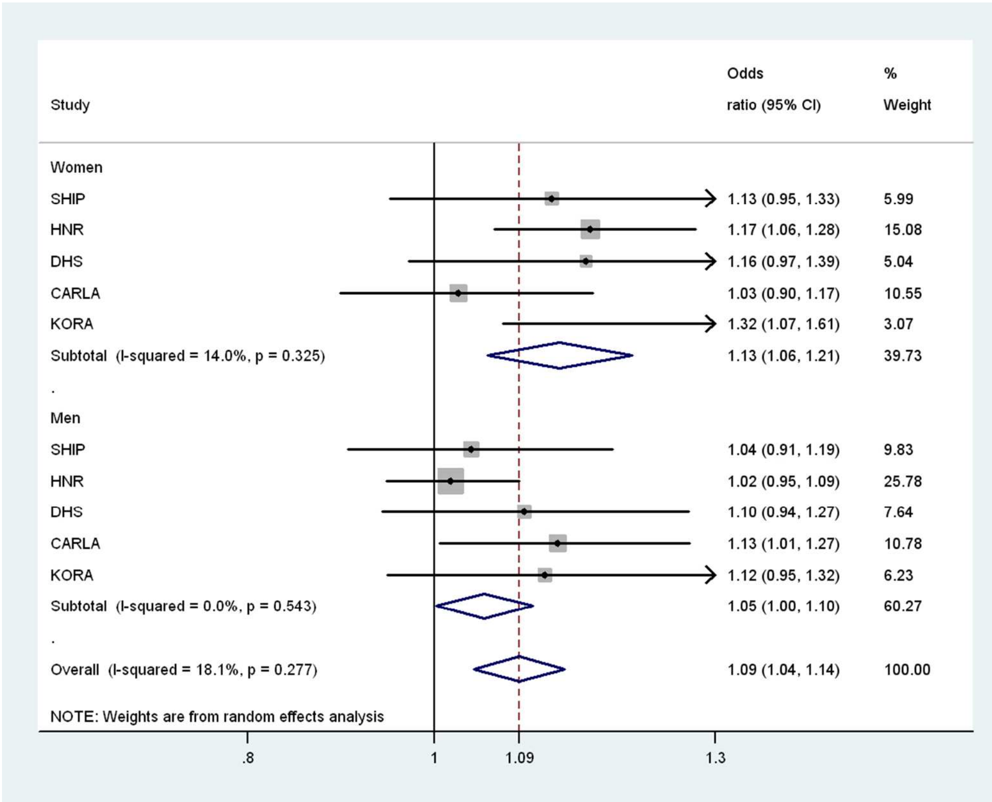


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**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6-7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6-7 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 8 |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6-7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7-8 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 7 |
| | | (*c*) Explain how missing data were addressed | 6 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | - |
| | | (*e*) Describe any sensitivity analyses | 8 |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 6/8 |
| | | (b) Give reasons for non-participation at each stage | 6 |
| | | (c) Consider use of a flow diagram | - |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 8/15 (table 2) |
| | | (b) Indicate number of participants with missing data for each variable of interest | 6 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 15 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 8-10/17 (table 3) |
| | | (*b*) Report category boundaries when continuous variables were categorized | 6 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | - |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 10 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 11-12 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 13 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 12 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 12 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 25 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

# Gender Differences in the Association of Individual Social Class and Neighborhood Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium

| | |
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| Keywords: | General diabetes < DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, PUBLIC HEALTH |

**Gender Differences in the Association of Individual Social Class and Neighborhood Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium**

**Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**

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**Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics, Socioeconomic Factors, Population-based

Word count: 3710

**Abstract** (word count: 253; max. 300)

**Objective:** To analyze gender differences in the relationship of individual social class, employment status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).

**Design:** Five cross-sectional studies.

**Setting:** Studies were conducted in five regions of Germany from 1997-2006.

**Participants:** The sample consisted of 8,871 individuals residing in 226 neighborhoods in five urban regions.

**Primary and secondary outcome measures:** Prevalent T2DM.

**Results:** We found significant multiplicative interactions between gender and the individual variables social class and employment status. Social class was statistically significant associated with T2DM in men and women, whereby this association was stronger in women (lower versus higher social class: odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34)) than men (lower versus higher social class: OR 1.78 (95% CI: 1.22-2.58)). Significant associations of employment status and T2DM were only found in women (unemployed versus employed: OR 1.73 (95% CI: 1.02-2.92); retired versus employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed: OR 1.64 (95% CI: 1.01-2.67)). Neighborhood unemployment rate was associated with T2DM in men (high versus low tertile: OR 1.52 (95% CI: 1.18-1.96)). Between-study and between-neighborhood variation in the T2DM prevalence was more pronounced in women. The considered covariates helped to explain statistically the variation in the T2DM prevalence among men, but not among women.

**Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the association was more pronounced in women. Employment status only affected T2DM in women. Neighborhood unemployment rate is an important predictor of T2DM in men, but not in women.

**Article Summary**

**Article focus**

- The aim of this study was to examine disparities in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM by gender in a pooled analysis of five population-based regional studies.

**Key messages**

- Social class was statistically significantly associated with T2DM among women and men, however, the association was stronger in women than men; particularly the individual employment status is an important determinant of T2DM in women.
- Between-study and between-neighborhood variance in T2DM was more pronounced in women, as already observed for obesity.
- Neighborhood unemployment rate was only associated with T2DM in men after the adjustment for individual variables.

**Strength and limitations of this study**

- Data of five population-based representative studies were applied linking data on the prevalence of T2DM to small areas and regions.
- This study adds knowledge to the research on the interaction of gender, social determinants and health on different levels.
- Limitations were as follows: The cross-sectional design does not allow causal conclusions; T2DM was based on a self-reported physician's diagnosis; Administrative definitions of neighborhoods could result in exposure misclassification and underestimation of neighborhood effects; Problem of residential selection.

**List of Abbreviations**

| | |
|---|---|
| CARLA | Cardiovascular Disease, Living and Ageing in Halle Study |
| CI | Confidence Interval |
| DHS | Dortmund Health Study |
| DIAB-CORE | Diabetes Collaborative Research of Epidemiologic Studies |
| HNR | Heinz Nixdorf Recall Study |
| KORA S4 | Cooperative Health Research in the Region of Augsburg Survey 4 |
| MOR | Median Odds Ratio |
| OR | Odds Ratio |
| SD | Standard Deviation |
| SE | Standard Error |
| SHIP | Study of Health in Pomerania |
| T2DM | Type 2 Diabetes Mellitus |
| $V_A$ | Area-Level Variance |

## Introduction

Gender differences in health inequality vary by the studied health outcome, the measure of social status and the stage of life course [1-3]. A systematic review of 23 case-control and cohort studies on socio-economic differences in the incidence of type 2 diabetes mellitus (T2DM) concluded that inequality in the risk of T2DM was stronger in women than men [4]. However, the results are diverse in respect to the magnitude in the association of T2DM and social status in men: A number of studies showed associations among both men and women [5-8], but there have been also studies published reporting associations only in women [9 10]. In respect to occupational status, contrasting results have been presented by Kumari et al. [11] and Maty et al. [12]. For instance, the first study showed a stronger inverse relationship between the civil service employment grade and the incidence of T2DM in men, applying data of the Whitehall study II [11].

Beyond an individual's social class, socio-economic characteristics of the neighborhood affect health [13-15]. As part of the Diabetes Collaborative Research of Epidemiologic Studies (DIAB-CORE) in Germany, Schipf et al. reported regional disparities in the age-standardized prevalence of T2DM [16]. In two recent studies, we found that the prevalence of T2DM varied across regions in Germany, even after adjustment for individual characteristics. These variations could in part be explained statistically by neighborhood unemployment rate within cities or by regional deprivation [17 18].

Gender differences may arise out of different exposures to social, psychosocial and behavioral determinants of health ("differential exposure hypothesis"). Another explanation might be a different vulnerability to health determinants, characteristics of the neighborhood and reaction to material, behavioral and psychosocial conditions of men and women ("differential vulnerability hypothesis") [2 19]. Differences in men's and women's perception of the neighborhood context and social status may be as well a source of health disparities. Stafford et al. examined gender differences in the relationship between self-rated health and the neighborhood context and found a larger impact of the neighborhood context on the health of women [19].

The aim of this study was (1) to investigate if the association of individual social class, individual employment status and neighborhood unemployment rate with prevalent T2DM differs for men and women in a pooled analysis of five population-based regional studies; and (2) to examine the extent to which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a sub-analysis, we performed study-specific calculations of the relationship between T2DM and social class in men and women.

## Methods

Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage cluster or stratified random sampling) and response proportions (56%-69%). The studies were approved by local ethics committees and informed written consent was obtained from the study participants. Within the five studies, similar instruments, questionnaires and medical measurements were applied to collect data. Study designs have been described elsewhere in more detail [20-24].

In brief, data on 11,688 subjects aged 45-74 years were provided. 2,280 individuals living in rural areas of KORA and SHIP were excluded from the sample, because these subjects could not be assigned to spatial units below the level of municipalities; so, that our study was limited to urban areas. Study participants were assigned to neighborhoods via addresses of residence at baseline (8 subjects could not be linked). The neighborhoods were defined by administrative units: statistical administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning regions (summary of city districts) in KORA and postal code areas in SHIP. Participants resided in 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of participants with missing information on individual characteristics (n=529), the final sample consisted of 8,871 residents in 226 neighborhoods.

Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded from the analyses to avoid inclusion of possible cases of type 1 diabetes.

Social class was measured with a summary score of income and education. Its' operationalization was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on individual educational and professional attainment, net household income and the occupational position of the main earner of a household. The three dimensions are transformed to an ordinal scale ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information on occupational status was not available for our analysis, the index was solely based on education and income, ranging between 2 and 14 points. The index was divided into three groups: higher social class, middle social class and lower social class. Study participants were classified in four employment status groups: employed, retired and unemployed individuals as well as persons with other forms of employment, including participants in vocational retraining, housewives and housemen.

