



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



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3 employed, retired and unemployed individuals as well as persons with other forms of employment, for  
4 example housewives. Among the marital status of the study participants, it was only known whether  
5 one lived with or without a partner. The dichotomized lifestyle variables smoking status (current  
6 smoker; former or never smoker), physical exercise (exercise; no exercise), measured body mass index  
7 (BMI) ( $<30 \text{ kg/m}^2$ ;  $\geq 30 \text{ kg/m}^2$ ) and alcohol consumption (no or moderate intake: women:  $\leq 20$   
8 grams per day; men:  $\leq 40$  grams per day; high intake: women:  $>20$  grams per day; men:  $>40$  grams  
9 per day) were summarized in an index of health-related behavior. Exercising included any exercise  
10 irrespective of frequency and duration. The lifestyle index was categorized: most healthy (no risk  
11 factor), healthy (one risk factor), less healthy (two risk factors), unhealthy (three risk factors) and most  
12 unhealthy (four risk factors). All variables were constructed following DIAB-CORE standard  
13 procedures for the homogenization of basic variables to ensure a high degree of comparability.

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15 Individual level data were combined with data on neighborhood unemployment rate for the median  
16 year of the data collection period of each study, obtained from the statistical offices of each considered  
17 city. Neighborhood unemployment rate was calculated as the number of unemployed residents in  
18 relation to the working-age population (15-64 years of age) and was used to define the socio-economic  
19 status of neighborhoods, since it is considered to be a strong predictor of health outcomes [21, 25, 26].  
20 Equally-sized tertiles of study-specific neighborhood unemployment rate were used for further  
21 analysis.  
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41 Crude and age-adjusted prevalence of T2DM (derived from a logistic regression) and corresponding  
42 95% confidence intervals (CI) were calculated by gender and socio-economic variables. A series of  
43 mixed effects logistic regression models was fitted. The models were adjusted for age, gender (if not  
44 stratified), social status, employment status, lifestyle and neighborhood unemployment rate. Gender-  
45 stratified regressions were modeled and regional and between-neighborhood variation in the  
46 prevalence of T2DM of men and women calculated. In addition, we estimated models including terms  
47 for gender and the socio-economic variables (social status, employment status and neighborhood  
48 unemployment rate) as main effects and an interaction term for the effect of the socio-economic  
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3 variable by gender taking the whole sample. The results were presented as odds ratios (OR) with  
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5 corresponding 95% CI.

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7 Our data set had the following hierarchical structure: individuals (level 1), nested within  
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9 neighborhoods (level 2), which were nested in study regions (level 3). Random effects were included  
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11 to capture regional (between-study) and between-neighborhood variation reported as median odds  
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13 ratios (MOR). The latter represents a transformation of the area-level variation ( $V_A$ ) on an OR-scale.  
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15 The MOR gives the median value of all ORs between a randomly chosen highest- and lowest-risk-  
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17 area. The MOR was calculated on the level of neighborhoods and study regions with the following  
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19 equation:  $MOR = \exp(\sqrt{(2 * V_A)} * 0.6745)$ , where 0.6745 is the 75<sup>th</sup> centile of the cumulative  
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21 distribution function of the normal distribution with mean zero and variance one [27, 28].  
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25 Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small  
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27 number of cases, the social status variable had to be applied as a continuous measure in this sub-  
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29 analysis (ranging between two points, highest social status, and 14 points, lowest social status). For  
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31 this purpose, inverse-variance weighting was used to estimate fixed and random effects summary  
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33 estimates and displayed in forest plots [29]. Q-statistic and  $I^2$  index were applied to assess  
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35 heterogeneity and the extent of heterogeneity between study results respectively [30]. Analyses were  
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37 performed in STATA/ SE 11.0.  
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## 40 **Results**

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42 In total, 8,870 subjects residing in 226 neighborhoods in five German regions were included in our  
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44 analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was  
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46 statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95%  
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48 CI 9.2-10.9) (significance derived from 95% CI). This pattern was observed in all five regional  
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50 studies. Demographic, social and lifestyle characteristics are reported in table 2. Women were more  
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52 often of low and medium social status and not employed than men, except in SHIP. Men, in contrast,  
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54 had more often an unhealthy life style. A higher proportion of women than men reported living  
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56 without a partner.  
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3 *Social status:* The age-adjusted prevalence of T2DM was statistically significantly lower in women  
4 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  
5 status women; 6.9% (95% CI: 5.9-8.1) versus 14.1% (95% CI: 11.8-16.7) in low social status men)  
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7 (table 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over  
8  
9 all social status groups. The social gradient in the chance of T2DM was stronger in women (OR in low  
10 versus high social status: 2.18 (95% CI: 1.34-3.55); OR in medium versus high social status: 1.85  
11 (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  
12 medium versus high social status: 1.04 (95% CI: 0.81-1.32)) (table 4).

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19 The interaction terms of the social status categories and gender were statistically significant in the  
20 fully adjusted regression model (gender\*low social status: coefficient (coef.): -0.62 (95% CI: -1.18- -  
21 0.05); gender\*medium social status: coef.: -0.75 (95% CI: -1.22- -0.27)). For women, the OR of  
22 T2DM was 2.86 (95% CI: 1.83-4.51) in the low versus high social status group and 2.20 (95% CI:  
23 1.44-3.37) in the medium versus high social status group (figure 1). Compared to women of high  
24 social status, high social status men had an OR of 2.83 (95% CI: 1.83-4.38) and medium and low  
25 status men an OR of 2.96 (95% CI: 1.94-4.50) and 4.37 (2.65-7.21), respectively.

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33 Regarding gender differences in health inequalities across regions, the effect estimates of the five  
34 studies were tested to be homogenous (figure 2, online supplement). A low social status was  
35 associated with a higher chance of T2DM, adjusted for age, employment status, marital status and  
36 neighborhood unemployment rate. In women, an increase of one point on the social status score  
37 (decrease in social status) was associated with an increase of 13% (pooled OR: 1.13 (95% CI: 1.06-  
38 1.21);  $I^2=14.0\%$ ;  $p=0.325$ ) in the chance of having T2DM. This association was smaller in men  
39 (pooled OR: 1.05 (95% CI: 1.00-1.10);  $I^2=0.0\%$ ;  $p=0.543$ ), although the differences between genders  
40 were not significant. This was observed in all studies, except CARLA.

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*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

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3 versus employed: 1.77 (95% CI: 1.04-3.02); OR in others versus employed: 1.73 (95% CI: 1.06-2.83))  
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5 (table 4).

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7 The interaction terms between the categories unemployed as well as retired and gender were  
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9 statistically significant in the fully adjusted model (gender\*unemployed: coef.: -0.72 (95% CI: -1.14- -  
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11 0.31); gender\*retired: coef.: -0.78 (95% CI: -1.43- -0.12)). Being unemployed, retired or a housewife  
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13 constituted an increased chance of T2DM in women (OR in unemployed: 2.07 (95% CI: 1.38-3.11);  
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15 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).  
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17 Compared to employed women, employed, unemployed and retired men showed an elevated chance of  
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19 having T2DM (OR in employed: 2.70 (1.86-3.91); OR in unemployed: 2.71 (95% CI: 1.82-4.04); OR  
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21 in retired: 2.35 (95% CI: 1.44-3.83); OR others: 4.84 (95% CI: 1.74-13.47)).  
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23 *Neighborhood unemployment rate:* Women and men residing in neighborhoods with a high  
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25 unemployment rate had a significantly higher prevalence of T2DM (8.3% (95% CI: 7.2-9.5),  
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27 respectively 10.9% (95% CI: 9.6-12.3)) than women and men in areas with low unemployment rate  
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29 (5.6% (95% CI: 4.8-6.6), respectively 7.4% (95% CI: 6.4-8.6)). Neighborhood unemployment rate was  
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31 statistically significantly associated with the prevalence of T2DM in men (OR of highest versus lowest  
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33 tertile: 1.46 (95% CI: 1.14-1.88)), while such an association was not observed in women (table 4). The  
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35 interaction terms between neighborhood unemployment rate and gender were not statistically  
36  
37 significant.  
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39 Regional (between-study) variation and between-neighborhood variation in the prevalence of T2DM  
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41 was larger in women than men. The prevalence of T2DM in men varied only between study regions  
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43 (model without covariates: MOR: 1.21;  $V_A$ : 0.04; SE: 0.04), which was fully explained by social  
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45 status, employment status, lifestyle and neighborhood unemployment rate. The T2DM prevalence in  
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47 women showed large variation across neighborhoods (model without covariates: MOR: 1.47;  $V_A$ :  
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49 0.16; SE: 0.10) and study regions (MOR: 1.31;  $V_A$ : 0.08; SE: 0.07), which was not dissolved by the  
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51 considered explanatory variables (fully adjusted model, between-neighborhood variation: MOR: 1.42;  
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53  $V_A$ : 0.14; SE: 0.09, between-study variation: MOR: 1.32;  $V_A$ : 0.08; SE: 0.07).  
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56 Individuals living without a partner showed statistically significantly higher prevalence than  
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58 individuals who lived with a partner irrespective of gender. In women and men, an unhealthy life style  
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3 was statistically significantly associated with a higher T2DM prevalence (table 3). In the gender-  
4 stratified regression models, the adjustment for life style reduced the social gradient in the prevalence  
5 of T2DM in both women and men (results not shown). The association between life style and the  
6 prevalence of T2DM was stronger in women than men (e.g. OR of unhealthy lifestyle versus most  
7 healthy lifestyle in women: 5.06 (95% CI: 3.06-8.37); OR of unhealthy lifestyle versus most healthy  
8 lifestyle in men 2.84 (95% CI: 1.85-4.35)).  
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### 19 Discussion

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21 This study assessed gender differences in the association of individual and neighborhood social factors  
22 with prevalent T2DM, using data from five regional population-based studies in Germany. Women  
23 and men with a low social status had a higher prevalence of T2DM, however men with a low social  
24 status had the highest chance of T2DM as compared to all other gender-social class subgroups. We  
25 found that the gradient in the prevalence of T2DM across social status groups was clearly stronger in  
26 women than men. This pattern was consistent across all regions but one (CARLA) and with prior  
27 studies [5-10]. Robbins et al. reported a significant association between social status and T2DM  
28 among Caucasian and African American women but an inconsistent relationship in men, using data  
29 from the Third National Health and Nutrition Examination Survey [10].  
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39 In our study, the individual employment status only had an impact on the chance of T2DM in women.  
40 Being unemployed, retired or a housewife yielded a higher chance of T2DM. Publications on the  
41 effects of paid employment on women's health discuss two contrasting theories for this finding: a  
42 health promoting function of employment due to role accumulation in contrast to the monotony,  
43 isolation, low status and self-esteem of housewives; and a health damaging effect due to role strains,  
44 e.g. stress due to multiple roles, and heavy job demands [31, 32]. Arber et al. found that paid work was  
45 beneficial for women without children or women over 40 years of age with children in Britain.  
46 Younger women with children experienced higher levels of illnesses and substantial strains from  
47 holding multiple roles [31]. Repetti et al. argues that the social support provided by colleagues has  
48 beneficial effects on women's health and helps buffering stress [32].  
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3 Regional and between-neighborhood variation in the prevalence of T2DM was larger in women than  
4 in men. We found that neighborhood unemployment rate played an important role in explaining  
5 regional health differences in men but not in women. Hence, we conclude that the residential  
6 environment is more important for the onset of T2DM in women than men. Previous work on regional  
7 variation in self-rated health and BMI also found larger regional variation in women [17, 33, 34].  
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11 The gender-specific pattern in the association between socio-economic status and the prevalence of  
12 T2DM need to be further explored, since the pathways are still unknown [10]. Macintyre et al. noted  
13 that socio-economic determinants vary in their meaning for men and women, since both genders are  
14 socialized in different ways with diverging social roles and coping strategies against stress; they hold  
15 different occupational positions in the labor market and have dissimilar access to material and psycho-  
16 social resources [35]. In our study, overall women were less likely to be of high social status, were less  
17 often employed, lived more often alone but were more often engaged in a favorable lifestyle than men.  
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29 To gain more insight in mechanisms of social inequalities on health, the analysis of population  
30 subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms  
31 operate identically in different population groups [17]. This work adds knowledge to the research on  
32 the interaction of gender, social determinants and health. So far, only few studies examined this  
33 interaction with regard to T2DM and no prior study considered socio-economic characteristics of the  
34 neighborhood. Data sources providing representative population-based data on the prevalence of  
35 T2DM with a linkage to small areas and regions are still rare.  
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44 Some limitations of this work should be acknowledged. We analyzed cross-sectional data analyses  
45 with limited causal conclusions. We could not use occupation as an indicator of social status in our  
46 analysis since the assessment was not comparable between studies. The prevalence of T2DM was  
47 based on a self-reported T2DM physician's diagnosis only. However, Okura et al. found a high  
48 accuracy between self-reports and medical records for diabetes and other chronic diseases [36].  
49 Another potential limitation is the selection by response (response proportions: 56%-69%), which  
50 might have affected our results.  
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3 We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not  
4 capture the immediate residential environment of our study participants. This could lead to exposure  
5 misclassification and underestimation of neighborhood effects [37]. The applied administrative  
6 definition of neighborhoods differed between studies and neighborhoods were diverse according to  
7 their area and population size. Another challenge in the research of neighborhood impact on health is  
8 the residential selection. Individuals may be selected into neighborhoods due to their individual  
9 characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [38,  
10 39]. Finally, we had no information on the residential history of the studies' participants, which could  
11 result in an underestimation of neighborhood effects on health [40].  
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23 In conclusion, our study identified different relationships of individual and neighborhood  
24 unemployment rate with the prevalence of T2DM for women and men. While being a man of low  
25 social status yielded the highest chance of T2DM, the social gradient in the prevalence of T2DM was  
26 clearly larger in women. Regional variance in the T2DM prevalence was larger in women than men.  
27 Whereas the major proportion of the variance in the T2DM prevalence remained unexplained in  
28 women, the regional variance in men was low and completely explained by individual and contextual  
29 socio-economic variables.  
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Table 1: Characteristics of The Five Studies (CARLA, DHS, KORA, HNR, and SHIP studies, 1997-2006)<sup>a</sup>