Neighborhood unemployment rate was applied as a proxy for the socio-economic status of the neighborhoods and calculated as the number of unemployed residents in relation to the working-age population (aged 15-64), obtained from the statistical offices of each considered city. The median year of the data collection period of each study was used as the reference year. A number of studies applied unemployment rate as a measure of deprivation and it was proven to be a strong predictor of health outcomes [22 27-29]. Campbell et al. highlighted that unemployment rate is a simple and good indicator for social and material deprivation, which is regularly updated and easily accessible [30]. For our analysis, equally-sized tertiles of study-specific neighborhood unemployment rate were used to detect a potential dose-response relationship. Hereafter, the authors refer to low, medium and high levels of unemployment rate in relative terms which corresponds, however, to considerably different levels of unemployment rate across study regions.

The variable marital status summarized information whether a study participant lived with or without a partner. Moreover, life style variables including smoking status (current smoker; former smoker; never smoker), physical exercise (exercise; no exercise), body mass index (BMI) (<30 kg/m²; >=30 kg/m²) and alcohol consumption (no or moderate intake: women: <=20 grams per day; men: <=40 grams per day; high intake: women: >20 grams per day; men: >40 grams per day) were considered. Physical exercise was measured as hours spent per week on all kinds of exercise training excluding low level exercise like walking. Due to homogenization procedure, physical exercise was operationalized as any exercise irrespective of frequency and duration. All variables were constructed following DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of comparability.

**Statistical Analysis**

Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual variables and neighborhood unemployment rate.

Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods (level 2), which were nested in study regions (level 3). To account for this data structure in our statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed effects logistic regression models. First, we tested for interactions between gender and individual social class, employment status and neighborhood unemployment rate. To do so, we estimated regression models including terms for gender and social class, employment status or neighborhood unemployment rate as main effects and an interaction term for the effect of social class, employment status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables age, marital status and the remaining social variables (social class/ employment status/ neighborhood unemployment rate) depending on the variable of interest. Life style factors, including smoking, alcohol consumption, BMI and physical activity were evaluated as potential mediators in the relationship between T2DM and individual social class, employment status or neighborhood unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.

Random effects were included to capture between-study and between-neighborhood variance reported as median odds ratios (MOR). The latter represents a transformation of the area-level variation ($V_A$) on an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and lowest-risk-area and was calculated on the level of neighborhoods and study regions with the following equation: $MOR = exp\left(\sqrt{(2 * V_A)} * 0.6745\right)$, where 0.6745 is the 75$^{th}$ centile of the cumulative distribution function of the normal distribution with mean zero and variance one [31 32].

Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small number of cases by study, the social class variable had to be applied as a continuous measure in this sub-analysis (ranging between two points, highest social class, and 14 points, lowest social class). For this purpose, inverse-variance weighting was used to estimate fixed and random effects summary estimates and displayed in forest plots [33]. Q-statistic and $I^2$ index were applied to assess heterogeneity and the extent of heterogeneity between study results respectively [34]. Analyses were performed in STATA/ SE 11.0.

**Results**

In total, 8,871 subjects residing in 226 neighborhoods in five urban regions were included in our analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95% CI 9.1-10.9) (significance derived from 95% CI). This pattern was observed in all five regional studies. Socio-demographic characteristics are reported in table 2. Compared to men, women belonged more often to the lower or middle social class and a higher proportion was not employed, except in SHIP. A higher proportion of women than men reported to live without a partner.

The age-adjusted prevalence of T2DM was statistically significantly lower in higher social class women and men than in the lower social class (4.7% (95% CI: 3.9-5.7) respectively 9.7% (95% CI: 8.3-11.5) in women; 6.9% (95% CI: 5.9-8.1) respectively 14.2% (95% CI: 11.8-16.8) in men) (table 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all social classes. Employed men had a statistically significantly lower age-adjusted T2DM prevalence with 7.3% (95% CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods, the highest age-adjusted prevalence of T2DM was found in women and men living in neighborhoods with a high unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)). Individuals living without a partner showed statistically significantly higher prevalence then individuals who lived with a partner irrespective of gender. Being physical inactive or having a BMI of 30 or above was statistically significantly associated with a higher T2DM prevalence in men and women.

In the fully adjusted multivariable analyses, the interaction terms of social class and gender were statistically significant. Among the employment status, we found significant multiplicative interactions between unemployed individuals and gender as well as between retired individuals and gender. The interaction terms between neighborhood unemployment rate and gender were not statistically significant.

The results of the gender-stratified multivariable regression analysis are presented in table 4. Among women and men, we found a statistically significant association of social class and T2DM. The social gradient in the odds of T2DM was reduced when the models were adjusted for age and the confounding variables. This reduction was particularly large in women. Overall, the association between social class and T2DM was stronger in women (lower versus higher social class: OR 2.68 (95% CI: 1.66-4.34)) than men (lower versus higher social class: OR 1.77 (95% CI: 1.22-2.58)) (model 3, table 4). Significant associations of employment status and T2DM were only found in women: In reference to employed women, retired women, unemployed women and women with other employment status had a 1.73, (95% CI: 1.02-2.92), a 1.77 (95% CI: 1.10-2.84) respectively a 1.64 (95% CI: 1.01-2.67) higher odds to have T2DM (model 3, table 4). The significant elevated odds of T2DM in retired men were dissolved by adjustment for age.

Women residing in neighborhoods with a medium level of unemployment showed significant elevated odds to have T2DM (OR 1.45 (95% CI: 1.03-2.04)) (model 2), which was dissolved when the model was adjusted by confounding variables. In contrast, men residing in neighborhoods with a high level of unemployment showed a 52% (95% CI: 1.18-1.96) higher odds to have T2DM than men in low unemployment neighborhoods in the confounder-adjusted model 3. T2DM was no longer associated with marital status after adjustment by confounding variables in model 3 (living without versus living with a partner: OR 1.17 (95% CI: 0.90-1.51) in women, OR 1.20 (95% CI: 0.89-1.61) in men).

As part of mediation analysis, the association of life style variables and social class, employment status and neighborhood unemployment rate as well as the association between type 2 diabetes and life style variables were tested. Type 2 diabetes was related to BMI and physical activity in men and women, but smoking only in men and alcohol consumption not in both (not taken into further consideration). BMI, physical activity and smoking were tested to be statistically significantly associated with social class, employment status and neighborhood unemployment rate with some exceptions: In women, physical exercise was not associated with employment status and smoking not related at all with social variables. Thereupon, the life style variables were introduced into model 4 and the estimates of social class, employment status and neighborhood unemployment rate evaluated in respect to reductions in the association with T2DM. In men and women, we observed reductions in the effects of individual social class, employment status and neighborhood unemployment rate when introducing these life style factors in the analysis. Especially, the association between social class and T2DM was strongly reduced in women and men. This reduction was mainly driven by BMI in women (solely adjusted by BMI, higher versus lower social class OR 1.73 (95% CI: 1.05-2.85)) and physical exercise in men (solely adjusted by physical exercise, higher versus lower social class OR 1.59 (95% CI: 1.09-2.32)), providing evidence that these life style variables partly mediated the relationship between social class and type 2 diabetes.

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. The prevalence of T2DM in men varied only between study regions (unadjusted model: MOR: 1.20; $V_A$: 0.04; SE: 0.03) (online supplemental material, table 5), which was fully explained statistically by age, social class, employment status, neighborhood unemployment rate, marital status and life style factors. The T2DM prevalence in women showed large variation across neighborhoods (unadjusted model: MOR: 1.47; $V_A$: 0.16; SE: 0.10) and study regions (unadjusted model: MOR: 1.31; $V_A$: 0.07; SE: 0.06), which was not dissolved by the considered explanatory variables (between-neighborhood variation: MOR: 1.32; $V_A$: 0.08; SE: 0.09, between-study variation: MOR: 1.29; $V_A$: 0.07; SE: 0.06) (model 5, table 5).

Regarding gender differences in health inequalities across regions, the effect estimates of the five studies were tested to be homogenous (figure 1). A low social class was associated with higher odds of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate. In women, an increase of one point on the social class score (decrease in social class) was associated with an increase of 13% (pooled OR: 1.13 (95% CI: 1.06-1.21); $I^2$=14.0%; p=0.325) in the odds of having T2DM. This association was smaller in men (pooled OR: 1.06 (95% CI: 1.00-1.11); $I^2$=0.0%;

p=0.456), although the differences between genders were not significant. This was observed in all studies, except CARLA.

**Discussion**

This study assessed gender differences in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM, using data from five regional population-based studies in Germany. Women and men belonging to the lower social class had a higher prevalence of T2DM. We found that the gradient in the prevalence of T2DM across social classes was clearly stronger in women than men. This pattern was consistent across all regions but CARLA and mainly in line with results of prior studies presenting only associations in women [7-9], or in men and women but more pronounced in women [5 6].

In our study, the individual employment status was only associated with T2DM in women. Being unemployed, retired or a housewife yielded higher odds of T2DM. However, since we were not able to consider occupational position in our analyses, the interpretation of these findings is limited. In the literature, two contrasting theories are discussed for the effects of paid employment on women's health. Employment can have a health promoting function due to role accumulation in contrast to the monotony, isolation, low social status and self-esteem of housewives. A health damaging effect could arise due to role strains, e.g. stress due to multiple roles, and heavy job demands [35 36].

Men residing in neighborhoods with a high level of unemployment rate were more likely to have T2DM than men in better-off neighborhoods. These effects remained even after adjustment for confounding and mediator variables, whereas associations between neighborhood unemployment rate and T2DM in women were dissolved by the introduction of confounding variables. These deviating effects of neighborhood unemployment rate between men and women may be explained by the fact that men were more often engaged in employment and, hence, depend more on the regional labor market and its employment opportunities than women. Potential underlying mechanisms in the relationship between neighborhood unemployment rate and T2DM include neighborhood resources such as the availability of grocery stores offering healthy food and recreational facilities [15], the adoption and maintenance of risky health behavior and psychosocial factors such as chronic stress [13 37].