	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)

<sup>a</sup> 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)<sup>a</sup>

Study period Number of neighborhoods (range of residing participants)	CARLA 12/2002-01/2006 37 (3-139)		DHS 09/2003-06/2004 60 (1-42)		KORA 10/1999-04/2001 17 (13-141)		HNR 12/2000-06/2003 106 (1-140)		SHIP 10/1997-03/2001 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 <sup>b</sup> (%)										
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

<sup>a</sup> 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)

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<sup>b</sup> dichotomized lifestyle variables: smoking status (current smoker; former or never smoker), physical exercise (exercise; no exercise), measured body mass index (BMI) (<30 kg/m<sup>2</sup>; >=30 kg/m<sup>2</sup>) 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)

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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) <sup>a, b</sup>

Individual Characteristics	Men						Women					
	No.	T2DM Cases	Crude Prevalence %	95% CI	Adjusted Prevalence %	95% CI	No.	T2DM Cases	Crude Prevalence %	95% CI	Adjusted Prevalence %	95% CI
<b>Social status</b>												
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
<b>Employment status</b>												
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
<b>Marital status</b>												
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
<b>Life style</b>												
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
<b>Neighborhood Characteristic</b>												
<b>Unemployment rate</b>												
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

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<sup>a</sup> 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)

<sup>b</sup> Age-adjusted prevalence are derived from logistic regression models in the whole sample

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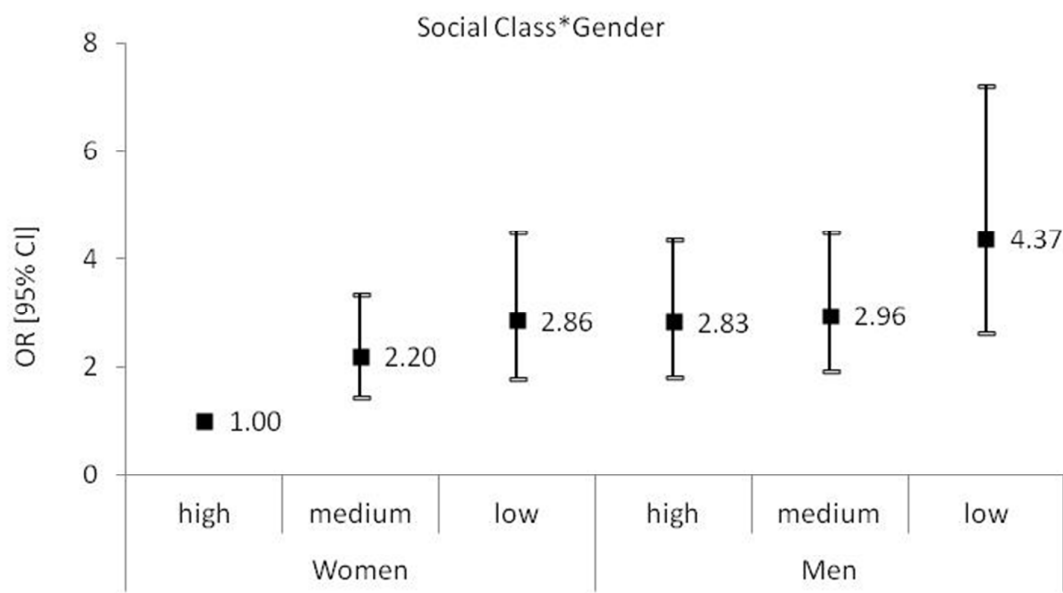
Table 4: Gender-Stratified Multi-Level Logistic Regression of Type 2 Diabetes by Individual Social Factors and Neighborhood Unemployment Rate<sup>a, b, c</sup>

	<b>Men</b>	<b>Women</b>
	OR (95% CI)	OR (95% CI)
<b>Age (cont.)</b>	1.05 (1.03-1.07)	1.06 (1.03-1.08)
<b>Social status (Reference: high social status)</b>		
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)
<b>Employment status (Reference: employed)</b>		
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)
<b>Marital status (Reference: living with a partner)</b>		
Living without a partner	1.21 (0.90-1.62)	1.18 (0.91-1.53)
<b>Lifestyle Index (Ref.: most healthy lifestyle)</b>		
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)
<b>Neighborhood Characteristic</b>		
<b>Unemployment rate (Reference: low unemployment rate)</b>		
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)
<b>Level 2: Neighborhoods n</b>	219	223
VA	0.00 (0.12)	0.32 (0.15)
Median Odds Ratio	1.00	1.35
<b>Level 3: Study Regions n</b>	5	5
VA	0.00 (0.07)	0.28 (0.12)
Median Odds Ratio	1.00	1.30

<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

<sup>b</sup> 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

<sup>c</sup> men: n=4,537, women: n=4,333

Figure 1: Logistic Regression of Type 2 Diabetes With Interaction of Social Status\*Gender<sup>a, b, c, d</sup>

<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

<sup>b</sup> Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

<sup>c</sup> 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

<sup>d</sup> n=8,870

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3 **Declaration of Competing Interests**  
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5 Nothing to declare.  
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**Data sharing statement**

No additional data available.

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**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 <sup>a, b, c, d</sup>

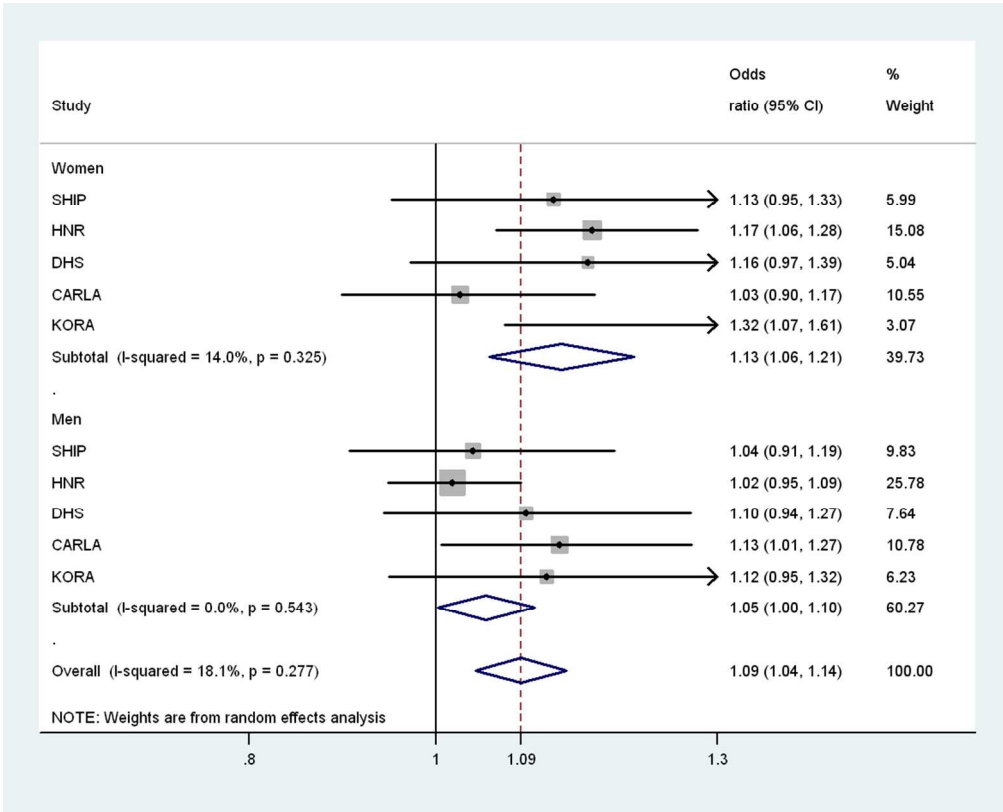
<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

<sup>b</sup> Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

<sup>c</sup> 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

<sup>d</sup> Heterogeneity tested via Q-statistic and I<sup>2</sup>-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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			

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
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://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

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Manuscripts

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3 **Gender Differences in The Association of Individual Social Class And Neighborhood**  
4 **Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from**  
5 **The DIAB-CORE Consortium**  
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9 **Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**  
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12 Grit Müller<sup>1</sup>, Saskia Hartwig<sup>2</sup>, Karin Halina Greiser<sup>2,3</sup>, Susanne Moebus<sup>4</sup>, Noreen Pundt<sup>4</sup>, Sabine  
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51 **Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics,  
52 Socioeconomic Factors, Population-based  
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54 Word count: 3632  
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3 **Abstract** (word count: 256; max. 300)  
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7 **Objective:** To analyze gender differences in the relationship of individual social class, employment  
8 status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).  
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11 **Design:** Five cross-sectional studies.  
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13 **Setting:** Studies were conducted in five regions of Germany from 1997-2006.  
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15 **Participants:** The sample consisted of 8,870 individuals residing in 226 neighborhoods in five urban  
16 regions.  
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19 **Primary and secondary outcome measures:** Prevalent T2DM.  
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21 **Results:** We found significant multiplicative interactions between gender and the individual variables  
22 social class and employment status (being unemployed, retired). Social class was statistically  
23 significant associated with T2DM in men and women, whereby this association was stronger in  
24 women (low versus high social class: odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34))  
25 than men (low versus high social class: OR 1.75 (95% CI: 1.20-2.54)). Significant associations of  
26 employment status and T2DM were only found in women (unemployed versus employed: OR 1.73  
27 (95% CI: 1.02-2.92); retired versus employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed:  
28 OR 1.64 (95% CI: 1.01-2.67)). Neighborhood unemployment rate was associated with T2DM in men  
29 (highest versus lowest tertile: OR 1.52 (95% CI: 1.18-1.96)). Between-study and between-  
30 neighborhood variation in the T2DM prevalence was more pronounced in women. The considered  
31 covariates helped to explain statistically the variation in the T2DM prevalence among men, but not  
32 among women.  
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45 **Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the  
46 association was more pronounced in women. Employment status only affected T2DM in women.  
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48 Neighborhood unemployment rate is an important predictor of T2DM in men, but not in women.  
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## 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 et 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,

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3 behavioral and psychosocial conditions of men and women (“differential vulnerability hypothesis”) [2  
4 19]. Differences in men’s and women’s perception of the neighborhood context and social status may  
5 be as well a source of health disparities [19]. Stafford et al. examined gender differences in the  
6 relationship between self-rated health and the neighborhood context and found a larger impact of the  
7 neighborhood context on the health of women [19].  
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11 The aim of this study was (1) to investigate if the association of individual social class, individual  
12 employment status and neighborhood unemployment rate with prevalent T2DM differs for men and  
13 women in a pooled analysis of five population-based regional studies; and (2) to examine the extent to  
14 which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a  
15 sub-analysis, we performed study-specific calculations of the relationship between T2DM and social  
16 class in men and women.  
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## 25 26 27 **Methods**

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29 Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular  
30 Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz  
31 Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA)  
32 S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997  
33 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage  
34 cluster or stratified random sampling) and response proportions (56%-69%). The studies were  
35 approved by local ethics committees and informed written consent was obtained from the study  
36 participants. Within the five studies, similar instruments, questionnaires and medical measurements  
37 were applied to collect data. Study designs have been described elsewhere in more detail [20-24].  
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41 In brief, data on 11,688 subjects aged 45-74 years were provided. 2,281 individuals living in rural  
42 areas of KORA and SHIP were excluded from the sample, because these subject could not be assigned  
43 to spatial units below the level of municipalities; so, that our study was limited to urban areas. Study  
44 participants were assigned to neighborhoods via addresses of residence at baseline (eight subjects  
45 could not be linked). The neighborhoods were defined by administrative units: statistical  
46 administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning  
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3 regions (summary of city districts) in KORA and postal code areas in SHIP. The 9,399 study  
4 participants of the sample resided in 227 neighborhoods of the total 236 neighborhoods in the five  
5 study regions. After further exclusion of participants with missing information on individual  
6 characteristics (n=529), the final sample consisted of 8,870 residents in 226 neighborhoods.  
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10 Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-  
11 reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic  
12 agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded  
13 from the analyses to avoid inclusion of possible cases of type 1 diabetes.  
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17 Social class was measured with a summary score of income and education. Its' operationalization  
18 was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on  
19 individual educational and professional attainment, net household income and the occupational  
20 position of the main earner of a household. The three dimensions are transformed to an ordinal scale  
21 ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information  
22 on occupational status was not available for our analysis, the index was solely based on education and  
23 income, ranging between 2 and 14 points. The index was divided into three groups: high social class,  
24 medium social class and low social class. Study participants were classified in four employment status  
25 groups: employed, retired and unemployed individuals as well as persons with other forms of  
26 employment, including participants in vocational retraining, housewives and housemen.  
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30 Neighborhood unemployment rate was applied as a proxy for the socio-economic status of the  
31 neighborhoods. Neighborhood unemployment rate was calculated as the number of unemployed  
32 residents in relation to the working-age population (15-64 years of age), obtained from the statistical  
33 offices of each considered city. The median year of the data collection period of each study was used  
34 as the reference year. A number of studies applied unemployment rate as a measure of deprivation and  
35 it was proven to be a strong predictor of health outcomes [22 27-29]. Campbell et al. highlighted that  
36 unemployment rate is a simple and good indicator for social and material deprivation, which is  
37 regularly updated and easily accessible [30]. For our analysis, equally-sized tertiles of study-specific  
38 neighborhood unemployment rate were used to detect a potential dose-response relationship.  
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3 The variable marital status summarized information whether a study participant lived with or without a  
4 partner. Moreover, life style variables including smoking status (current smoker; former smoker; never  
5 smoker), physical exercise (exercise; no exercise), body mass index (BMI) ( $<30 \text{ kg/m}^2$ ;  $\geq 30 \text{ kg/m}^2$ )  
6 and alcohol consumption (no or moderate intake: women:  $\leq 20$  grams per day; men:  $\leq 40$  grams per  
7 day; high intake: women:  $>20$  grams per day; men:  $>40$  grams per day) were considered. Exercising  
8 included any exercise irrespective of frequency and duration. All variables were constructed following  
9 DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of  
10 comparability.  
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### 20 21 **Statistical Analysis**