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. We found that individual social class, employment status and neighborhood unemployment rate played an important role in explaining statistically regional differences in the prevalence of T2DM in men. A large fraction of the detected variation in the prevalence of T2DM on the level of neighborhoods and regions remained statistically unexplained in women, suggesting that there were characteristics on the individual, neighborhood and regional level that determine the presence of T2DM and which were not considered in our analysis. Previous work on regional variation in self-rated health and BMI also found larger regional variation in women [19 38 39].

The gender-specific pattern in the association between social class and the prevalence of T2DM need to be further explored, since the pathways are still unknown [6]. Macintyre et al. noted that socio-economic determinants vary in their meaning for men and women, since both genders are socialized in different ways with diverging social roles and coping strategies against stress; they hold different occupational positions in the labor market and have dissimilar access to material and psycho-social resources [40]. In our study, overall women were less likely to be in the higher social class and were less often employed.

To gain more insight in mechanisms of social inequalities on health, the analysis of population subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms operate identically in different population groups [19]. This work adds knowledge to the research on the interaction of gender, social determinants and health. So far, only few studies examined this interaction with regard to T2DM and to our knowledge no study considered neighborhood unemployment rate in regard to that, so far. Data sources providing representative population-based data on the prevalence of T2DM with a linkage to small areas and regions are still rare.

Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited causal conclusions. We could not use occupation as an indicator of social class in our analysis since the assessment was not comparable between studies. The prevalence of T2DM was based on a self-reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative [42]. Another potential limitation is the selection by response (response proportions: 56%-69%), which might have affected our results. The exclusion of participants from the initial sample due to missing information on individual characteristics (mainly due to missing information on net household income) could have led to an underestimation of the social gradient in T2DM, because these subjects were on average older, more often female, out of employment and with a lower educational status. However, a sensitivity analysis showed similar results applying education as measure of social class.

We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not capture the immediate neighborhood of residence of our study participants. This could lead to exposure misclassification and underestimation of neighborhood effects [43]. The applied administrative definition of neighborhoods differed between studies and neighborhoods were diverse according to their area and population size. Another challenge in the research of neighborhood impact on health is the residential selection. Individuals may be selected into neighborhoods due to individual characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [44 45]. Finally, we had no information on the residential history of the study participants, which could result in an underestimation of neighborhood effects on health [46].

In conclusion, our study identified different relationships of individual social class, employment status and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men and women, the prevalence of T2DM was inversely related to social class. This social gradient was stronger in women. Regional variance in the T2DM prevalence was larger in women than men. Whereas the major proportion of the variance in the T2DM prevalence remained statistically unexplained in women, the regional variance in men was low and completely explained by the considered variables.

**Table 1: Characteristics of the 5 Population-Based Studies (CARLA, DHS, KORA, HNR, and SHIP, Germany, 1997-2006)[a]**

| | CARLA | DHS | KORA | HNR | SHIP |
|---|---|---|---|---|---|
| **Study period** | 12/2002-01/2006 | 09/2003-06/2004 | 10/1999-04/2001 | 12/2000-06/2003 | 10/1997-03/2001 |
| **Federal state (Region)** | Saxony-Anhalt (east) | North Rhine-Westphalia (west) | Bavaria (south) | North Rhine-Westphalia (west) | Mecklenburg-West Pomerania (northeast) |
| **Sampling** | stratified random sampling | stratified random sampling | two-stage cluster sampling | stratified random sampling | two-stage cluster sampling |
| **Cities** | Halle (Saale) | Dortmund | Augsburg | Bochum, Essen, Mülheim | Greifswald, Stralsund |
| **Neighborhoods (n)/ Types** | 43/ city districts | 62/ statistical administrative units | 17/ planning regions | 108/ statistical administrative units | 6/ clusters of city districts |
| **Total population (neighborhood range)** | 238,078 (18 - 19,210) | 587,607 (476 - 25,686) | 252,725 (2,730 - 37,246) | 1,142,112 (262 - 32,466) | 115,962 (5,230 - 31,154) |
| **Unemployment rate (%; neighborhood range)[b]** | 14.1 (3.9 - 22.5) | 15.3 (5.0 - 27.7) | 4.8 (1.9 - 7.6) | 7.5 (1.7 - 13.5) | 13.1 (9.9 - 14.9) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)
[b] Data on neighborhood unemployment were collected in the year 1999 in SHIP, in 2000 in KORA, in the years 2001 in HNR and in 2003 in CARLA and DHS

**Table 2: Participants Characteristics in the 5 Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006)[a]**

| Study | CARLA | | DHS | | KORA | | HNR | | SHIP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | men | women | men | women | men | women | men | women | men | women |
| **Participants 45-74 with full information** | 719 | 638 | 414 | 411 | 533 | 494 | 2,257 | 2,175 | 615 | 615 |
| **Number of neighborhoods (range of residing participants)** | 37 (3-139) | | 60 (1-42) | | 17 (13-141) | | 106 (1-140) | | 6 (95-396) | |
| **Crude diabetes prevalence (%) (95% CI)** | 12.9 (10.6-15.6) | 12.1 (9.6-14.9) | 11.8 (8.9-15.3) | 7.8 (5.4-10.8) | 7.1 (5.1-9.7) | 5.5 (3.6-7.9) | 8.9 (7.8-10.2) | 5.9 (5.0-7.0) | 11.7 (9.3-14.5) | 9.6 (7.4-12.2) |
| **Mean age (SD)** | 61.0 (8.0) | 60.4 (7.7) | 60.9 (8.4) | 59.7 (8.5) | 58.9 (8.6) | 58.8 (8.4) | 59.5 (7.8) | 59.4 (7.8) | 60.3 (8.3) | 58.8 (8.3) |
| **Social class % (n)** | | | | | | | | | | |
| lower | 7.4 (53) | 13.0 (83) | 11.1 (46) | 23.8 (98) | 6.0 (32) | 16.4 (81) | 6.2 (140) | 19.7 (429) | 12.2 (75) | 26.0 (160) |
| middle | 61.3 (441) | 65.1 (415) | 46.1 (191) | 46.2 (190) | 48.4 (258) | 54.1 (267) | 53.0 (1195) | 55.9 (1215) | 67.3 (414) | 63.1 (388) |
| higher | 31.3 (225) | 21.9 (140) | 42.8 (177) | 29.9 (123) | 45.6 (243) | 29.6 (146) | 40.9 (922) | 24.4 (531) | 20.5 (126) | 10.9 (67) |
| **Employment status % (n)** | | | | | | | | | | |
| employed | 34.9 (251) | 30.6 (195) | 38.7 (160) | 34.8 (143) | 50.3 (268) | 35.0 (173) | 46.4 (1047) | 31.9 (693) | 33.3 (205) | 35.1 (216) |
| retired | 48.1 (346) | 52.0 (332) | 51.9 (215) | 33.8 (139) | 43.0 (229) | 39.3 (194) | 47.6 (1075) | 37.4 (813) | 54.0 (332) | 49.6 (305) |
| unemployed | 15.2 (109) | 12.4 (79) | 7.3 (30) | 6.1 (25) | 6.4 (34) | 8.9 (44) | 5.7 (129) | 7.5 (162) | 12.4 (76) | 14.5 (89) |
| others | 1.8 (13) | 5.0 (32) | 2.2 (9) | 25.3 (104) | 0.4 (2) | 16.8 (83) | 0.3 (6) | 23.3 (507) | 0.3 (2) | 0.8 (5) |
| **Marital status (%)** | | | | | | | | | | |
| living with a partner | 89.0 (640) | 73.4 (468) | 86.7 (359) | 71.5 (294) | 82.4 (439) | 67.2 (332) | 90.2 (2035) | 74.7 (1624) | 88.3 (543) | 68.8 (423) |
| living without a partner | 11.0 (79) | 26.7 (170) | 13.3 (55) | 28.5 (117) | 17.6 (94) | 32.8 (162) | 9.8 (222) | 25.3 (551) | 11.7 (72) | 31.2 (192) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

**Table 3: Gender-Stratified Crude and Age-Adjusted Prevalence of Type 2 Diabetes Mellitus by Individual Variables and Neighborhood Unemployment Rate with Data From Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006) [a, b]**