22 Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived  
23 from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual  
24 variables and neighborhood unemployment rate.  
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28 Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods  
29 (level 2), which were nested in study regions (level 3). To account for this data structure in our  
30 statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed  
31 effects logistic regression models. First, we tested for interactions between gender and individual  
32 social class, employment status and neighborhood unemployment rate. To do so, we estimated  
33 regression models including terms for gender and social class, employment status or neighborhood  
34 unemployment rate as main effects and an interaction term for the effect of social class, employment  
35 status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were  
36 conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables  
37 age, marital status and the remaining social variables (social class/ employment status/ neighborhood  
38 unemployment rate) depending on the variable of interest. Life style factors, including smoking,  
39 alcohol consumption, BMI and physical activity were evaluated as potential mediators in the  
40 relationship between T2DM and individual social class, employment status or neighborhood  
41 unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.  
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3 Random effects were included to capture between-study and between-neighborhood variance reported  
4 as median odds ratios (MOR). The latter represents a transformation of the area-level variation ( $V_A$ ) on  
5 an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and  
6 lowest-risk-area. The MOR was calculated on the level of neighborhoods and study regions with the  
7 following equation:  $MOR = \exp(\sqrt{(2 * V_A)} * 0.6745)$ , where 0.6745 is the 75<sup>th</sup> centile of the  
8 cumulative distribution function of the normal distribution with mean zero and variance one [31 32].  
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11 Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small  
12 number of cases, the social class variable had to be applied as a continuous measure in this sub-  
13 analysis (ranging between two points, highest social class, and 14 points, lowest social class). For this  
14 purpose, inverse-variance weighting was used to estimate fixed and random effects summary estimates  
15 and displayed in forest plots [33]. Q-statistic and  $I^2$  index were applied to assess heterogeneity and the  
16 extent of heterogeneity between study results respectively [34]. Analyses were performed in STATA/  
17 SE 11.0.  
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## 32 Results

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34 In total, 8,870 subjects residing in 226 neighborhoods in five urban regions were included in our  
35 analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was  
36 statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95%  
37 CI 9.2-10.9) (significance derived from 95% CI). This pattern was observed in all five regional  
38 studies. Socio-demographic characteristics are reported in table 2. Women belonged more often to the  
39 low or medium social class and a higher proportion was not employed compared to men, except in  
40 SHIP. A higher proportion of women than men reported to live without a partner.  
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48 The age-adjusted prevalence of T2DM was statistically significantly lower in high social class women  
49 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  
50 women; 6.9% (95% CI: 5.9-8.1) respectively 14.1% (95% CI: 11.8-16.7) in men) (table 3). Women  
51 had a statistically significantly lower age-adjusted T2DM prevalence than men over all social classes.  
52 Employed men had a statistically significantly lower age-adjusted T2DM prevalence with 7.3% (95%  
53 CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods, the highest age-  
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3 adjusted prevalence of T2DM was found in women and men living in neighborhoods with a high  
4 unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)). Individuals  
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6 living without a partner showed statistically significantly higher prevalence than individuals who lived  
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8 with a partner irrespective of gender. Being physical inactive or having a BMI of 30 or above was  
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10 statistically significantly associated with a higher T2DM prevalence in men and women.

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12 In the fully adjusted multivariable analyses, the interaction terms of social class and gender were  
13 statistically significant. Among the employment status, we found significant multiplicative interactions  
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15 between unemployed individuals and gender as well as between retired individuals and gender. The  
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17 interaction terms between neighborhood unemployment rate and gender were not statistically  
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19 significant.  
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23 The results of the gender-stratified multivariable regression analysis are presented in table 4. Among  
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25 women and men, we found a statistically significant association of social class and T2DM. The social  
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27 gradient in the odds of T2DM was reduced when the models were adjusted for age and the  
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29 confounding variables. This reduction was particularly large in women. Overall, the association  
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31 between social class and T2DM was stronger in women (low versus high social class: OR 2.68 (95%  
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33 CI: 1.66-4.34); medium versus high social class: OR 2.02 (95% CI: 1.31-3.13)) than men (low versus  
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35 high social class: OR 1.75 (95% CI: 1.20-2.54); medium versus high social class: OR 1.13 (95% CI:  
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37 0.89-1.43)) (model 3, table 4). Significant associations of employment status and T2DM were only  
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39 found in women: In reference to employed women, unemployed women, retired women and women  
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41 with other employment status had a 1.73, (95% CI: 1.02-2.92), a 1.77 (95% CI: 1.10-2.84)  
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43 respectively a 1.64 (95% CI: 1.01-2.67)) higher odds to have T2DM. The significant elevated odds of  
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45 T2DM in retired men were dissolved by adjustment for age. Women residing in neighborhoods with a  
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47 medium level of unemployment showed a significant elevated odds to have T2DM (OR 1.45 (95% CI:  
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49 1.03-2.04), model 2), which was dissolved when the model was adjusted by confounding variables. In  
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51 contrast, men residing in neighborhoods with a high level of unemployment showed a 52% (95% CI:  
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53 1.18-1.96) higher odds to have T2DM than men in low unemployment neighborhoods in the  
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55 confounder-adjusted model 3. T2DM was no longer associated with marital status after adjustment by  
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3 confounding variables in model 3 (living without versus living with a partner: OR 1.17 (95% CI: 0.90-  
4 1.51) in women, OR 1.19 (95% CI: 0.88-1.59) in men).

5  
6 In model 4, the life style factors BMI, physical activity and smoking (only men) were introduced in  
7 the model. These life style factors were previously evaluated to be associated with social class,  
8 employment status (not associated with physical exercise in women) and neighborhood unemployment  
9 rate as well with the presence of type 2 diabetes (smoking only in men). In men and women, we  
10 observed effect modifications among individual social class, employment status and neighborhood  
11 unemployment rate when introducing these life style factors into the analysis. Especially, the  
12 association between social class and T2DM was strongly reduced in women mainly accounted by the  
13 BMI.  
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16 Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women  
17 than men. The prevalence of T2DM in men varied only between study regions (model 1: MOR: 1.21;  
18  $V_A$ : 0.04; SE: 0.04), which was fully explained statistically by age, social class, employment status,  
19 neighborhood unemployment rate, marital status and life style factors. The T2DM prevalence in  
20 women showed large variation across neighborhoods (model 1: MOR: 1.47;  $V_A$ : 0.16; SE: 0.10) and  
21 study regions (model 1: MOR: 1.31;  $V_A$ : 0.08; SE: 0.07), which was not dissolved by the considered  
22 explanatory variables (model 4, between-neighborhood variation: MOR: 1.42;  $V_A$ : 0.13; SE: 0.10,  
23 between-study variation: MOR: 1.27;  $V_A$ : 0.06; SE: 0.06).  
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26 Regarding gender differences in health inequalities across regions, the effect estimates of the five  
27 studies were tested to be homogenous (figure 1). A low social class was associated with a higher odds  
28 of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate.  
29 In women, an increase of one point on the social class score (decrease in social class) was associated  
30 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  
31 having T2DM. This association was smaller in men (pooled OR: 1.05 (95% CI: 1.00-1.10);  $I^2=0.0\%$ ;  
32  $p=0.543$ ), although the differences between genders were not significant. This was observed in all  
33 studies, except CARLA.  
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## 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

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3 in men. A large fraction of the detected variation in the prevalence of T2DM on the level of  
4 neighborhoods and regions remained statistically unexplained in women, suggesting that there were  
5 characteristics on the individual, neighborhood and regional level that determine the presence of  
6 T2DM and which were not considered in our analysis. Previous work on regional variation in self-  
7 rated health and BMI also found larger regional variation in women [19 38 39].  
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11 The gender-specific pattern in the association between social class and the prevalence of T2DM need  
12 to be further explored, since the pathways are still unknown [8]. Macintyre et al. noted that socio-  
13 economic determinants vary in their meaning for men and women, since both genders are socialized in  
14 different ways with diverging social roles and coping strategies against stress; they hold different  
15 occupational positions in the labor market and have dissimilar access to material and psycho-social  
16 resources [40]. In our study, overall women were less likely to be in the high social class and were less  
17 often employed.  
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21 To gain more insight in mechanisms of social inequalities on health, the analysis of population  
22 subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms  
23 operate identically in different population groups [19]. This work adds knowledge to the research on  
24 the interaction of gender, social determinants and health. So far, only few studies examined this  
25 interaction with regard to T2DM and to our knowledge no study considered neighborhood  
26 unemployment rate in regard to that, so far. Data sources providing representative population-based  
27 data on the prevalence of T2DM with a linkage to small areas and regions are still rare.  
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31 Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited  
32 causal conclusions. We could not use occupation as an indicator of social class in our analysis since  
33 the assessment was not comparable between studies. The prevalence of T2DM was based on a self-  
34 reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2  
35 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports  
36 and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded  
37 that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of  
38 self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative  
39 [42]. Another potential limitation is the selection by response (response proportions: 56%-69%),  
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3 which might have affected our results. The exclusion of participants from the initial sample due to  
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5 missing information on individual characteristics (mainly due to missing information on net household  
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7 income) could have led to an underestimation of the social gradient in T2DM, because these subjects  
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9 were on average older, more often female, out of employment and with a lower educational status.  
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11 However, a sensitivity analysis showed similar results applying education as measure of social class.  
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13 We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not  
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15 capture the immediate neighborhood of residence of our study participants. This could lead to  
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17 exposure misclassification and underestimation of neighborhood effects [43]. The applied  
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19 administrative definition of neighborhoods differed between studies and neighborhoods were diverse  
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21 according to their area and population size. Another challenge in the research of neighborhood impact  
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23 on health is the residential selection. Individuals may be selected into neighborhoods due to their  
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25 individual characteristics, such as residents of poor areas cannot afford moving to better-off  
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27 neighborhoods [44 45]. Finally, we had no information on the residential history of the study  
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29 participants, which could result in an underestimation of neighborhood effects on health [46].  
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33 In conclusion, our study identified different relationships of individual social class, employment status  
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35 and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men  
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37 and women, the prevalence of T2DM was inversely related to social class. This social gradient was  
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39 stronger in women. Regional variance in the T2DM prevalence was larger in women than men.  
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41 Whereas the major proportion of the variance in the T2DM prevalence remained statistically  
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43 unexplained in women, the regional variance in men was low and completely explained by the  
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45 considered variables.  
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Table 1: Characteristics of The Five Studies (CARLA, DHS, KORA, HNR, and SHIP studies, Germany, 1997-2006)<sup>a</sup>

	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)

<sup>a</sup> 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)<sup>a</sup>

Study	CARLA		DHS		KORA		HNR		SHIP	
	men	women	men	women	men	women	men	women	men	women
<b>Study period</b>	12/2002-01/2006		09/2003-06/2004		10/1999-04/2001		12/2000-06/2003		10/1997-03/2001	
<b>Participants 45-74 with full information</b>	719	638	414	411	532	494	2,257	2,175	615	615
<b>Number of neighborhoods (range of residing participants)</b>	37 (3-139)		60 (1-42)		17 (13-141)		106 (1-140)		6 (95-396)	
<b>Crude diabetes prevalence (%) (95% CI)</b>	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)
<b>Mean age (SD)</b>	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)
<b>Social class % (n)</b>										
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)
<b>Employment status % (n)</b>										
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)
<b>Marital status (%)</b>										
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)

<sup>a</sup> 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)<sup>a, b</sup>

	Men						Women					
	No.	Crude Prevalence T2D Cases	%	95% CI	Age-adjusted Prevalence %	95% CI	No.	Crude Prevalence T2D Cases	%	95% CI	Age-adjusted Prevalence %	95% CI
<b>Social class</b>												
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
<b>Employment status</b>												
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
<b>Marital status</b>												
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
<b>Physical exercise</b>												
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
<b>Smoking</b>												
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
current 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
<b>BMI</b>												

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< 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
<b>Alcohol consumption</b>												
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
<b>Unemployment rate</b>												
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

<sup>a</sup> 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)

<sup>b</sup> 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<sup>a, b, c</sup>

		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)
<b>Model 1<sup>d</sup></b>	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)
<b>Model 2<sup>e</sup></b>	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)
<b>Model 3<sup>f</sup></b>	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)
<b>Model 4<sup>g, h</sup></b>	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)

<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

<sup>b</sup> 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

<sup>c</sup> men: n=4,537, women: n=4,333

<sup>d</sup> Model 1: unadjusted

<sup>e</sup> Model 2: adjusted by age

<sup>f</sup> Model 3: adjusted by other confounders: social class, employment status, neighborhood unemployment rate, marital status

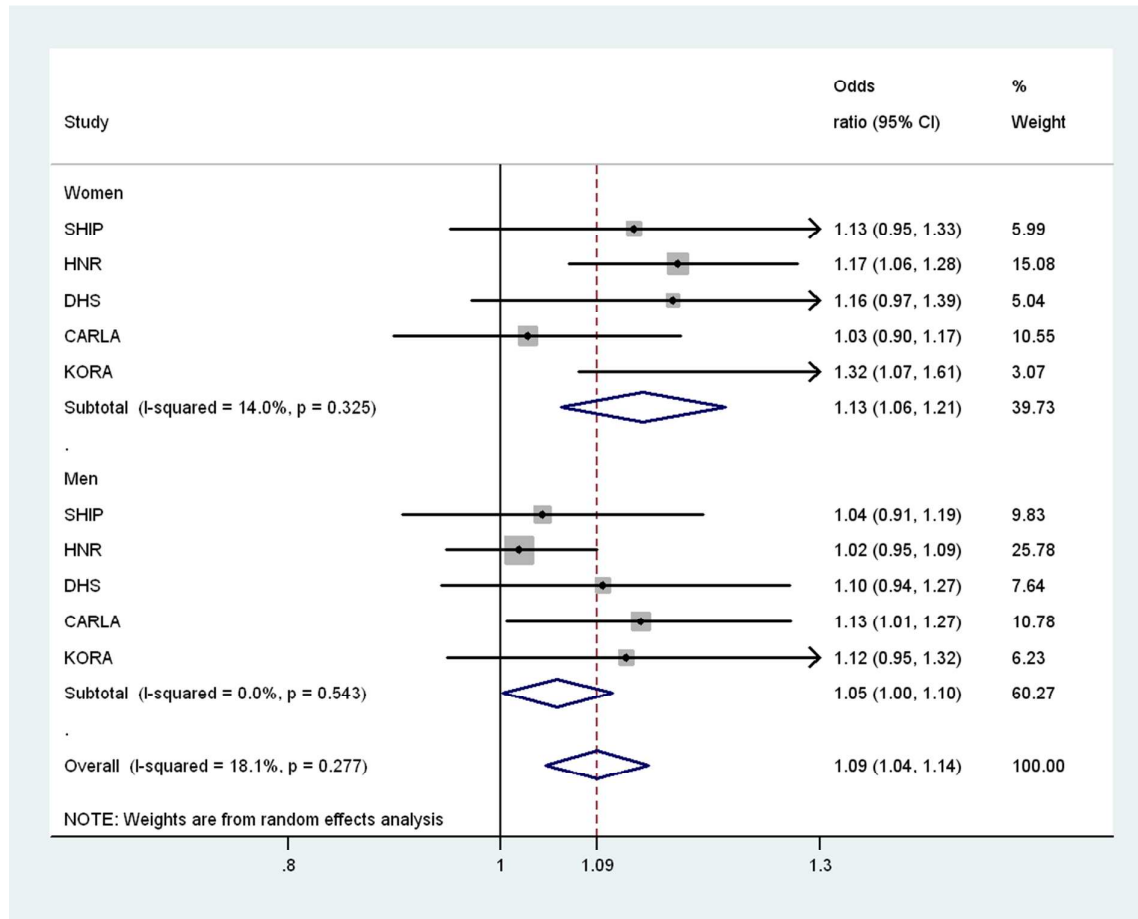
<sup>g</sup> Model 4: adjusted by mediators: BMI, physical exercise, smoking (only for men)

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<sup>h</sup> Sample size n=8,731 due to 139 missing values on life style factors

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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<sup>a, b, c, d</sup>



<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

<sup>b</sup> Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

<sup>c</sup> 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

<sup>d</sup> Heterogeneity tested via Q-statistic and I<sup>2</sup>-index

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**Declaration of Competing Interests**

Nothing to declare.

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3 **Data sharing statement**  
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5 There is no additional data available.  
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**Patient consent**

Obtained.

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**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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3 **Gender Differences in The Association of Individual Social Class And Neighborhood**  
4 **Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from**  
5 **The DIAB-CORE Consortium**  
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9 **Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**  
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12 Grit Müller<sup>1</sup>, Saskia Hartwig<sup>2</sup>, Karin Halina Greiser<sup>2,3</sup>, Susanne Moebus<sup>4</sup>, Noreen Pundt<sup>4</sup>, Sabine  
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51 **Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics,  
52 Socioeconomic Factors, Population-based  
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3 **Abstract** (word count: 256; max. 300)  
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7 **Objective:** To analyze gender differences in the relationship of individual social class, employment  
8 status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).  
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11 **Design:** Five cross-sectional studies.

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

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15 **Participants:** The sample consisted of 8,870 individuals residing in 226 neighborhoods in five urban  
16 regions.  
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19 **Primary and secondary outcome measures:** Prevalent T2DM.

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21 **Results:** We found significant multiplicative interactions between gender and the individual variables  
22 social class and employment status (being unemployed, retired). Social class was statistically  
23 significant associated with T2DM in men and women, whereby this association was stronger in  
24 women (low versus high social class: odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34))  
25 than men (low versus high social class: OR 1.75 (95% CI: 1.20-2.54)). Significant associations of  
26 employment status and T2DM were only found in women (unemployed versus employed: OR 1.73  
27 (95% CI: 1.02-2.92); retired versus employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed:  
28 OR 1.64 (95% CI: 1.01-2.67)). Neighborhood unemployment rate was associated with T2DM in men  
29 (highest versus lowest tertile: OR 1.52 (95% CI: 1.18-1.96)). Between-study and between-  
30 neighborhood variation in the T2DM prevalence was more pronounced in women. The considered  
31 covariates helped to explain statistically the variation in the T2DM prevalence among men, but not  
32 among women.  
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45 **Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the  
46 association was more pronounced in women. Employment status only affected T2DM in women.  
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48 Neighborhood unemployment rate is an important predictor of T2DM in men, but not in women.  
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## 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 et 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,

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3 behavioral and psychosocial conditions of men and women (“differential vulnerability hypothesis”) [2  
4 19]. Differences in men’s and women’s perception of the **neighborhood context** and social status may  
5 be as well a source of **health disparities** [19]. Stafford et al. examined gender differences in the  
6 relationship between self-rated health and the neighborhood context **and found a larger impact of the**  
7 **neighborhood context** on the health of women [19].

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

## 28 **Methods**

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

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

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

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

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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.

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3 The variable marital status summarized information whether a study participant lived with or without a  
4 partner. Moreover, life style variables including smoking status (current smoker; former smoker; never  
5 smoker), physical exercise (exercise; no exercise), body mass index (BMI) ( $<30 \text{ kg/m}^2$ ;  $\geq 30 \text{ kg/m}^2$ )  
6 and alcohol consumption (no or moderate intake: women:  $\leq 20$  grams per day; men:  $\leq 40$  grams per  
7 day; high intake: women:  $>20$  grams per day; men:  $>40$  grams per day) were considered. Exercising  
8 included any exercise irrespective of frequency and duration. All variables were constructed following  
9 DIAB-CORE standard procedures for the homogenization of basic variables to ensure a high degree of  
10 comparability.  
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### 20 21 **Statistical Analysis**

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23 Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived  
24 from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual  
25 variables and neighborhood unemployment rate.  
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29 Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods  
30 (level 2), which were nested in study regions (level 3). To account for this data structure in our  
31 statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed  
32 effects logistic regression models. First, we tested for interactions between gender and individual  
33 social class, employment status and neighborhood unemployment rate. To do so, we estimated  
34 regression models including terms for gender and social class, employment status or neighborhood  
35 unemployment rate as main effects and an interaction term for the effect of social class, employment  
36 status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were  
37 conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables  
38 age, marital status and the remaining social variables (social class/ employment status/ neighborhood  
39 unemployment rate) depending on the variable of interest. Life style factors, including smoking,  
40 alcohol consumption, BMI and physical activity were evaluated as potential mediators in the  
41 relationship between T2DM and individual social class, employment status or neighborhood  
42 unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.  
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3 Random effects were included to capture between-study and between-neighborhood variance reported  
4 as median odds ratios (MOR). The latter represents a transformation of the area-level variation ( $V_A$ ) on  
5 an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and  
6 lowest-risk-area. The MOR was calculated on the level of neighborhoods and study regions with the  
7 following equation:  $MOR = \exp(\sqrt{(2 * V_A)} * 0.6745)$ , where 0.6745 is the 75<sup>th</sup> centile of the  
8 cumulative distribution function of the normal distribution with mean zero and variance one [31 32].

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

## 31 Results

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

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41 The age-adjusted prevalence of T2DM was statistically significantly lower in high social class women  
42 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  
43 women; 6.9% (95% CI: 5.9-8.1) respectively 14.1% (95% CI: 11.8-16.7) in men) (table 3). Women  
44 had a statistically significantly lower age-adjusted T2DM prevalence than men over all social classes.  
45 Employed men had a statistically significantly lower age-adjusted T2DM prevalence with 7.3% (95%  
46 CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods, the highest age-

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3 adjusted prevalence of T2DM was found in women and men living in neighborhoods with a high  
4 unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)). Individuals  
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6 living without a partner showed statistically significantly higher prevalence than individuals who lived  
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8 with a partner irrespective of gender. Being physical inactive or having a BMI of 30 or above was  
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10 statistically significantly associated with a higher T2DM prevalence in men and women.

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

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23 The results of the gender-stratified multivariable regression analysis are presented in table 4. Among  
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25 women and men, we found a statistically significant association of social class and T2DM. The social  
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27 gradient in the odds of T2DM was reduced when the models were adjusted for age and the  
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29 confounding variables. This reduction was particularly large in women. Overall, the association  
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31 between social class and T2DM was stronger in women (low versus high social class: OR 2.68 (95%  
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33 CI: 1.66-4.34); medium versus high social class: OR 2.02 (95% CI: 1.31-3.13)) than men (low versus  
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35 high social class: OR 1.75 (95% CI: 1.20-2.54); medium versus high social class: OR 1.13 (95% CI:  
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37 0.89-1.43)) (model 3, table 4). Significant associations of employment status and T2DM were only  
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39 found in women: In reference to employed women, unemployed women, retired women and women  
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41 with other employment status had a 1.73, (95% CI: 1.02-2.92), a 1.77 (95% CI: 1.10-2.84)  
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43 respectively a 1.64 (95% CI: 1.01-2.67)) higher odds to have T2DM. The significant elevated odds of  
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45 T2DM in retired men were dissolved by adjustment for age. Women residing in neighborhoods with a  
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47 medium level of unemployment showed a significant elevated odds to have T2DM (OR 1.45 (95% CI:  
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49 1.03-2.04), model 2), which was dissolved when the model was adjusted by confounding variables. In  
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51 contrast, men residing in neighborhoods with a high level of unemployment showed a 52% (95% CI:  
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53 1.18-1.96) higher odds to have T2DM than men in low unemployment neighborhoods in the  
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55 confounder-adjusted model 3. T2DM was no longer associated with marital status after adjustment by  
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3 confounding variables in model 3 (living without versus living with a partner: OR 1.17 (95% CI: 0.90-  
4 1.51) in women, OR 1.19 (95% CI: 0.88-1.59) in men).

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6 In model 4, the life style factors BMI, physical activity and smoking (only men) were introduced in  
7 the model. These life style factors were previously evaluated to be associated with social class,  
8 employment status (not associated with physical exercise in women) and neighborhood unemployment  
9 rate as well with the presence of type 2 diabetes (smoking only in men). In men and women, we  
10 observed effect modifications among individual social class, employment status and neighborhood  
11 unemployment rate when introducing these life style factors into the analysis. Especially, the  
12 association between social class and T2DM was strongly reduced in women mainly accounted by the  
13 BMI.  
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16 Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women  
17 than men. The prevalence of T2DM in men varied only between study regions (model 1: MOR: 1.21;  
18  $V_A$ : 0.04; SE: 0.04), which was fully explained statistically by age, social class, employment status,  
19 neighborhood unemployment rate, marital status and life style factors. The T2DM prevalence in  
20 women showed large variation across neighborhoods (model 1: MOR: 1.47;  $V_A$ : 0.16; SE: 0.10) and  
21 study regions (model 1: MOR: 1.31;  $V_A$ : 0.08; SE: 0.07), which was not dissolved by the considered  
22 explanatory variables (model 4, between-neighborhood variation: MOR: 1.42;  $V_A$ : 0.13; SE: 0.10,  
23 between-study variation: MOR: 1.27;  $V_A$ : 0.06; SE: 0.06).  
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26 Regarding gender differences in health inequalities across regions, the effect estimates of the five  
27 studies were tested to be homogenous (figure 1). A low social class was associated with a higher odds  
28 of T2DM, adjusted for age, employment status, marital status and neighborhood unemployment rate.  
29 In women, an increase of one point on the social class score (decrease in social class) was associated  
30 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  
31 having T2DM. This association was smaller in men (pooled OR: 1.05 (95% CI: 1.00-1.10);  $I^2=0.0%$ ;  
32  $p=0.543$ ), although the differences between genders were not significant. This was observed in all  
33 studies, except CARLA.  
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## 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

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3 in men. A large fraction of the detected variation in the prevalence of T2DM on the level of  
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5 neighborhoods and regions remained statistically unexplained in women, suggesting that there were  
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7 characteristics on the individual, neighborhood and regional level that determine the presence of  
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9 T2DM and which were not considered in our analysis. Previous work on regional variation in self-  
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11 rated health and BMI also found larger regional variation in women [19 38 39].