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude Prevalence | | | | Age-adjusted Prevalence | | Crude Prevalence | | | | Age-adjusted Prevalence | |
| | No. | T2D Cases | % | 95% CI | % | 95% CI | No. | T2D Cases | % | 95% CI | % | 95% CI |
| **Social class** | | | | | | | | | | | | |
| lower | 346 | 57 | 16.5 | 12.7-20.8 | 14.2 | 11.8-16.8 | 851 | 104 | 12.2 | 10.1-14.6 | 9.7 | 8.3-11.5 |
| middle | 2499 | 267 | 10.7 | 9.5-12.0 | 9.7 | 8.7-10.8 | 2475 | 194 | 7.8 | 6.8-9.0 | 6.6 | 5.8-7.5 |
| higher | 1693 | 129 | 7.6 | 6.4-9.0 | 6.9 | 5.9-8.1 | 1007 | 26 | 2.6 | 1.7-3.8 | 4.7 | 3.8-5.6 |
| **Employment status** | | | | | | | | | | | | |
| employed | 1931 | 126 | 6.5 | 5.5-7.7 | 7.3 | 6.2-8.7 | 1420 | 39 | 2.8 | 2.0-3.7 | 5.5 | 4.6-6.7 |
| retired | 2197 | 290 | 13.2 | 11.8-14.7 | 10.2 | 8.8-11.7 | 1783 | 213 | 11.9 | 10.5-13.5 | 7.8 | 6.6-9.1 |
| unemployed | 378 | 32 | 8.5 | 5.9-11.7 | 10.3 | 8.0-13.2 | 399 | 26 | 6.5 | 4.3-9.4 | 7.8 | 6.0-10.2 |
| others | 32 | 5 | 15.6 | 5.3-32.8 | 8.7 | 6.4-11.6 | 731 | 46 | 6.3 | 4.6-8.3 | 6.6 | 5.0-8.6 |
| **Marital status** | | | | | | | | | | | | |
| Living with a partner | 4016 | 387 | 9.6 | 8.7-10.6 | 8.7 | 7.9-9.5 | 3141 | 199 | 6.3 | 5.5-7.2 | 6.2 | 5.4-7.0 |
| Living without a partner | 522 | 66 | 12.6 | 9.9-15.8 | 11.5 | 9.7-13.6 | 1192 | 125 | 10.5 | 8.8-12.4 | 8.3 | 7.1-9.7 |
| **Physical exercise** | | | | | | | | | | | | |
| physical exercise | 2474 | 194 | 7.8 | 6.8-9.0 | 7.5 | 6.6-8.4 | 2266 | 136 | 6.0 | 5.1-7.1 | 5.5 | 4.8-6.3 |
| no physical exercise | 2013 | 258 | 12.8 | 11.4-14.4 | 10.9 | 9.8-12.2 | 1990 | 178 | 8.9 | 7.7-10.3 | 8.1 | 7.2-9.2 |
| **Smoking** | | | | | | | | | | | | |
| never smoked | 1370 | 113 | 8.2 | 6.8-9.8 | 8.4 | 7.2-9.7 | 2502 | 208 | 8.3 | 7.3-9.5 | 6.5 | 5.7-7.4 |
| ex-smoker | 2067 | 241 | 11.7 | 10.3-13.1 | 9.5 | 8.5-10.8 | 936 | 72 | 7.7 | 6.1-9.6 | 7.5 | 6.3-8.8 |
| crurrent smoker | 1050 | 98 | 9.3 | 7.6-11.3 | 8.7 | 7.3-10.3 | 815 | 34 | 4.2 | 2.9-5.8 | 6.8 | 5.6-8.2 |
| **BMI** | | | | | | | | | | | | |
| < 30 | 3220 | 260 | 8.1 | 7.2-9.1 | 6.6 | 5.8-7.4 | 2996 | 123 | 4.1 | 3.4-4.9 | 4.7 | 4.1-5.4 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ≥ 30 | 1267 | 192 | 15.2 | 13.2-17.2 | 15.4 | 13.8-17.3 | 1260 | 191 | 15.2 | 13.2-17.3 | 11.4 | 10.0-12.9 |
| **Alcohol consumption** | | | | | | | | | | | | |
| no or moderate intake | 3974 | 414 | 10.4 | 9.5-11.4 | 9.2 | 8.4-10.2 | 4018 | 303 | 7.5 | 6.7-8.4 | 6.8 | 6.1-7.6 |
| high intake | 513 | 38 | 7.4 | 5.3-10.0 | 7.4 | 5.6-9.6 | 238 | 11 | 4.6 | 2.3-8.1 | 5.4 | 4.0-7.3 |
| **Unemployment rate** | | | | | | | | | | | | |
| low | 1519 | 125 | 8.2 | 6.9-9.7 | 7.4 | 6.4-8.6 | 1384 | 85 | 6.1 | 4.9-7.5 | 5.6 | 4.8-6.6 |
| medium | 1579 | 144 | 9.1 | 7.7-10.6 | 8.7 | 7.6-9.9 | 1527 | 120 | 7.9 | 6.6-9.3 | 6.6 | 5.7-7.6 |
| high | 1440 | 184 | 12.8 | 11.1-14.6 | 10.9 | 9.6-12.3 | 1422 | 119 | 8.4 | 7.0-9.9 | 8.3 | 7.2-9.5 |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)
[b] Age-adjusted prevalence are derived from logistic regression models

**Table 4: Gender-Stratified Multi-Level Logistic Regression of Type 2 Diabetes Mellitus by Individual Social Class, Employment Status and Neighborhood Unemployment Rate [a, b, c]**

| | | Social class (Reference: higher social class) | | Employment status (Reference: employed) | | | Unemployment rate (Reference: low unemployment rate) | |
|---|---|---|---|---|---|---|---|---|
| | | **middle** | **lower** | **retired** | **unemployed** | **others** | **medium** | **high** |
| | | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Model 1[d]** | Women | 3.11 (2.04-4.73) | 5.37 (3.44-8.40) | 4.71 (3.31-6.69) | 2.36 (1.41-3.95) | 2.65 (1.69-4.14) | 1.45 (1.03-2.04) | 1.26 (0.89-1.79) |
| | Men | 1.42 (1.14-1.77) | 2.31 (1.65-3.24) | 2.14 (1.71-2.66) | 1.24 (0.82-1.87) | 2.38 (0.89-6.33) | 1.15 (0.89-1.49) | 1.58 (1.24-2.02) |
| **Model 2[e]** | Women | 2.25 (1.46-3.45) | 3.16 (1.99-5.03) | 2.01 (1.26-3.21) | 2.07 (1.23-3.48) | 1.77 (1.10-2.85) | 1.45 (1.03-2.04) | 1.25 (0.88-1.78) |
| | Men | 1.21 (0.96-1.51) | 2.03 (1.44-2.86) | 1.25 (0.90-1.73) | 1.17 (0.78-1.76) | 1.98 (0.74-5.29) | 1.12 (0.87-1.45) | 1.62 (1.27-2.07) |
| **Model 3[f]** | Women | 2.02 (1.31-3.13) | 2.68 (1.66-4.34) | 1.77 (1.10-2.84) | 1.73 (1.02-2.92) | 1.64 (1.01-2.67) | 1.36 (0.96-1.93) | 1.13 (0.79-1.62) |
| | Men | 1.13 (0.89-1.43) | 1.78 (1.22-2.58) | 1.09 (0.77-1.52) | 0.94 (0.61-1.44) | 2.00 (0.74-5.39) | 1.08 (0.83-1.40) | 1.52 (1.18-1.96) |
| **Model 4[g, h]** | Women | 1.52 (0.98-2.37) | 1.66 (1.01-2.75) | 1.66 (1.02-2.69) | 1.67 (0.97-2.88) | 1.69 (1.02-2.78) | 1.20 (0.85-1.69) | 1.02 (0.72-1.46) |
| | Men | 1.03 (0.81-1.31) | 1.48 (1.00-2.18) | 1.01 (0.72-1.42) | 0.91 (0.59-1.40) | 1.69 (0.62-4.61) | 1.06 (0.82-1.38) | 1.46 (1.13-1.87) |

[a] Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

[b] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[c] men: n=4,538, women: n=4,333

[d] Model 1: unadjusted

[e] Model 2: adjusted by age

[f] Model 3: adjusted by age, social class, employment status, neighborhood unemployment rate, marital status

[g] Model 4: adjusted by age, social class, employment status, neighborhood unemployment rate, marital status, BMI, physical exercise, smoking (only for men)

[h] Sample size n=8,732 due to 139 missing values on life style factors

[a] Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

[b] Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

[c] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[d] Heterogeneity tested via Q-statistic and $I^2$-index

## Declaration of Competing Interests

Nothing to declare.

### Data sharing statement

No additional data available.

**Patient consent**

Obtained.

**Contribution**

The authors G.M., K.B. (DHS), S.H., K.H.G. (CARLA), S.M., N.P. (HNR), S.S., H.V. (SHIP), W.M., and C.M. (KORA) researched data. G.M. developed the study conception, performed the statistical analyses and drafted the manuscript. K.B. contributed to the study conception, statistical analyses and data interpretation. W.R. and T.T. contributed to the pooling of data. All authors critically reviewed the manuscript and contributed to the interpretation of the results.

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Figure legend:

**Figure 1: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes Mellitus for the Social Class Score (Range: 2-14 Points) in Women and Men [a, b, c, d]**

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# Gender Differences in the Association of Individual Social Class and Neighborhood Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from The DIAB-CORE Consortium

**Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**

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**Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics, Socioeconomic Factors, Population-based

Word count: 3710

**Abstract** (word count: 253; max. 300)

**Objective:** To analyze gender differences in the relationship of individual social class, employment status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).

**Design:** Five cross-sectional studies.

**Setting:** Studies were conducted in five regions of Germany from 1997-2006.

**Participants:** The sample consisted of 8,871 individuals residing in 226 neighborhoods in five urban regions.

**Primary and secondary outcome measures:** Prevalent T2DM.

**Results:** We found significant multiplicative interactions between gender and the individual variables social class and employment status. Social class was statistically significant associated with T2DM in men and women, whereby this association was stronger in women (lower versus higher social class: odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34)) than men (lower versus higher social class: OR 1.78 (95% CI: 1.22-2.58)). Significant associations of employment status and T2DM were only found in women (unemployed versus employed: OR 1.73 (95% CI: 1.02-2.92); retired versus employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed: OR 1.64 (95% CI: 1.01-2.67)). Neighborhood unemployment rate was associated with T2DM in men (high versus low tertile: OR 1.52 (95% CI: 1.18-1.96)). Between-study and between-neighborhood variation in the T2DM prevalence was more pronounced in women. The considered covariates helped to explain statistically the variation in the T2DM prevalence among men, but not among women.

**Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the association was more pronounced in women. Employment status only affected T2DM in women. Neighborhood unemployment rate is an important predictor of T2DM in men, but not in women.

## Article Summary

### Article focus

- The aim of this study was to examine disparities in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM by gender in a pooled analysis of five population-based regional studies.

### Key messages

- Social class was statistically significantly associated with T2DM among women and men, however, the association was stronger in women than men; particularly the individual employment status is an important determinant of T2DM in women.
- Between-study and between-neighborhood variance in T2DM was more pronounced in women, as already observed for obesity.
- Neighborhood unemployment rate was only associated with T2DM in men after the adjustment for individual variables.

### Strength and limitations of this study

- Data of five population-based representative studies were applied linking data on the prevalence of T2DM to small areas and regions.
- This study adds knowledge to the research on the interaction of gender, social determinants and health on different levels.
- Limitations were as follows: The cross-sectional design does not allow causal conclusions; T2DM was based on a self-reported physician's diagnosis; Administrative definitions of neighborhoods could result in exposure misclassification and underestimation of neighborhood effects; Problem of residential selection.

## List of Abbreviations

| | |
|---|---|
| CARLA | Cardiovascular Disease, Living and Ageing in Halle Study |
| CI | Confidence Interval |
| DHS | Dortmund Health Study |
| DIAB-CORE | Diabetes Collaborative Research of Epidemiologic Studies |
| HNR | Heinz Nixdorf Recall Study |
| KORA S4 | Cooperative Health Research in the Region of Augsburg Survey 4 |
| MOR | Median Odds Ratio |
| OR | Odds Ratio |
| SD | Standard Deviation |
| SE | Standard Error |
| SHIP | Study of Health in Pomerania |
| T2DM | Type 2 Diabetes Mellitus |
| $V_A$ | Area-Level Variance |

## Introduction

Gender differences in health inequality vary by the studied health outcome, the measure of social status and the stage of life course [1-3]. A systematic review of 23 case-control and cohort studies on socio-economic differences in the incidence of type 2 diabetes mellitus (T2DM) concluded that inequality in the risk of T2DM was stronger in women than men [4]. However, the results are diverse in respect to the magnitude in the association of T2DM and social status in men: A number of studies showed associations among both men and women [5-8], but there have been also studies published reporting associations only in women [9 10]. In respect to occupational status, contrasting results have been presented by Kumari et al. [11] and Maty et al. [12]. For instance, the first study showed a stronger inverse relationship between the civil service employment grade and the incidence of T2DM in men, applying data of the Whitehall study II [11].

Beyond an individual's social class, socio-economic characteristics of the neighborhood affect health [13-15]. As part of the Diabetes Collaborative Research of Epidemiologic Studies (DIAB-CORE) in Germany, Schipf et al. reported regional disparities in the age-standardized prevalence of T2DM [16]. In two recent studies, we found that the prevalence of T2DM varied across regions in Germany, even after adjustment for individual characteristics. These variations could in part be explained statistically by neighborhood unemployment rate within cities or by regional deprivation [17 18].

Gender differences may arise out of different exposures to social, psychosocial and behavioral determinants of health ("differential exposure hypothesis"). Another explanation might be a different vulnerability to health determinants, characteristics of the neighborhood and reaction to material, behavioral and psychosocial conditions of men and women ("differential vulnerability hypothesis") [2 19]. Differences in men's and women's perception of the neighborhood context and social status may be as well a source of health disparities. Stafford et al. examined gender differences in the relationship between self-rated health and the neighborhood context and found a larger impact of the neighborhood context on the health of women [19].

The aim of this study was (1) to investigate if the association of individual social class, individual employment status and neighborhood unemployment rate with prevalent T2DM differs for men and women in a pooled analysis of five population-based regional studies; and (2) to examine the extent to which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a sub-analysis, we performed study-specific calculations of the relationship between T2DM and social class in men and women.

**Methods**

Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage cluster or stratified random sampling) and response proportions (56%-69%). The studies were approved by local ethics committees and informed written consent was obtained from the study participants. Within the five studies, similar instruments, questionnaires and medical measurements were applied to collect data. Study designs have been described elsewhere in more detail [20-24].

In brief, data on 11,688 subjects aged 45-74 years were provided. 2,280 individuals living in rural areas of KORA and SHIP were excluded from the sample, because these subjects could not be assigned to spatial units below the level of municipalities; so, that our study was limited to urban areas. Study participants were assigned to neighborhoods via addresses of residence at baseline (8 subjects could not be linked). The neighborhoods were defined by administrative units: statistical administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning regions (summary of city districts) in KORA and postal code areas in SHIP. Participants resided in 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of participants with missing information on individual characteristics (n=529), the final sample consisted of 8,871 residents in 226 neighborhoods.

Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded from the analyses to avoid inclusion of possible cases of type 1 diabetes.

Social class was measured with a summary score of income and education. Its' operationalization was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on individual educational and professional attainment, net household income and the occupational position of the main earner of a household. The three dimensions are transformed to an ordinal scale ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information on occupational status was not available for our analysis, the index was solely based on education and income, ranging between 2 and 14 points. The index was divided into three groups: higher social class, middle social class and lower social class. Study participants were classified in four employment status groups: employed, retired and unemployed individuals as well as persons with other forms of employment, including participants in vocational retraining, housewives and housemen.

Neighborhood unemployment rate was applied as a proxy for the socio-economic status of the neighborhoods and calculated as the number of unemployed residents in relation to the working-age population (aged 15-64), obtained from the statistical offices of each considered city. The median year of the data collection period of each study was used as the reference year. A number of studies applied unemployment rate as a measure of deprivation and it was proven to be a strong predictor of health outcomes [22 27-29]. Campbell et al. highlighted that unemployment rate is a simple and good indicator for social and material deprivation, which is regularly updated and easily accessible [30]. For our analysis, equally-sized tertiles of study-specific neighborhood unemployment rate were used to detect a potential dose-response relationship. Hereafter, the authors refer to low, medium and high levels of unemployment rate in relative terms which corresponds, however, to considerably different levels of unemployment rate across study regions.

The variable marital status summarized information whether a study participant lived with or without a partner. Moreover, life style variables including smoking status (current smoker; former smoker; never smoker), physical exercise (exercise; no exercise), body mass index (BMI) (<30 kg/m²; >=30 kg/m²) and alcohol consumption (no or moderate intake: women: <=20 grams per day; men: <=40 grams per day; high intake: women: >20 grams per day; men: >40 grams per day) were considered. Physical exercise was measured as hours spent per week on all kinds of exercise training excluding low level exercise like walking. Due to homogenization procedure, physical exercise was operationalized as any exercise irrespective of frequency and duration. All variables were constructed following DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of comparability.

**Statistical Analysis**

Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual variables and neighborhood unemployment rate.

Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods (level 2), which were nested in study regions (level 3). To account for this data structure in our statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed effects logistic regression models. First, we tested for interactions between gender and individual social class, employment status and neighborhood unemployment rate. To do so, we estimated regression models including terms for gender and social class, employment status or neighborhood unemployment rate as main effects and an interaction term for the effect of social class, employment status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables age, marital status and the remaining social variables (social class/ employment status/ neighborhood unemployment rate) depending on the variable of interest. Life style factors, including smoking, alcohol consumption, BMI and physical activity were evaluated as potential mediators in the relationship between T2DM and individual social class, employment status or neighborhood unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.

Random effects were included to capture between-study and between-neighborhood variance reported as median odds ratios (MOR). The latter represents a transformation of the area-level variation ($V_A$) on an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and lowest-risk-area and was calculated on the level of neighborhoods and study regions with the following equation: $MOR = exp\left(\sqrt{(2 * V_A)} * 0.6745\right)$, where 0.6745 is the 75$^{th}$ centile of the cumulative distribution function of the normal distribution with mean zero and variance one [31 32].

Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small number of cases by study, the social class variable had to be applied as a continuous measure in this sub-analysis (ranging between two points, highest social class, and 14 points, lowest social class). For this purpose, inverse-variance weighting was used to estimate fixed and random effects summary estimates and displayed in forest plots [33]. Q-statistic and $I^2$ index were applied to assess heterogeneity and the extent of heterogeneity between study results respectively [34]. Analyses were performed in STATA/ SE 11.0.

**Results**

In total, 8,871 subjects residing in 226 neighborhoods in five urban regions were included in our analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95% CI 9.1-10.9) (significance derived from 95% CI). This pattern was observed in all five regional studies. Socio-demographic characteristics are reported in table 2. Compared to men, women belonged more often to the lower or middle social class and a higher proportion was not employed, except in SHIP. A higher proportion of women than men reported to live without a partner.

The age-adjusted prevalence of T2DM was statistically significantly lower in higher social class women and men than in the lower social class (4.7% (95% CI: 3.9-5.7) respectively 9.7% (95% CI: 8.3-11.5) in women; 6.9% (95% CI: 5.9-8.1) respectively 14.2% (95% CI: 11.8-16.8) in men) (table 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all social classes. Employed men had a statistically significantly lower age-adjusted T2DM prevalence with 7.3% (95% CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods, the highest age-adjusted prevalence of T2DM was found in women and men living in neighborhoods with a high unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)). Individuals living without a partner showed statistically significantly higher prevalence then individuals who lived with a partner irrespective of gender. Being physical inactive or having a BMI of 30 or above was statistically significantly associated with a higher T2DM prevalence in men and women.

In the fully adjusted multivariable analyses, the interaction terms of social class and gender were statistically significant. Among the employment status, we found significant multiplicative interactions between unemployed individuals and gender as well as between retired individuals and gender. The interaction terms between neighborhood unemployment rate and gender were not statistically significant.

The results of the gender-stratified multivariable regression analysis are presented in table 4. Among women and men, we found a statistically significant association of social class and T2DM. The social gradient in the odds of T2DM was reduced when the models were adjusted for age and the confounding variables. This reduction was particularly large in women. Overall, the association between social class and T2DM was stronger in women (lower versus higher social class: OR 2.68 (95% CI: 1.66-4.34)) than men (lower versus higher social class: OR 1.77 (95% CI: 1.22-2.58)) (model 3, table 4). Significant associations of employment status and T2DM were only found in women: In reference to employed women, retired women, unemployed women and women with other employment status had a 1.73, (95% CI: 1.02-2.92), a 1.77 (95% CI: 1.10-2.84) respectively a 1.64 (95% CI: 1.01-2.67) higher odds to have T2DM (model 3, table 4). The significant elevated odds of T2DM in retired men were dissolved by adjustment for age.

Women residing in neighborhoods with a medium level of unemployment showed significant elevated odds to have T2DM (OR 1.45 (95% CI: 1.03-2.04)) (model 2), which was dissolved when the model was adjusted by confounding variables. In contrast, men residing in neighborhoods with a high level of unemployment showed a 52% (95% CI: 1.18-1.96) higher odds to have T2DM than men in low unemployment neighborhoods in the confounder-adjusted model 3. T2DM was no longer associated with marital status after adjustment by confounding variables in model 3 (living without versus living with a partner: OR 1.17 (95% CI: 0.90-1.51) in women, OR 1.20 (95% CI: 0.89-1.61) in men).