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

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

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41 Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited  
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43 causal conclusions. We could not use occupation as an indicator of social class in our analysis since  
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45 the assessment was not comparable between studies. The prevalence of T2DM was based on a self-  
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47 reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2  
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49 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports  
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51 and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded  
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53 that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of  
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55 self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative  
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57 [42]. Another potential limitation is the selection by response (response proportions: 56%-69%),  
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3 which might have affected our results. The exclusion of participants from the initial sample due to  
4 missing information on individual characteristics (mainly due to missing information on net household  
5 income) could have led to an underestimation of the social gradient in T2DM, because these subjects  
6 were on average older, more often female, out of employment and with a lower educational status.  
7 However, a sensitivity analysis showed similar results applying education as measure of social class.  
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10 We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not  
11 capture the immediate neighborhood of residence of our study participants. This could lead to  
12 exposure misclassification and underestimation of neighborhood effects [43]. The applied  
13 administrative definition of neighborhoods differed between studies and neighborhoods were diverse  
14 according to their area and population size. Another challenge in the research of neighborhood impact  
15 on health is the residential selection. Individuals may be selected into neighborhoods due to their  
16 individual characteristics, such as residents of poor areas cannot afford moving to better-off  
17 neighborhoods [44 45]. Finally, we had no information on the residential history of the study  
18 participants, which could result in an underestimation of neighborhood effects on health [46].  
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33 In conclusion, our study identified different relationships of individual social class, employment status  
34 and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men  
35 and women, the prevalence of T2DM was inversely related to social class. This social gradient was  
36 stronger in women. Regional variance in the T2DM prevalence was larger in women than men.  
37 Whereas the major proportion of the variance in the T2DM prevalence remained statistically  
38 unexplained in women, the regional variance in men was low and completely explained by the  
39 considered variables.  
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Table 1: Characteristics of The Five Studies (CARLA, DHS, KORA, HNR, and SHIP studies, Germany, 1997-2006)<sup>a</sup>

	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)

<sup>a</sup> 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)<sup>a</sup>

Study	CARLA		DHS		KORA		HNR		SHIP	
	men	women	men	women	men	women	men	women	men	women
<b>Study period</b>	12/2002-01/2006		09/2003-06/2004		10/1999-04/2001		12/2000-06/2003		10/1997-03/2001	
<b>Participants 45-74 with full information</b>	719	638	414	411	532	494	2,257	2,175	615	615
<b>Number of neighborhoods (range of residing participants)</b>	37 (3-139)		60 (1-42)		17 (13-141)		106 (1-140)		6 (95-396)	
<b>Crude diabetes prevalence (%) (95% CI)</b>	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)
<b>Mean age (SD)</b>	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)
<b>Social class % (n)</b>										
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)
<b>Employment status % (n)</b>										
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)
<b>Marital status (%)</b>										
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)

<sup>a</sup> 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) <sup>a, b</sup>

	Men						Women					
	No.	Crude Prevalence T2D Cases	%	95% CI	Age-adjusted Prevalence %	95% CI	No.	Crude Prevalence T2D Cases	%	95% CI	Age-adjusted Prevalence %	95% CI
<b>Social class</b>												
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
<b>Employment status</b>												
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
<b>Marital status</b>												
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
<b>Physical exercise</b>												
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
<b>Smoking</b>												
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
current 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
<b>BMI</b>												

< 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
<b>Alcohol consumption</b>												
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
<b>Unemployment rate</b>												
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

<sup>a</sup> 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)

<sup>b</sup> 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<sup>a, b, c</sup>

		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)
<b>Model 1<sup>d</sup></b>	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)
<b>Model 2<sup>e</sup></b>	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)
<b>Model 3<sup>f</sup></b>	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)
<b>Model 4<sup>g, h</sup></b>	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)

<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

<sup>b</sup> 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

<sup>c</sup> men: n=4,537, women: n=4,333

<sup>d</sup> Model 1: unadjusted

<sup>e</sup> Model 2: adjusted by age

<sup>f</sup> Model 3: adjusted by other confounders: social class, employment status, neighborhood unemployment rate, marital status

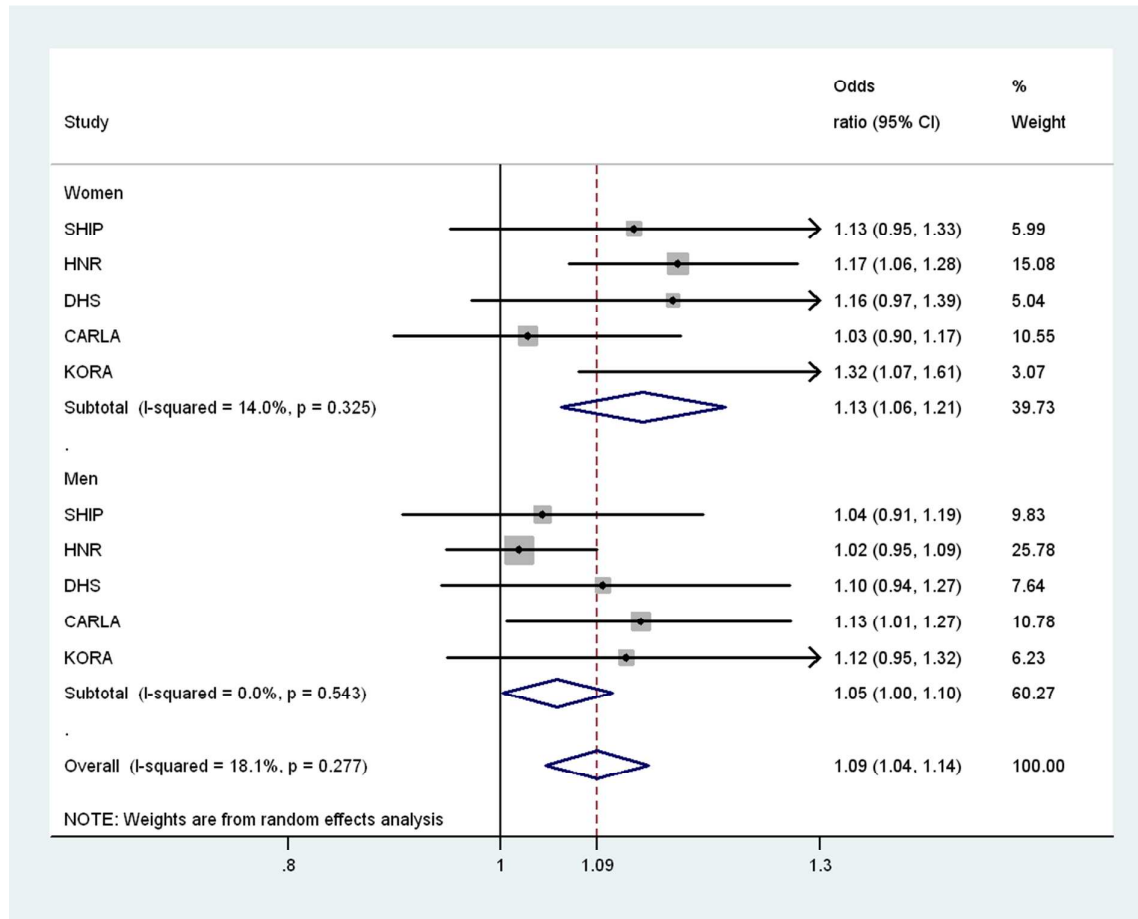
<sup>g</sup> Model 4: adjusted by mediators: BMI, physical exercise, smoking (only for men)

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<sup>h</sup> Sample size n=8,731 due to 139 missing values on life style factors

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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<sup>a, b, c, d</sup>



<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

<sup>b</sup> Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

<sup>c</sup> 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

<sup>d</sup> Heterogeneity tested via Q-statistic and I<sup>2</sup>-index

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**Declaration of Competing Interests**

Nothing to declare.

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3 **Data sharing statement**  
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**Patient consent**

Obtained.

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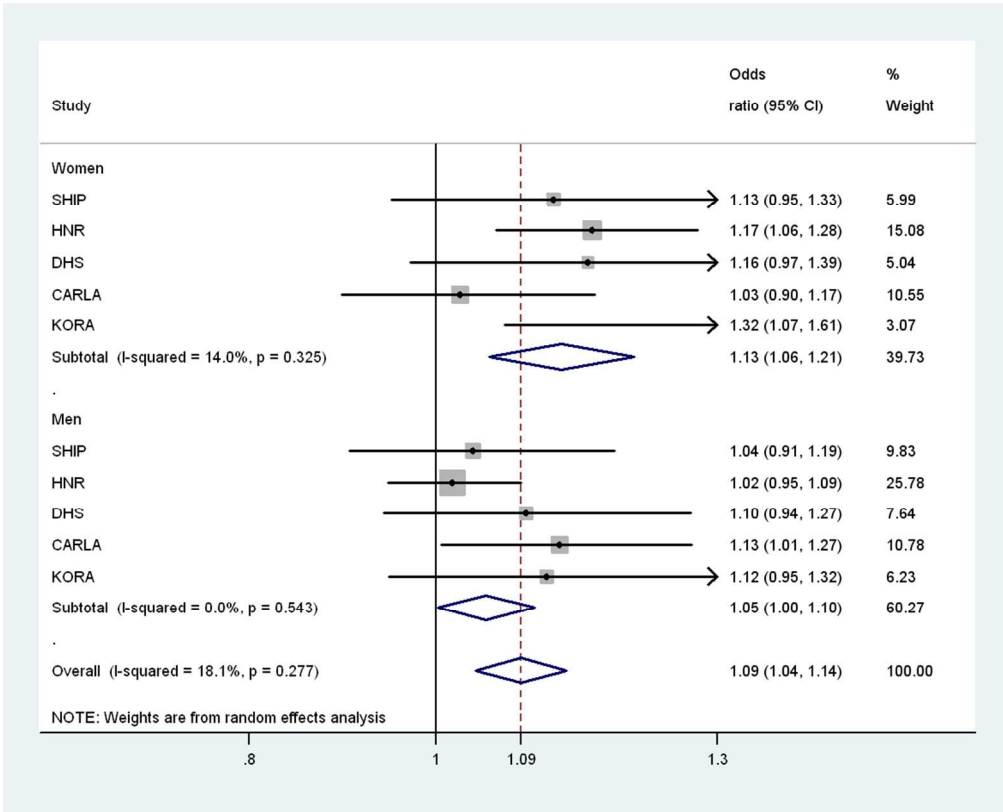
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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			



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
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://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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3 **Gender Differences in the Association of Individual Social Class and Neighborhood**  
4 **Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from**  
5 **The DIAB-CORE Consortium**  
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9 **Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**  
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12 Grit Müller<sup>1</sup>, Saskia Hartwig<sup>2</sup>, Karin Halina Greiser<sup>2,3</sup>, Susanne Moebus<sup>4</sup>, Noreen Pundt<sup>4</sup>, Sabine  
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51 **Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics,  
52 Socioeconomic Factors, Population-based  
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54 Word count: 3710  
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3 **Abstract** (word count: 253; max. 300)  
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7 **Objective:** To analyze gender differences in the relationship of individual social class, employment  
8 status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).  
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11 **Design:** Five cross-sectional studies.  
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13 **Setting:** Studies were conducted in five regions of Germany from 1997-2006.  
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15 **Participants:** The sample consisted of 8,871 individuals residing in 226 neighborhoods in five urban  
16 regions.  
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19 **Primary and secondary outcome measures:** Prevalent T2DM.  
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21 **Results:** We found significant multiplicative interactions between gender and the individual variables  
22 social class and employment status. Social class was statistically significant associated with T2DM in  
23 men and women, whereby this association was stronger in women (lower versus higher social class:  
24 odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34)) than men (lower versus higher social  
25 class: OR 1.78 (95% CI: 1.22-2.58)). Significant associations of employment status and T2DM were  
26 only found in women (unemployed versus employed: OR 1.73 (95% CI: 1.02-2.92); retired versus  
27 employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed: OR 1.64 (95% CI: 1.01-2.67)).  
28 Neighborhood unemployment rate was associated with T2DM in men (high versus low tertile: OR  
29 1.52 (95% CI: 1.18-1.96)). Between-study and between-neighborhood variation in the T2DM  
30 prevalence was more pronounced in women. The considered covariates helped to explain statistically  
31 the variation in the T2DM prevalence among men, but not among women.  
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43 **Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the  
44 association was more pronounced in women. Employment status only affected T2DM in women.  
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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



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3 which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a  
4 sub-analysis, we performed study-specific calculations of the relationship between T2DM and social  
5 class in men and women.  
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## 10 **Methods**

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12 Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular  
13 Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz  
14 Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA)  
15 S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997  
16 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage  
17 cluster or stratified random sampling) and response proportions (56%-69%). The studies were  
18 approved by local ethics committees and informed written consent was obtained from the study  
19 participants. Within the five studies, similar instruments, questionnaires and medical measurements  
20 were applied to collect data. Study designs have been described elsewhere in more detail [20-24].  
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24 In brief, data on 11,688 subjects aged 45-74 years were provided. 2,280 individuals living in rural  
25 areas of KORA and SHIP were excluded from the sample, because these subjects could not be  
26 assigned to spatial units below the level of municipalities; so, that our study was limited to urban  
27 areas. Study participants were assigned to neighborhoods via addresses of residence at baseline (8  
28 subjects could not be linked). The neighborhoods were defined by administrative units: statistical  
29 administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning  
30 regions (summary of city districts) in KORA and postal code areas in SHIP. Participants resided in  
31 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of  
32 participants with missing information on individual characteristics (n=529), the final sample consisted  
33 of 8,871 residents in 226 neighborhoods.  
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52 Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-  
53 reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic  
54 agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded  
55 from the analyses to avoid inclusion of possible cases of type 1 diabetes.  
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3 Social class was measured with a summary score of income and education. Its' operationalization  
4 was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on  
5 individual educational and professional attainment, net household income and the occupational  
6 position of the main earner of a household. The three dimensions are transformed to an ordinal scale  
7 ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information  
8 on occupational status was not available for our analysis, the index was solely based on education and  
9 income, ranging between 2 and 14 points. The index was divided into three groups: higher social class,  
10 middle social class and lower social class. Study participants were classified in four employment  
11 status groups: employed, retired and unemployed individuals as well as persons with other forms of  
12 employment, including participants in vocational retraining, housewives and housemen.