As part of mediation analysis, the association of life style variables and social class, employment status and neighborhood unemployment rate as well as the association between type 2 diabetes and life style variables were tested. Type 2 diabetes was related to BMI and physical activity in men and women, but smoking only in men and alcohol consumption not in both (not taken into further consideration). BMI, physical activity and smoking were tested to be statistically significantly associated with social class, employment status and neighborhood unemployment rate with some exceptions: In women, physical exercise was not associated with employment status and smoking not related at all with social variables. Thereupon, the life style variables were introduced into model 4 and the estimates of social class, employment status and neighborhood unemployment rate evaluated in respect to reductions in the association with T2DM. In men and women, we observed reductions in the effects of individual social class, employment status and neighborhood unemployment rate when introducing these life style factors in the analysis. Especially, the association between social class and T2DM was strongly reduced in women and men. This reduction was mainly driven by BMI in women (solely adjusted by BMI, higher versus lower social class OR 1.73 (95% CI: 1.05-2.85)) and physical exercise in men (solely adjusted by physical exercise, higher versus lower social class OR 1.59 (95% CI: 1.09-2.32)), providing evidence that these life style variables partly mediated the relationship between social class and type 2 diabetes.

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. The prevalence of T2DM in men varied only between study regions (unadjusted model: MOR: 1.20; $V_A$: 0.04; SE: 0.03) (online supplemental material, table 5), which was fully explained statistically by age, social class, employment status, neighborhood unemployment rate, marital status and life style factors. The T2DM prevalence in women showed large variation across neighborhoods (unadjusted model: MOR: 1.47; $V_A$: 0.16; SE: 0.10) and study regions (unadjusted model: MOR: 1.31; $V_A$: 0.07; SE: 0.06), which was not dissolved by the considered explanatory variables (between-neighborhood variation: MOR: 1.32; $V_A$: 0.08; SE: 0.09, between-study variation: MOR: 1.29; $V_A$: 0.07; SE: 0.06) (model 5, table 5).

Regarding gender differences in health inequalities across regions, the effect estimates of the five studies were tested to be homogenous (figure 1). A low social class was associated with higher odds of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate. In women, an increase of one point on the social class score (decrease in social class) was associated with an increase of 13% (pooled OR: 1.13 (95% CI: 1.06-1.21); $I^2$=14.0%; p=0.325) in the odds of having T2DM. This association was smaller in men (pooled OR: 1.06 (95% CI: 1.00-1.11); $I^2$=0.0%;

p=0.456), although the differences between genders were not significant. This was observed in all studies, except CARLA.

**Discussion**

This study assessed gender differences in the association of individual social class, employment status and neighborhood unemployment rate with prevalent T2DM, using data from five regional population-based studies in Germany. Women and men belonging to the lower social class had a higher prevalence of T2DM. We found that the gradient in the prevalence of T2DM across social classes was clearly stronger in women than men. This pattern was consistent across all regions but CARLA and mainly in line with results of prior studies presenting only associations in women [7-9], or in men and women but more pronounced in women [5 6].

In our study, the individual employment status was only associated with T2DM in women. Being unemployed, retired or a housewife yielded higher odds of T2DM. However, since we were not able to consider occupational position in our analyses, the interpretation of these findings is limited. In the literature, two contrasting theories are discussed for the effects of paid employment on women's health. Employment can have a health promoting function due to role accumulation in contrast to the monotony, isolation, low social status and self-esteem of housewives. A health damaging effect could arise due to role strains, e.g. stress due to multiple roles, and heavy job demands [35 36].

Men residing in neighborhoods with a high level of unemployment rate were more likely to have T2DM than men in better-off neighborhoods. These effects remained even after adjustment for confounding and mediator variables, whereas associations between neighborhood unemployment rate and T2DM in women were dissolved by the introduction of confounding variables. These deviating effects of neighborhood unemployment rate between men and women may be explained by the fact that men were more often engaged in employment and, hence, depend more on the regional labor market and its employment opportunities than women. Potential underlying mechanisms in the relationship between neighborhood unemployment rate and T2DM include neighborhood resources such as the availability of grocery stores offering healthy food and recreational facilities [15], the adoption and maintenance of risky health behavior and psychosocial factors such as chronic stress [13 37].

Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women than men. We found that individual social class, employment status and neighborhood unemployment rate played an important role in explaining statistically regional differences in the prevalence of T2DM in men. A large fraction of the detected variation in the prevalence of T2DM on the level of neighborhoods and regions remained statistically unexplained in women, suggesting that there were characteristics on the individual, neighborhood and regional level that determine the presence of T2DM and which were not considered in our analysis. Previous work on regional variation in self-rated health and BMI also found larger regional variation in women [19 38 39].

The gender-specific pattern in the association between social class and the prevalence of T2DM need to be further explored, since the pathways are still unknown [6]. Macintyre et al. noted that socio-economic determinants vary in their meaning for men and women, since both genders are socialized in different ways with diverging social roles and coping strategies against stress; they hold different occupational positions in the labor market and have dissimilar access to material and psycho-social resources [40]. In our study, overall women were less likely to be in the higher social class and were less often employed.

To gain more insight in mechanisms of social inequalities on health, the analysis of population subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms operate identically in different population groups [19]. This work adds knowledge to the research on the interaction of gender, social determinants and health. So far, only few studies examined this interaction with regard to T2DM and to our knowledge no study considered neighborhood unemployment rate in regard to that, so far. Data sources providing representative population-based data on the prevalence of T2DM with a linkage to small areas and regions are still rare.

Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited causal conclusions. We could not use occupation as an indicator of social class in our analysis since the assessment was not comparable between studies. The prevalence of T2DM was based on a self-reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative [42]. Another potential limitation is the selection by response (response proportions: 56%-69%), which might have affected our results. The exclusion of participants from the initial sample due to missing information on individual characteristics (mainly due to missing information on net household income) could have led to an underestimation of the social gradient in T2DM, because these subjects were on average older, more often female, out of employment and with a lower educational status. However, a sensitivity analysis showed similar results applying education as measure of social class.

We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not capture the immediate neighborhood of residence of our study participants. This could lead to exposure misclassification and underestimation of neighborhood effects [43]. The applied administrative definition of neighborhoods differed between studies and neighborhoods were diverse according to their area and population size. Another challenge in the research of neighborhood impact on health is the residential selection. Individuals may be selected into neighborhoods due to individual characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [44 45]. Finally, we had no information on the residential history of the study participants, which could result in an underestimation of neighborhood effects on health [46].

In conclusion, our study identified different relationships of individual social class, employment status and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men and women, the prevalence of T2DM was inversely related to social class. This social gradient was stronger in women. Regional variance in the T2DM prevalence was larger in women than men. Whereas the major proportion of the variance in the T2DM prevalence remained statistically unexplained in women, the regional variance in men was low and completely explained by the considered variables.

**Table 1: Characteristics of the 5 Population-Based Studies (CARLA, DHS, KORA, HNR, and SHIP, Germany, 1997-2006)[a]**

| | CARLA | DHS | KORA | HNR | SHIP |
|---|---|---|---|---|---|
| **Study period** | 12/2002-01/2006 | 09/2003-06/2004 | 10/1999-04/2001 | 12/2000-06/2003 | 10/1997-03/2001 |
| **Federal state (Region)** | Saxony-Anhalt (east) | North Rhine-Westphalia (west) | Bavaria (south) | North Rhine-Westphalia (west) | Mecklenburg-West Pomerania (northeast) |
| **Sampling** | stratified random sampling | stratified random sampling | two-stage cluster sampling | stratified random sampling | two-stage cluster sampling |
| **Cities** | Halle (Saale) | Dortmund | Augsburg | Bochum, Essen, Mülheim | Greifswald, Stralsund |
| **Neighborhoods (n)/ Types** | 43/ city districts | 62/ statistical administrative units | 17/ planning regions | 108/ statistical administrative units | 6/ clusters of city districts |
| **Total population (neighborhood range)** | 238,078 (18 - 19,210) | 587,607 (476 - 25,686) | 252,725 (2,730 - 37,246) | 1,142,112 (262 - 32,466) | 115,962 (5,230 - 31,154) |
| **Unemployment rate (%; neighborhood range)[b]** | 14.1 (3.9 - 22.5) | 15.3 (5.0 - 27.7) | 4.8 (1.9 - 7.6) | 7.5 (1.7 - 13.5) | 13.1 (9.9 - 14.9) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

[b] Data on neighborhood unemployment were collected in the year 1999 in SHIP, in 2000 in KORA, in the years 2001 in HNR and in 2003 in CARLA and DHS

**Table 2: Participants Characteristics in the 5 Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006)[a]**

| Study | CARLA | | DHS | | KORA | | HNR | | SHIP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | men | women | men | women | men | women | men | women | men | women |
| **Participants 45-74 with full information** | 719 | 638 | 414 | 411 | 533 | 494 | 2,257 | 2,175 | 615 | 615 |
| **Number of neighborhoods (range of residing participants)** | 37 (3-139) | | 60 (1-42) | | 17 (13-141) | | 106 (1-140) | | 6 (95-396) | |
| **Crude diabetes prevalence (%) (95% CI)** | 12.9 (10.6-15.6) | 12.1 (9.6-14.9) | 11.8 (8.9-15.3) | 7.8 (5.4-10.8) | 7.1 (5.1-9.7) | 5.5 (3.6-7.9) | 8.9 (7.8-10.2) | 5.9 (5.0-7.0) | 11.7 (9.3-14.5) | 9.6 (7.4-12.2) |
| **Mean age (SD)** | 61.0 (8.0) | 60.4 (7.7) | 60.9 (8.4) | 59.7 (8.5) | 58.9 (8.6) | 58.8 (8.4) | 59.5 (7.8) | 59.4 (7.8) | 60.3 (8.3) | 58.8 (8.3) |
| **Social class % (n)** | | | | | | | | | | |
| lower | 7.4 (53) | 13.0 (83) | 11.1 (46) | 23.8 (98) | 6.0 (32) | 16.4 (81) | 6.2 (140) | 19.7 (429) | 12.2 (75) | 26.0 (160) |
| middle | 61.3 (441) | 65.1 (415) | 46.1 (191) | 46.2 (190) | 48.4 (258) | 54.1 (267) | 53.0 (1195) | 55.9 (1215) | 67.3 (414) | 63.1 (388) |
| higher | 31.3 (225) | 21.9 (140) | 42.8 (177) | 29.9 (123) | 45.6 (243) | 29.6 (146) | 40.9 (922) | 24.4 (531) | 20.5 (126) | 10.9 (67) |
| **Employment status % (n)** | | | | | | | | | | |
| employed | 34.9 (251) | 30.6 (195) | 38.7 (160) | 34.8 (143) | 50.3 (268) | 35.0 (173) | 46.4 (1047) | 31.9 (693) | 33.3 (205) | 35.1 (216) |
| retired | 48.1 (346) | 52.0 (332) | 51.9 (215) | 33.8 (139) | 43.0 (229) | 39.3 (194) | 47.6 (1075) | 37.4 (813) | 54.0 (332) | 49.6 (305) |
| unemployed | 15.2 (109) | 12.4 (79) | 7.3 (30) | 6.1 (25) | 6.4 (34) | 8.9 (44) | 5.7 (129) | 7.5 (162) | 12.4 (76) | 14.5 (89) |
| others | 1.8 (13) | 5.0 (32) | 2.2 (9) | 25.3 (104) | 0.4 (2) | 16.8 (83) | 0.3 (6) | 23.3 (507) | 0.3 (2) | 0.8 (5) |
| **Marital status (%)** | | | | | | | | | | |
| living with a partner | 89.0 (640) | 73.4 (468) | 86.7 (359) | 71.5 (294) | 82.4 (439) | 67.2 (332) | 90.2 (2035) | 74.7 (1624) | 88.3 (543) | 68.8 (423) |
| living without a partner | 11.0 (79) | 26.7 (170) | 13.3 (55) | 28.5 (117) | 17.6 (94) | 32.8 (162) | 9.8 (222) | 25.3 (551) | 11.7 (72) | 31.2 (192) |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)

**Table 3: Gender-Stratified Crude and Age-Adjusted Prevalence of Type 2 Diabetes Mellitus by Individual Variables and Neighborhood Unemployment Rate with Data From Five Population-Based Studies (CARLA, DHS, KORA, HNR, SHIP, Germany, 1997-2006) [a, b]**

| | Men | | | | | | Women | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude Prevalence | | | | Age-adjusted Prevalence | | Crude Prevalence | | | | Age-adjusted Prevalence | |
| | No. | T2D Cases | % | 95% CI | % | 95% CI | No. | T2D Cases | % | 95% CI | % | 95% CI |
| **Social class** | | | | | | | | | | | | |
| lower | 346 | 57 | 16.5 | 12.7-20.8 | 14.2 | 11.8-16.8 | 851 | 104 | 12.2 | 10.1-14.6 | 9.7 | 8.3-11.5 |
| middle | 2499 | 267 | 10.7 | 9.5-12.0 | 9.7 | 8.7-10.8 | 2475 | 194 | 7.8 | 6.8-9.0 | 6.6 | 5.8-7.5 |
| higher | 1693 | 129 | 7.6 | 6.4-9.0 | 6.9 | 5.9-8.1 | 1007 | 26 | 2.6 | 1.7-3.8 | 4.7 | 3.8-5.6 |
| **Employment status** | | | | | | | | | | | | |
| employed | 1931 | 126 | 6.5 | 5.5-7.7 | 7.3 | 6.2-8.7 | 1420 | 39 | 2.8 | 2.0-3.7 | 5.5 | 4.6-6.7 |
| retired | 2197 | 290 | 13.2 | 11.8-14.7 | 10.2 | 8.8-11.7 | 1783 | 213 | 11.9 | 10.5-13.5 | 7.8 | 6.6-9.1 |
| unemployed | 378 | 32 | 8.5 | 5.9-11.7 | 10.3 | 8.0-13.2 | 399 | 26 | 6.5 | 4.3-9.4 | 7.8 | 6.0-10.2 |
| others | 32 | 5 | 15.6 | 5.3-32.8 | 8.7 | 6.4-11.6 | 731 | 46 | 6.3 | 4.6-8.3 | 6.6 | 5.0-8.6 |
| **Marital status** | | | | | | | | | | | | |
| Living with a partner | 4016 | 387 | 9.6 | 8.7-10.6 | 8.7 | 7.9-9.5 | 3141 | 199 | 6.3 | 5.5-7.2 | 6.2 | 5.4-7.0 |
| Living without a partner | 522 | 66 | 12.6 | 9.9-15.8 | 11.5 | 9.7-13.6 | 1192 | 125 | 10.5 | 8.8-12.4 | 8.3 | 7.1-9.7 |
| **Physical exercise** | | | | | | | | | | | | |
| physical exercise | 2474 | 194 | 7.8 | 6.8-9.0 | 7.5 | 6.6-8.4 | 2266 | 136 | 6.0 | 5.1-7.1 | 5.5 | 4.8-6.3 |
| no physical exercise | 2013 | 258 | 12.8 | 11.4-14.4 | 10.9 | 9.8-12.2 | 1990 | 178 | 8.9 | 7.7-10.3 | 8.1 | 7.2-9.2 |
| **Smoking** | | | | | | | | | | | | |
| never smoked | 1370 | 113 | 8.2 | 6.8-9.8 | 8.4 | 7.2-9.7 | 2502 | 208 | 8.3 | 7.3-9.5 | 6.5 | 5.7-7.4 |
| ex-smoker | 2067 | 241 | 11.7 | 10.3-13.1 | 9.5 | 8.5-10.8 | 936 | 72 | 7.7 | 6.1-9.6 | 7.5 | 6.3-8.8 |
| crurrent smoker | 1050 | 98 | 9.3 | 7.6-11.3 | 8.7 | 7.3-10.3 | 815 | 34 | 4.2 | 2.9-5.8 | 6.8 | 5.6-8.2 |
| **BMI** | | | | | | | | | | | | |
| < 30 | 3220 | 260 | 8.1 | 7.2-9.1 | 6.6 | 5.8-7.4 | 2996 | 123 | 4.1 | 3.4-4.9 | 4.7 | 4.1-5.4 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ≥ 30 | 1267 | 192 | 15.2 | 13.2-17.2 | 15.4 | 13.8-17.3 | 1260 | 191 | 15.2 | 13.2-17.3 | 11.4 | 10.0-12.9 |
| **Alcohol consumption** | | | | | | | | | | | | |
| no or moderate intake | 3974 | 414 | 10.4 | 9.5-11.4 | 9.2 | 8.4-10.2 | 4018 | 303 | 7.5 | 6.7-8.4 | 6.8 | 6.1-7.6 |
| high intake | 513 | 38 | 7.4 | 5.3-10.0 | 7.4 | 5.6-9.6 | 238 | 11 | 4.6 | 2.3-8.1 | 5.4 | 4.0-7.3 |
| **Unemployment rate** | | | | | | | | | | | | |
| low | 1519 | 125 | 8.2 | 6.9-9.7 | 7.4 | 6.4-8.6 | 1384 | 85 | 6.1 | 4.9-7.5 | 5.6 | 4.8-6.6 |
| medium | 1579 | 144 | 9.1 | 7.7-10.6 | 8.7 | 7.6-9.9 | 1527 | 120 | 7.9 | 6.6-9.3 | 6.6 | 5.7-7.6 |
| high | 1440 | 184 | 12.8 | 11.1-14.6 | 10.9 | 9.6-12.3 | 1422 | 119 | 8.4 | 7.0-9.9 | 8.3 | 7.2-9.5 |

[a] the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP)
[b] Age-adjusted prevalence are derived from logistic regression models

**Table 4: Gender-Stratified Multi-Level Logistic Regression of Type 2 Diabetes Mellitus by Individual Social Class, Employment Status and Neighborhood Unemployment Rate [a, b, c]**

| | | Social class (Reference: higher social class) | | Employment status (Reference: employed) | | | Unemployment rate (Reference: low unemployment rate) | |
|---|---|---|---|---|---|---|---|---|
| | | middle | lower | retired | unemployed | others | medium | high |
| | | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| **Model 1[d]** | Women | 3.11 (2.04-4.73) | 5.37 (3.44-8.40) | 4.71 (3.31-6.69) | 2.36 (1.41-3.95) | 2.65 (1.69-4.14) | 1.45 (1.03-2.04) | 1.26 (0.89-1.79) |
| | Men | 1.42 (1.14-1.77) | 2.31 (1.65-3.24) | 2.14 (1.71-2.66) | 1.24 (0.82-1.87) | 2.38 (0.89-6.33) | 1.15 (0.89-1.49) | 1.58 (1.24-2.02) |
| **Model 2[e]** | Women | 2.25 (1.46-3.45) | 3.16 (1.99-5.03) | 2.01 (1.26-3.21) | 2.07 (1.23-3.48) | 1.77 (1.10-2.85) | 1.45 (1.03-2.04) | 1.25 (0.88-1.78) |
| | Men | 1.21 (0.96-1.51) | 2.03 (1.44-2.86) | 1.25 (0.90-1.73) | 1.17 (0.78-1.76) | 1.98 (0.74-5.29) | 1.12 (0.87-1.45) | 1.62 (1.27-2.07) |
| **Model 3[f]** | Women | 2.02 (1.31-3.13) | 2.68 (1.66-4.34) | 1.77 (1.10-2.84) | 1.73 (1.02-2.92) | 1.64 (1.01-2.67) | 1.36 (0.96-1.93) | 1.13 (0.79-1.62) |
| | Men | 1.13 (0.89-1.43) | 1.78 (1.22-2.58) | 1.09 (0.77-1.52) | 0.94 (0.61-1.44) | 2.00 (0.74-5.39) | 1.08 (0.83-1.40) | 1.52 (1.18-1.96) |
| **Model 4[g, h]** | Women | 1.52 (0.98-2.37) | 1.66 (1.01-2.75) | 1.66 (1.02-2.69) | 1.67 (0.97-2.88) | 1.69 (1.02-2.78) | 1.20 (0.85-1.69) | 1.02 (0.72-1.46) |
| | Men | 1.03 (0.81-1.31) | 1.48 (1.00-2.18) | 1.01 (0.72-1.42) | 0.91 (0.59-1.40) | 1.69 (0.62-4.61) | 1.06 (0.82-1.38) | 1.46 (1.13-1.87) |