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

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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/m<sup>2</sup>;  $\geq 30$  kg/m<sup>2</sup>)  
and alcohol consumption (no or moderate intake: women:  $\leq 20$  grams per day; men:  $\leq 40$  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

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3 exercise irrespective of frequency and duration. All variables were constructed following DIAB-  
4 CORE standard procedures for the homogenization of basic variables to ensure a high degree of  
5 comparability.  
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### 11 **Statistical Analysis**

12 Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived  
13 from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual  
14 variables and neighborhood unemployment rate.  
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17 Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods  
18 (level 2), which were nested in study regions (level 3). To account for this data structure in our  
19 statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed  
20 effects logistic regression models. First, we tested for interactions between gender and individual  
21 social class, employment status and neighborhood unemployment rate. To do so, we estimated  
22 regression models including terms for gender and social class, employment status or neighborhood  
23 unemployment rate as main effects and an interaction term for the effect of social class, employment  
24 status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were  
25 conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables  
26 age, marital status and the remaining social variables (social class/ employment status/ neighborhood  
27 unemployment rate) depending on the variable of interest. Life style factors, including smoking,  
28 alcohol consumption, BMI and physical activity were evaluated as potential mediators in the  
29 relationship between T2DM and individual social class, employment status or neighborhood  
30 unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.  
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33 Random effects were included to capture between-study and between-neighborhood variance reported  
34 as median odds ratios (MOR). The latter represents a transformation of the area-level variation ( $V_A$ ) on  
35 an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and  
36 lowest-risk-area and was calculated on the level of neighborhoods and study regions with the  
37 following equation:  $MOR = \exp(\sqrt{(2 * V_A)} * 0.6745)$ , where 0.6745 is the 75<sup>th</sup> centile of the  
38 cumulative distribution function of the normal distribution with mean zero and variance one [31 32].  
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3 Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small  
4 number of cases by study, the social class variable had to be applied as a continuous measure in this  
5 sub-analysis (ranging between two points, highest social class, and 14 points, lowest social class). For  
6 this purpose, inverse-variance weighting was used to estimate fixed and random effects summary  
7 estimates and displayed in forest plots [33]. Q-statistic and  $I^2$  index were applied to assess  
8 heterogeneity and the extent of heterogeneity between study results respectively [34]. Analyses were  
9 performed in STATA/ SE 11.0.  
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## 19 Results

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21 In total, 8,871 subjects residing in 226 neighborhoods in five urban regions were included in our  
22 analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was  
23 statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95%  
24 CI 9.1-10.9) (significance derived from 95% CI). This pattern was observed in all five regional  
25 studies. Socio-demographic characteristics are reported in table 2. Compared to men, women belonged  
26 more often to the lower or middle social class and a higher proportion was not employed, except in  
27 SHIP. A higher proportion of women than men reported to live without a partner.  
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35 The age-adjusted prevalence of T2DM was statistically significantly lower in higher social class  
36 women and men than in the lower social class (4.7% (95% CI: 3.9-5.7) respectively 9.7% (95% CI:  
37 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  
38 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all  
39 social classes. Employed men had a statistically significantly lower age-adjusted T2DM prevalence  
40 with 7.3% (95% CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods,  
41 the highest age-adjusted prevalence of T2DM was found in women and men living in neighborhoods  
42 with a high unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)).  
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Individuals living without a partner showed statistically significantly higher prevalence than  
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.

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3 In the fully adjusted multivariable analyses, the interaction terms of social class and gender were  
4 statistically significant. Among the employment status, we found significant multiplicative interactions  
5 between unemployed individuals and gender as well as between retired individuals and gender. The  
6 interaction terms between neighborhood unemployment rate and gender were not statistically  
7 significant.  
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11 The results of the gender-stratified multivariable regression analysis are presented in table 4. Among  
12 women and men, we found a statistically significant association of social class and T2DM. The social  
13 gradient in the odds of T2DM was reduced when the models were adjusted for age and the  
14 confounding variables. This reduction was particularly large in women. Overall, the association  
15 between social class and T2DM was stronger in women (lower versus higher social class: OR 2.68  
16 (95% CI: 1.66-4.34)) than men (lower versus higher social class: OR 1.77 (95% CI: 1.22-2.58))  
17 (model 3, table 4). Significant associations of employment status and T2DM were only found in  
18 women: In reference to employed women, retired women, unemployed women and women with other  
19 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  
20 (95% CI: 1.01-2.67) higher odds to have T2DM (model 3, table 4). The significant elevated odds of  
21 T2DM in retired men were dissolved by adjustment for age.  
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35 Women residing in neighborhoods with a medium level of unemployment showed significant elevated  
36 odds to have T2DM (OR 1.45 (95% CI: 1.03-2.04)) (model 2), which was dissolved when the model  
37 was adjusted by confounding variables. In contrast, men residing in neighborhoods with a high level  
38 of unemployment showed a 52% (95% CI: 1.18-1.96) higher odds to have T2DM than men in low  
39 unemployment neighborhoods in the confounder-adjusted model 3. T2DM was no longer associated  
40 with marital status after adjustment by confounding variables in model 3 (living without versus living  
41 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).  
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49 As part of mediation analysis, the association of life style variables and social class, employment  
50 status and neighborhood unemployment rate as well as the association between type 2 diabetes and life  
51 style variables were tested. Type 2 diabetes was related to BMI and physical activity in men and  
52 women, but smoking only in men and alcohol consumption not in both (not taken into further  
53 consideration). BMI, physical activity and smoking were tested to be statistically significantly  
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3 associated with social class, employment status and neighborhood unemployment rate with some  
4 exceptions: In women, physical exercise was not associated with employment status and smoking not  
5 related at all with social variables. Thereupon, the life style variables were introduced into model 4  
6 and the estimates of social class, employment status and neighborhood unemployment rate evaluated  
7 in respect to reductions in the association with T2DM. In men and women, we observed reductions in  
8 the effects of individual social class, employment status and neighborhood unemployment rate when  
9 introducing these life style factors in the analysis. Especially, the association between social class and  
10 T2DM was strongly reduced in women and men. This reduction was mainly driven by BMI in women  
11 (solely adjusted by BMI, higher versus lower social class OR 1.73 (95% CI: 1.05-2.85)) and physical  
12 exercise in men (solely adjusted by physical exercise, higher versus lower social class OR 1.59 (95%  
13 CI: 1.09-2.32)), providing evidence that these life style variables partly mediated the relationship  
14 between social class and type 2 diabetes.

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27 Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women  
28 than men. The prevalence of T2DM in men varied only between study regions (unadjusted model:  
29 MOR: 1.20;  $V_A$ : 0.04; SE: 0.03) (online supplemental material, table 5), which was fully explained  
30 statistically by age, social class, employment status, neighborhood unemployment rate, marital status  
31 and life style factors. The T2DM prevalence in women showed large variation across neighborhoods  
32 (unadjusted model: MOR: 1.47;  $V_A$ : 0.16; SE: 0.10) and study regions (unadjusted model: MOR: 1.31;  
33  $V_A$ : 0.07; SE: 0.06), which was not dissolved by the considered explanatory variables (between-  
34 neighborhood variation: MOR: 1.32;  $V_A$ : 0.08; SE: 0.09, between-study variation: MOR: 1.29;  $V_A$ :  
35 0.07; SE: 0.06) (model 5, table 5).

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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);  $I^2=0.0\%$ ;

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3 p=0.456), although the differences between genders were not significant. This was observed in all  
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5 studies, except CARLA.  
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## 10 11 **Discussion**

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13 This study assessed gender differences in the association of individual social class, employment status  
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15 and neighborhood unemployment rate with prevalent T2DM, using data from five regional population-  
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17 based studies in Germany. Women and men belonging to the lower social class had a higher  
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19 prevalence of T2DM. We found that the gradient in the prevalence of T2DM across social classes was  
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21 clearly stronger in women than men. This pattern was consistent across all regions but CARLA and  
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23 mainly in line with results of prior studies presenting only associations in women [7-9], or in men and  
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25 women but more pronounced in women [5 6].  
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28 In our study, the individual employment status was only associated with T2DM in women. Being  
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30 unemployed, retired or a housewife yielded higher odds of T2DM. However, since we were not able to  
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32 consider occupational position in our analyses, the interpretation of these findings is limited. In the  
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34 literature, two contrasting theories are discussed for the effects of paid employment on women's  
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36 health. Employment can have a health promoting function due to role accumulation in contrast to the  
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38 monotony, isolation, low social status and self-esteem of housewives. A health damaging effect could  
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40 arise due to role strains, e.g. stress due to multiple roles, and heavy job demands [35 36].

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42 Men residing in neighborhoods with a high level of unemployment rate were more likely to have  
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44 T2DM than men in better-off neighborhoods. These effects remained even after adjustment for  
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46 confounding and mediator variables, whereas associations between neighborhood unemployment rate  
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48 and T2DM in women were dissolved by the introduction of confounding variables. These deviating  
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50 effects of neighborhood unemployment rate between men and women may be explained by the fact  
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52 that men were more often engaged in employment and, hence, depend more on the regional labor  
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54 market and its employment opportunities than women. Potential underlying mechanisms in the  
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56 relationship between neighborhood unemployment rate and T2DM include neighborhood resources  
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58 such as the availability of grocery stores offering healthy food and recreational facilities [15], the  
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3 adoption and maintenance of risky health behavior and psychosocial factors such as chronic stress [13  
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7 Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women  
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9 than men. We found that individual social class, employment status and neighborhood unemployment  
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11 rate played an important role in explaining statistically regional differences in the prevalence of T2DM  
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13 in men. A large fraction of the detected variation in the prevalence of T2DM on the level of  
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15 neighborhoods and regions remained statistically unexplained in women, suggesting that there were  
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17 characteristics on the individual, neighborhood and regional level that determine the presence of  
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19 T2DM and which were not considered in our analysis. Previous work on regional variation in self-  
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21 rated health and BMI also found larger regional variation in women [19 38 39].

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

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

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51 Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited  
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53 causal conclusions. We could not use occupation as an indicator of social class in our analysis since  
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55 the assessment was not comparable between studies. The prevalence of T2DM was based on a self-  
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57 reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2  
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3 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports  
4 and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded  
5 that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of  
6 self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative  
7 [42]. Another potential limitation is the selection by response (response proportions: 56%-69%),  
8 which might have affected our results. The exclusion of participants from the initial sample due to  
9 missing information on individual characteristics (mainly due to missing information on net household  
10 income) could have led to an underestimation of the social gradient in T2DM, because these subjects  
11 were on average older, more often female, out of employment and with a lower educational status.  
12 However, a sensitivity analysis showed similar results applying education as measure of social class.  
13 We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not  
14 capture the immediate neighborhood of residence of our study participants. This could lead to  
15 exposure misclassification and underestimation of neighborhood effects [43]. The applied  
16 administrative definition of neighborhoods differed between studies and neighborhoods were diverse  
17 according to their area and population size. Another challenge in the research of neighborhood impact  
18 on health is the residential selection. Individuals may be selected into neighborhoods due to individual  
19 characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [44  
20 45]. Finally, we had no information on the residential history of the study participants, which could  
21 result in an underestimation of neighborhood effects on health [46].  
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43 In conclusion, our study identified different relationships of individual social class, employment status  
44 and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men  
45 and women, the prevalence of T2DM was inversely related to social class. This social gradient was  
46 stronger in women. Regional variance in the T2DM prevalence was larger in women than men.  
47 Whereas the major proportion of the variance in the T2DM prevalence remained statistically  
48 unexplained in women, the regional variance in men was low and completely explained by the  
49 considered variables.  
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Table 1: Characteristics of the 5 Population-Based Studies (CARLA, DHS, KORA, HNR, and SHIP, Germany, 1997-2006)<sup>a</sup>

	CARLA	DHS	KORA	HNR	SHIP
<b>Study period</b>	12/2002-01/2006	09/2003-06/2004	10/1999-04/2001	12/2000-06/2003	10/1997-03/2001
<b>Federal state (Region)</b>	Saxony-Anhalt (east)	North Rhine-Westphalia (west)	Bavaria (south)	North Rhine-Westphalia (west)	Mecklenburg-West Pomerania (northeast)
<b>Sampling</b>	stratified random sampling	stratified random sampling	two-stage cluster sampling	stratified random sampling	two-stage cluster sampling
<b>Cities</b>	Halle (Saale)	Dortmund	Augsburg	Bochum, Essen, Mülheim	Greifswald, Stralsund
<b>Neighborhoods (n)/ Types</b>	43/ city districts	62/ statistical administrative units	17/ planning regions	108/ statistical administrative units	6/ clusters of city districts
<b>Total population (neighborhood range)</b>	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)
<b>Unemployment rate (%; neighborhood range)<sup>b</sup></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)

<sup>a</sup> 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)

<sup>b</sup> 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)<sup>a</sup>**

Study	CARLA		DHS		KORA		HNR		SHIP	
	men	women	men	women	men	women	men	women	men	women
<b>Participants 45-74 with full information</b>	719	638	414	411	533	494	2,257	2,175	615	615
<b>Number of neighborhoods (range of residing participants)</b>	37 (3-139)		60 (1-42)		17 (13-141)		106 (1-140)		6 (95-396)	
<b>Crude diabetes prevalence (%) (95% CI)</b>	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)
<b>Mean age (SD)</b>	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)
<b>Social class % (n)</b>										
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)
<b>Employment status % (n)</b>										
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)
<b>Marital status (%)</b>										
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)

<sup>a</sup> 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) <sup>a, b</sup>**

	Men						Women					
	No.	Crude Prevalence			Age-adjusted Prevalence		No.	Crude Prevalence			Age-adjusted Prevalence	
		T2D Cases	%	95% CI	%	95% CI		T2D Cases	%	95% CI	%	95% CI
<b>Social class</b>												
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
<b>Employment status</b>												
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
<b>Marital status</b>												
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
<b>Physical exercise</b>												
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
<b>Smoking</b>												
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
current 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
<b>BMI</b>												
< 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

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≥ 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
<b>Alcohol consumption</b>												
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
<b>Unemployment rate</b>												
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

<sup>a</sup> 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)

<sup>b</sup> 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<sup>a, b, c</sup>**

		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)
<b>Model 1<sup>d</sup></b>	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)
<b>Model 2<sup>e</sup></b>	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)
<b>Model 3<sup>f</sup></b>	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)
<b>Model 4<sup>g, h</sup></b>	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)

<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

<sup>b</sup> 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

<sup>c</sup> men: n=4,538, women: n=4,333

<sup>d</sup> Model 1: unadjusted

<sup>e</sup> Model 2: adjusted by age

<sup>f</sup> Model 3: adjusted by age, social class, employment status, neighborhood unemployment rate, marital status

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

<sup>h</sup> Sample size n=8,732 due to 139 missing values on life style factors

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11 <sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects

12 Logistic Regression Models

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14 <sup>b</sup> Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

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

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23 <sup>d</sup> Heterogeneity tested via Q-statistic and I<sup>2</sup>-index  
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3 **Declaration of Competing Interests**  
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**Data sharing statement**

No additional data available.

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**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 <sup>a, b, c, d</sup>**

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3 **Gender Differences in the Association of Individual Social Class and Neighborhood**  
4 **Unemployment Rate With Prevalent Type 2 Diabetes Mellitus: A Cross-sectional Study from**  
5 **The DIAB-CORE Consortium**  
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9 **Short title: Gender Differences in the Association of Socio-Economic Factors With Diabetes**  
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51 **Keywords:** Type 2 Diabetes mellitus, Gender, Multilevel Analysis, Residence Characteristics,  
52 Socioeconomic Factors, Population-based  
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3 **Abstract** (word count: 253; max. 300)  
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7 **Objective:** To analyze gender differences in the relationship of individual social class, employment  
8 status and neighborhood unemployment rate with present type 2 diabetes mellitus (T2DM).  
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10 **Design:** Five cross-sectional studies.  
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12 **Setting:** Studies were conducted in five regions of Germany from 1997-2006.  
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14 **Participants:** The sample consisted of 8,871 individuals residing in 226 neighborhoods in five urban  
15 regions.  
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18 **Primary and secondary outcome measures:** Prevalent T2DM.  
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20 **Results:** We found significant multiplicative interactions between gender and the individual variables  
21 social class and employment status. Social class was statistically significant associated with T2DM in  
22 men and women, whereby this association was stronger in women (lower versus higher social class:  
23 odds ratio (OR) 2.68 (95% confidence intervals (CI): 1.66-4.34)) than men (lower versus higher social  
24 class: OR 1.78 (95% CI: 1.22-2.58)). Significant associations of employment status and T2DM were  
25 only found in women (unemployed versus employed: OR 1.73 (95% CI: 1.02-2.92); retired versus  
26 employed: OR 1.77 (95% CI: 1.10-2.84); others versus employed: OR 1.64 (95% CI: 1.01-2.67)).  
27 Neighborhood unemployment rate was associated with T2DM in men (high versus low tertile: OR  
28 1.52 (95% CI: 1.18-1.96)). Between-study and between-neighborhood variation in the T2DM  
29 prevalence was more pronounced in women. The considered covariates helped to explain statistically  
30 the variation in the T2DM prevalence among men, but not among women.  
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43 **Conclusions:** Social class was inversely associated with T2DM in both men and women, whereby the  
44 association was more pronounced in women. Employment status only affected T2DM in women.  
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## 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

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3 which the prevalence of T2DM varies by gender between neighborhoods and regions in Germany. In a  
4 sub-analysis, we performed study-specific calculations of the relationship between T2DM and social  
5 class in men and women.  
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## 8 9 10 **Methods**

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12 Within the DIAB-CORE, cross-sectional data of five regional studies were pooled: the Cardiovascular  
13 Disease, Living and Ageing in Halle Study (CARLA), the Dortmund Health Study (DHS), the Heinz  
14 Nixdorf Recall Study (HNR), the Cooperative Health Research in the Region of Augsburg (KORA)  
15 S4 Study, and the Study of Health in Pomerania (SHIP). Data collection was conducted between 1997  
16 and 2006. The studies have similar study designs (population-based), sampling procedures (two-stage  
17 cluster or stratified random sampling) and response proportions (56%-69%). The studies were  
18 approved by local ethics committees and informed written consent was obtained from the study  
19 participants. Within the five studies, similar instruments, questionnaires and medical measurements  
20 were applied to collect data. Study designs have been described elsewhere in more detail [20-24].  
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23 In brief, data on 11,688 subjects aged 45-74 years were provided. 2,280 individuals living in rural  
24 areas of KORA and SHIP were excluded from the sample, because these subjects could not be  
25 assigned to spatial units below the level of municipalities; so, that our study was limited to urban  
26 areas. Study participants were assigned to neighborhoods via addresses of residence at baseline (8  
27 subjects could not be linked). The neighborhoods were defined by administrative units: statistical  
28 administrative units (subdivision of city districts) in HNR and DHS, city districts in CARLA, planning  
29 regions (summary of city districts) in KORA and postal code areas in SHIP. Participants resided in  
30 227 neighborhoods of the total 236 neighborhoods in the five study regions. After further exclusion of  
31 participants with missing information on individual characteristics (n=529), the final sample consisted  
32 of 8,871 residents in 226 neighborhoods.  
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36 Based on the definition of the DIAB-CORE Consortium [25], a T2DM case was defined as self-  
37 reported physician-diagnosed T2DM or self-reported T2DM treatment (insulin, oral anti-diabetic  
38 agents, dietary treatment). Subjects reporting an age at diagnosis of 30 years or younger were excluded  
39 from the analyses to avoid inclusion of possible cases of type 1 diabetes.  
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3 Social class was measured with a summary score of income and education. Its' operationalization  
4 was derived from the Winkler-Index of Socioeconomic Status [26], which summarizes information on  
5 individual educational and professional attainment, net household income and the occupational  
6 position of the main earner of a household. The three dimensions are transformed to an ordinal scale  
7 ranging from 1 to 7 and summed up to an index with a scale from 3 to 21 points. Since the information  
8 on occupational status was not available for our analysis, the index was solely based on education and  
9 income, ranging between 2 and 14 points. The index was divided into three groups: higher social class,  
10 middle social class and lower social class. Study participants were classified in four employment  
11 status groups: employed, retired and unemployed individuals as well as persons with other forms of  
12 employment, including participants in vocational retraining, housewives and housemen.

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

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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/m<sup>2</sup>; >=30 kg/m<sup>2</sup>)  
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

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3 exercise irrespective of frequency and duration. All variables were constructed following DIAB-  
4 CORE standard procedures for the homogenization of basic variables to ensure a high degree of  
5 comparability.  
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### 10 **Statistical Analysis**

11 Descriptive analysis included the calculation of crude and age-adjusted prevalence of T2DM (derived  
12 from a logistic regression) and corresponding 95% confidence intervals (CI) by gender for individual  
13 variables and neighborhood unemployment rate.  
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18 Our data set had a hierarchical structure including individuals (level 1), nested within neighborhoods  
19 (level 2), which were nested in study regions (level 3). To account for this data structure in our  
20 statistical analysis, multi-level modeling methods were applied. We conducted a series of mixed  
21 effects logistic regression models. First, we tested for interactions between gender and individual  
22 social class, employment status and neighborhood unemployment rate. To do so, we estimated  
23 regression models including terms for gender and social class, employment status or neighborhood  
24 unemployment rate as main effects and an interaction term for the effect of social class, employment  
25 status or neighborhood unemployment rate by gender. Second, gender-stratified analyses were  
26 conducted with a stepwise modeling strategy. The models were adjusted for the confounding variables  
27 age, marital status and the remaining social variables (social class/ employment status/ neighborhood  
28 unemployment rate) depending on the variable of interest. Life style factors, including smoking,  
29 alcohol consumption, BMI and physical activity were evaluated as potential mediators in the  
30 relationship between T2DM and individual social class, employment status or neighborhood  
31 unemployment rate. The results were presented as odds ratios (OR) with corresponding 95% CI.  
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48 Random effects were included to capture between-study and between-neighborhood variance reported  
49 as median odds ratios (MOR). The latter represents a transformation of the area-level variation ( $V_A$ ) on  
50 an OR-scale. The MOR gives the median value of all ORs between a randomly chosen highest- and  
51 lowest-risk-area **and** was calculated on the level of neighborhoods and study regions with the  
52 following equation:  $MOR = \exp(\sqrt{(2 * V_A)} * 0.6745)$ , where 0.6745 is the 75<sup>th</sup> centile of the  
53 cumulative distribution function of the normal distribution with mean zero and variance one [31 32].  
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3 Study-specific analyses were performed and analyzed with meta-analytical tools. Due to the small  
4 number of cases **by study**, the social class variable had to be applied as a continuous measure in this  
5 sub-analysis (ranging between two points, highest social class, and 14 points, lowest social class). For  
6 this purpose, inverse-variance weighting was used to estimate fixed and random effects summary  
7 estimates and displayed in forest plots [33]. Q-statistic and  $I^2$  index were applied to assess  
8 heterogeneity and the extent of heterogeneity between study results respectively [34]. Analyses were  
9 performed in STATA/ SE 11.0.  
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## 19 Results

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21 In total, **8,871** subjects residing in 226 neighborhoods in five urban regions were included in our  
22 analysis. Characteristics of the five studies are displayed in table 1. The crude T2DM prevalence was  
23 statistically significantly lower among women than men, 7.5% (95% CI 6.7-8.3) versus 10.0% (95%  
24 CI **9.1-10.9**) (significance derived from 95% CI). This pattern was observed in all five regional  
25 studies. Socio-demographic characteristics are reported in table 2. **Compared to men, women belonged**  
26 **more often to the lower or middle social class and a higher proportion was not employed**, except in  
27 SHIP. A higher proportion of women than men reported to live without a partner.  
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35 The age-adjusted prevalence of T2DM was statistically significantly lower in **higher** social class  
36 women and men than in the **lower** social class (4.7% (95% CI: 3.9-5.7) respectively 9.7% (95% CI:  
37 **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  
38 3). Women had a statistically significantly lower age-adjusted T2DM prevalence than men over all  
39 social classes. Employed men had a statistically significantly lower age-adjusted T2DM prevalence  
40 with 7.3% (95% CI: 6.2-8.7) than retired men with 10.2% (95% CI: 8.8-11.7). Across neighborhoods,  
41 the highest age-adjusted prevalence of T2DM was found in women and men living in neighborhoods  
42 with a high unemployment rate (8.3% (95% CI: 7.2-9.5), respectively 10.9% (95% CI: 9.6-12.3)).  
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Individuals living without a partner showed statistically significantly higher prevalence than  
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.

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

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12 The results of the gender-stratified multivariable regression analysis are presented in table 4. Among  
13 women and men, we found a statistically significant association of social class and T2DM. The social  
14 gradient in the odds of T2DM was reduced when the models were adjusted for age and the  
15 confounding variables. This reduction was particularly large in women. Overall, the association  
16 between social class and T2DM was stronger in women (lower versus higher social class: OR 2.68  
17 (95% CI: 1.66-4.34)) than men (lower versus higher social class: OR 1.77 (95% CI: 1.22-2.58))  
18 (model 3, table 4). Significant associations of employment status and T2DM were only found in  
19 women: In reference to employed women, retired women, unemployed women and women with other  
20 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  
21 (95% CI: 1.01-2.67) higher odds to have T2DM (model 3, table 4). The significant elevated odds of  
22 T2DM in retired men were dissolved by adjustment for age.