[a] Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

[b] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[c] men: n=4,538, women: n=4,333

[d] Model 1: unadjusted

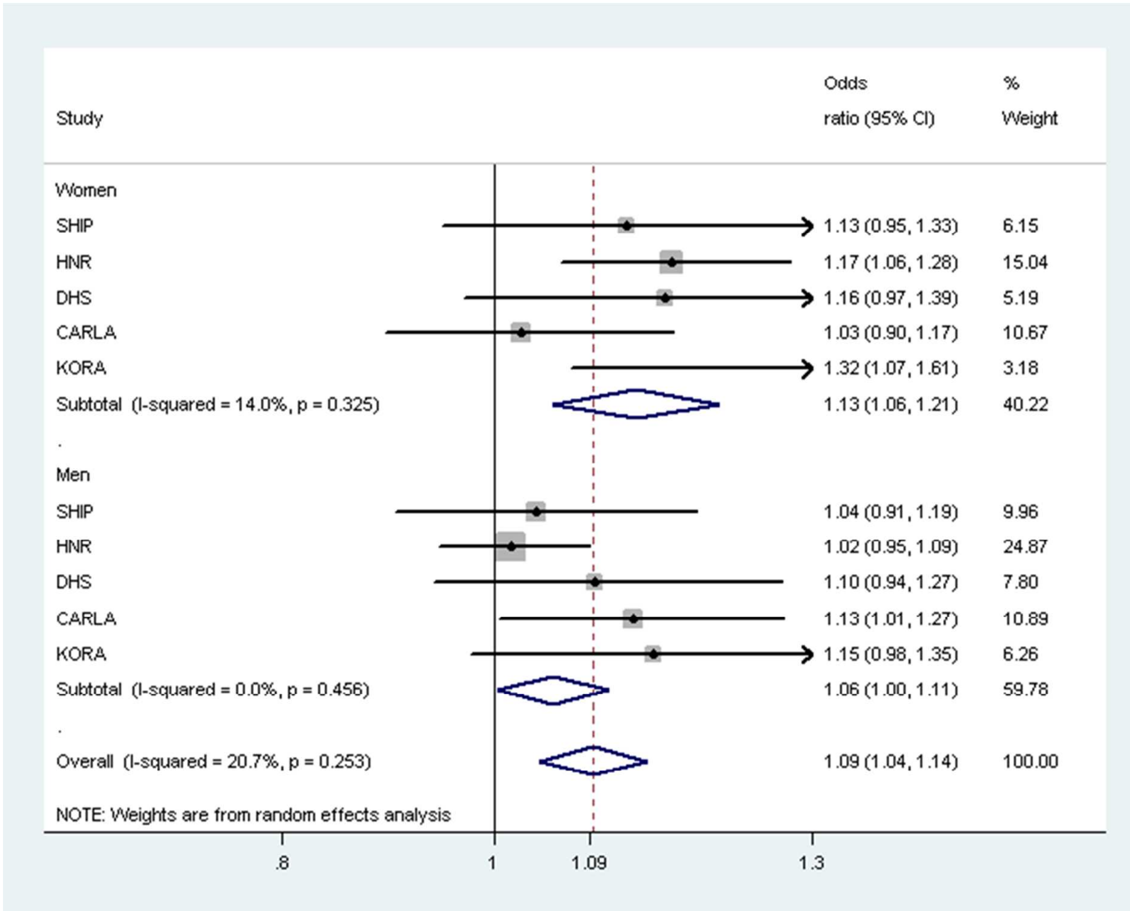
[e] Model 2: adjusted by age

[f] Model 3: adjusted by age, social class, employment status, neighborhood unemployment rate, marital status

[g] Model 4: adjusted by age, social class, employment status, neighborhood unemployment rate, marital status, BMI, physical exercise, smoking (only for men)

[h] Sample size n=8,732 due to 139 missing values on life style factors

**Figure 1: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes Mellitus for the Social Class Score (Range: 2-14 Points) in Women and Men [a, b, c, d]**




[a] Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

[b] Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

[c] Data From Five Population-Based Studies: the Cardiovascular Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA) S4 Study, and the Study of Health in Pomerania (SHIP), Germany, 1997-2006

[d] Heterogeneity tested via Q-statistic and $I^2$-index

**Declaration of Competing Interests**

Nothing to declare.

**Data sharing statement**

There is no additional data available.

**Patient consent**

Obtained.

**Contribution**

The authors G.M., K.B. (DHS), S.H., K.H.G. (CARLA), S.M., N.P. (HNR), S.S., H.V. (SHIP), W.M., and C.M. (KORA) researched data. G.M. developed the study conception, performed the statistical analyses and drafted the manuscript. K.B. contributed to the study conception, statistical analyses and data interpretation. W.R. and T.T. contributed to the pooling of data. All authors critically reviewed the manuscript and contributed to the interpretation of the results.

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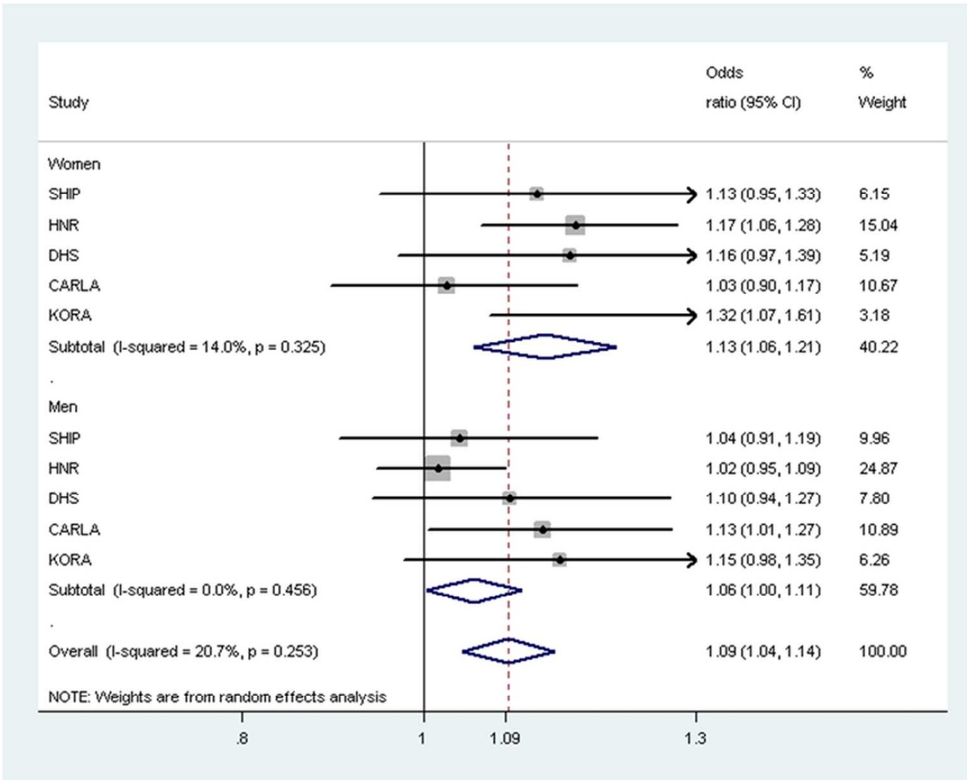
**Figure 1: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes Mellitus for the Social Class Score (Range: 2-14 Points) in Women and Men [a, b, c, d]**

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**Online Supplemental Material**

**Table 5: Model Parameter derived from 3-Level Mixed Effects Regression of Type 2 Diabetes**

| | **Women** | | | | **Men** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Neighborhood** | | **Study Region** | | **Neighborhood** | | **Study Region** | |
| | $V_A$ | MOR | $V_A$ | MOR | $V_A$ | MOR | $V_A$ | MOR |
| **Model 1** | 0.16 (0.10) | 1.47 | 0.08 (0.07) | 1.31 | 0.00 (0.00) | 1.00 | 0.04 (0.03) | 1.20 |
| **Model 2** | 0.15 (0.10) | 1.45 | 0.07 (0.06) | 1.30 | 0.00 (0.00) | 1.00 | 0.02 (0.02) | 1.15 |
| **Model 3** | 0.15 (0.10) | 1.45 | 0.07 (0.06) | 1.29 | 0.00 (0.00) | 1.00 | 0.02 (0.02) | 1.13 |
| **Model 4** | 0.14 (0.09) | 1.42 | 0.08 (0.07) | 1.32 | 0.00 (0.00) | 1.00 | 0.00 (0.01) | 1.05 |
| **Model 5** | 0.08 (0.09) | 1.32 | 0.07 (0.06) | 1.29 | 0.00 (0.00) | 1.00 | 0.00 (0.00) | 1.00 |

[d] Model 1: unadjusted
[e] Model 2: adjusted by age
[f] Model 3: adjusted by age, social class, employment status, marital status
[f] Model 4: adjusted by age, social class, employment status, marital status, neighborhood unemployment rate
[g] Model 5: additionally adjusted by mediators: BMI, physical exercise, smoking (only for men)

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| **Section/Topic** | **Item #** | **Recommendation** | **Reported on page #** |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6-7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6-7 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 8 |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6-7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7-8 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 7 |
| | | (*c*) Explain how missing data were addressed | 6 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | - |
| | | (*e*) Describe any sensitivity analyses | 8 |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 6/8 |
| | | (b) Give reasons for non-participation at each stage | 6 |
| | | (c) Consider use of a flow diagram | - |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 8/15 (table 2) |
| | | (b) Indicate number of participants with missing data for each variable of interest | 6 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 15 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 8-10/17 (table 3) |
| | | (*b*) Report category boundaries when continuous variables were categorized | 6 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | - |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 10 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 11-12 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 13 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 12 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 12 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 25 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.