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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

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3 associated with social class, employment status and neighborhood unemployment rate with some  
4 exceptions: In women, physical exercise was not associated with employment status and smoking not  
5 related at all with social variables. Thereupon, the life style variables were introduced into model 4  
6 and the estimates of social class, employment status and neighborhood unemployment rate evaluated  
7 in respect to reductions in the association with T2DM. In men and women, we observed reductions in  
8 the effects of individual social class, employment status and neighborhood unemployment rate when  
9 introducing these life style factors in the analysis. Especially, the association between social class and  
10 T2DM was strongly reduced in women and men. This reduction was mainly driven by BMI in women  
11 (solely adjusted by BMI, higher versus lower social class OR 1.73 (95% CI: 1.05-2.85)) and physical  
12 exercise in men (solely adjusted by physical exercise, higher versus lower social class OR 1.59 (95%  
13 CI: 1.09-2.32)), providing evidence that these life style variables partly mediated the relationship  
14 between social class and type 2 diabetes.

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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);  $I^2=0.0\%$ ;

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3  $p=0.456$ ), although the differences between genders were not significant. This was observed in all  
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5 studies, except CARLA.  
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## 10 11 **Discussion**

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13 This study assessed gender differences in the association of individual social class, employment status  
14 and neighborhood unemployment rate with prevalent T2DM, using data from five regional population-  
15 based studies in Germany. Women and men belonging to the **lower** social class had a higher  
16 prevalence of T2DM. We found that the gradient in the prevalence of T2DM across social classes was  
17 clearly stronger in women than men. This pattern was consistent across all regions but CARLA and  
18 **mainly** in line with results of prior studies presenting only associations in women [7-9], or in men and  
19 women but more pronounced in women [5 6].  
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27 In our study, the individual employment status was only associated with T2DM in women. Being  
28 unemployed, retired or a housewife yielded higher odds of T2DM. However, since we were not able to  
29 consider occupational position in our analyses, the interpretation of these findings is limited. In the  
30 literature, two contrasting theories are discussed for the effects of paid employment on women's  
31 health. Employment can have a health promoting function due to role accumulation in contrast to the  
32 monotony, isolation, low **social** status and self-esteem of housewives. A health damaging effect could  
33 arise due to role strains, e.g. stress due to multiple roles, and heavy job demands [35 36].  
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41 Men residing in neighborhoods with a high level of unemployment rate were more likely to have  
42 T2DM than men in better-off neighborhoods. These effects remained even after adjustment for  
43 confounding and mediator variables, whereas associations between neighborhood unemployment rate  
44 and T2DM in women were dissolved by the introduction of confounding variables. These deviating  
45 effects of neighborhood unemployment rate between men and women may be explained by the fact  
46 that men were more often engaged in employment and, hence, depend more on the regional labor  
47 market and its employment opportunities than women. Potential underlying mechanisms in the  
48 relationship between neighborhood unemployment **rate** and T2DM include neighborhood resources  
49 such as the availability of grocery stores offering healthy food and recreational facilities [15], the  
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3 adoption and maintenance of risky health behavior and psychosocial factors such as chronic stress [13  
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7 Between-study and between-neighborhood variation in the prevalence of T2DM was larger in women  
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9 than men. We found that individual social class, employment status and neighborhood unemployment  
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11 rate played an important role in explaining statistically regional differences in the prevalence of T2DM  
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13 in men. A large fraction of the detected variation in the prevalence of T2DM on the level of  
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15 neighborhoods and regions remained statistically unexplained in women, suggesting that there were  
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17 characteristics on the individual, neighborhood and regional level that determine the presence of  
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19 T2DM and which were not considered in our analysis. Previous work on regional variation in self-  
20  
21 rated health and BMI also found larger regional variation in women [19 38 39].

22  
23 The gender-specific pattern in the association between social class and the prevalence of T2DM need  
24  
25 to be further explored, since the pathways are still unknown [6]. Macintyre et al. noted that socio-  
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27 economic determinants vary in their meaning for men and women, since both genders are socialized in  
28  
29 different ways with diverging social roles and coping strategies against stress; they hold different  
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31 occupational positions in the labor market and have dissimilar access to material and psycho-social  
32  
33 resources [40]. In our study, overall women were less likely to be in the **higher** social class and were  
34  
35 less often employed.

36  
37 To gain more insight in mechanisms of social inequalities on health, the analysis of population  
38  
39 subgroups is essential, since one limitation of the existing literature is the assumption that mechanisms  
40  
41 operate identically in different population groups [19]. This work adds knowledge to the research on  
42  
43 the interaction of gender, social determinants and health. So far, only few studies examined this  
44  
45 interaction with regard to T2DM and to our knowledge no study considered neighborhood  
46  
47 unemployment rate in regard to that, so far. Data sources providing representative population-based  
48  
49 data on the prevalence of T2DM with a linkage to small areas and regions are still rare.

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51 Some limitations of this work should be acknowledged. We analyzed cross-sectional data with limited  
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53 causal conclusions. We could not use occupation as an indicator of social class in our analysis since  
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55 the assessment was not comparable between studies. The prevalence of T2DM was based on a self-  
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57 reported T2DM physician's diagnosis only, which could not be validated. Therefore, undetected type 2  
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3 diabetes could be a source of bias. However, Okura et al. found a high accuracy between self-reports  
4 and medical records for diabetes and other chronic diseases [41]. Recently, Jackson et al. concluded  
5 that self-reported diabetes is a valid outcome for observational studies from an accuracy of 91.8% of  
6 self-reported prevalent diabetes validated by medical records based on the Women's Health Initiative  
7 [42]. Another potential limitation is the selection by response (response proportions: 56%-69%),  
8 which might have affected our results. The exclusion of participants from the initial sample due to  
9 missing information on individual characteristics (mainly due to missing information on net household  
10 income) could have led to an underestimation of the social gradient in T2DM, because these subjects  
11 were on average older, more often female, out of employment and with a lower educational status.  
12 However, a sensitivity analysis showed similar results applying education as measure of social class.  
13 We used administrative definitions for neighborhoods. Hence, neighborhoods in our study may not  
14 capture the immediate neighborhood of residence of our study participants. This could lead to  
15 exposure misclassification and underestimation of neighborhood effects [43]. The applied  
16 administrative definition of neighborhoods differed between studies and neighborhoods were diverse  
17 according to their area and population size. Another challenge in the research of neighborhood impact  
18 on health is the residential selection. Individuals may be selected into neighborhoods due to individual  
19 characteristics, such as residents of poor areas cannot afford moving to better-off neighborhoods [44  
20 45]. Finally, we had no information on the residential history of the study participants, which could  
21 result in an underestimation of neighborhood effects on health [46].  
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43 In conclusion, our study identified different relationships of individual social class, employment status  
44 and neighborhood unemployment rate with the prevalence of T2DM for women and men. In both men  
45 and women, the prevalence of T2DM was inversely related to social class. This social gradient was  
46 stronger in women. Regional variance in the T2DM prevalence was larger in women than men.  
47 Whereas the major proportion of the variance in the T2DM prevalence remained statistically  
48 unexplained in women, the regional variance in men was low and completely explained by the  
49 considered variables.  
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**Table 1: Characteristics of the 5 Population-Based Studies (CARLA, DHS, KORA, HNR, and SHIP, Germany, 1997-2006)<sup>a</sup>**

	<b>CARLA</b>	<b>DHS</b>	<b>KORA</b>	<b>HNR</b>	<b>SHIP</b>
<b>Study period</b>	12/2002-01/2006	09/2003-06/2004	10/1999-04/2001	12/2000-06/2003	10/1997-03/2001
<b>Federal state (Region)</b>	Saxony-Anhalt (east)	North Rhine-Westphalia (west)	Bavaria (south)	North Rhine-Westphalia (west)	Mecklenburg-West Pomerania (northeast)
<b>Sampling</b>	stratified random sampling	stratified random sampling	two-stage cluster sampling	stratified random sampling	two-stage cluster sampling
<b>Cities</b>	Halle (Saale)	Dortmund	Augsburg	Bochum, Essen, Mülheim	Greifswald, Stralsund
<b>Neighborhoods (n)/ Types</b>	43/ city districts	62/ statistical administrative units	17/ planning regions	108/ statistical administrative units	6/ clusters of city districts
<b>Total population (neighborhood range)</b>	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)
<b>Unemployment rate (%; neighborhood range)<sup>b</sup></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)

<sup>a</sup> 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)

<sup>b</sup> 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)<sup>a</sup>**

Study	CARLA		DHS		KORA		HNR		SHIP	
	men	women	men	women	men	women	men	women	men	women
<b>Participants 45-74 with full information</b>	<b>719</b>	<b>638</b>	<b>414</b>	<b>411</b>	<b>533</b>	<b>494</b>	<b>2,257</b>	<b>2,175</b>	<b>615</b>	<b>615</b>
<b>Number of neighborhoods (range of residing participants)</b>	37 (3-139)		60 (1-42)		17 (13-141)		106 (1-140)		6 (95-396)	
<b>Crude diabetes prevalence (%) (95% CI)</b>	12.9 (10.6-15.6)	12.1 (9.6-14.9)	11.8 (8.9-15.3)	7.8 (5.4-10.8)	<b>7.1 (5.1-9.7)</b>	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)
<b>Mean age (SD)</b>	61.0 (8.0)	60.4 ( <b>7.7</b> )	60.9 (8.4)	59.7 (8.5)	58.9 (8.6)	58.8 (8.4)	<b>59.5</b> (7.8)	59.4 ( <b>7.8</b> )	60.3 (8.3)	58.8 (8.3)
<b>Social class % (n)</b>										
lower	7.4 (53)	13.0 (83)	11.1 (46)	23.8 (98)	<b>6.0 (32)</b>	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)	<b>48.4</b> (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)	<b>45.6</b> (243)	29.6 (146)	40.9 (922)	24.4 (531)	20.5 (126)	10.9 (67)
<b>Employment status % (n)</b>										
employed	34.9 (251)	30.6 (195)	38.7 (160)	34.8 (143)	<b>50.3</b> (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)	<b>43.0</b> (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)
<b>Marital status (%)</b>										
living with a partner	89.0 (640)	73.4 (468)	86.7 (359)	71.5 (294)	<b>82.4</b> (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)	<b>17.6</b> (94)	32.8 (162)	9.8 (222)	25.3 (551)	11.7 (72)	31.2 (192)

<sup>a</sup> 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)<sup>a, b</sup>**

	Men						Women					
	No.	Crude Prevalence			Age-adjusted Prevalence		No.	Crude Prevalence			Age-adjusted Prevalence	
		T2D Cases	%	95% CI	%	95% CI		T2D Cases	%	95% CI	%	95% CI
<b>Social class</b>												
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
<b>Employment status</b>												
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
<b>Marital status</b>												
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
<b>Physical exercise</b>												
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
<b>Smoking</b>												
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
current 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
<b>BMI</b>												
< 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
<b>Alcohol consumption</b>												
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
<b>Unemployment rate</b>												
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

<sup>a</sup> 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)

<sup>b</sup> 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 <sup>a, b, c</sup>**

		Social class (Reference: <b>higher</b> social class)		Employment status (Reference: employed)			Unemployment rate (Reference: low unemployment rate)	
		middle	<b>lower</b>	retired	unemployed	others	<b>medium</b>	high
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Model 1<sup>d</sup></b>	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	<b>1.42 (1.14-1.77)</b>	<b>2.31 (1.65-3.24)</b>	<b>2.14 (1.71-2.66)</b>	1.24 (0.82-1.87)	<b>2.38 (0.89-6.33)</b>	<b>1.15 (0.89-1.49)</b>	1.58 (1.24-2.02)
<b>Model 2<sup>e</sup></b>	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)	<b>2.03 (1.44-2.86)</b>	<b>1.25 (0.90-1.73)</b>	<b>1.17 (0.78-1.76)</b>	<b>1.98 (0.74-5.29)</b>	<b>1.12 (0.87-1.45)</b>	<b>1.62 (1.27-2.07)</b>
<b>Model 3<sup>f</sup></b>	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)	<b>1.78 (1.22-2.58)</b>	1.09 (0.77-1.52)	0.94 (0.61-1.44)	<b>2.00 (0.74-5.39)</b>	1.08 (0.83-1.40)	1.52 (1.18-1.96)
<b>Model 4<sup>g, h</sup></b>	Women	<b>1.52 (0.98-2.37)</b>	<b>1.66 (1.01-2.75)</b>	<b>1.66 (1.02-2.69)</b>	<b>1.67 (0.97-2.88)</b>	1.69 (1.02-2.78)	<b>1.20 (0.85-1.69)</b>	<b>1.02 (0.72-1.46)</b>
	Men	1.03 (0.81-1.31)	<b>1.48 (1.00-2.18)</b>	<b>1.01 (0.72-1.42)</b>	0.91 (0.59-1.40)	<b>1.69 (0.62-4.61)</b>	<b>1.06 (0.82-1.38)</b>	<b>1.46 (1.13-1.87)</b>

<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Three-Level Mixed Effects Logistic Regression Models

<sup>b</sup> 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

<sup>c</sup> men: n=4,538, women: n=4,333

<sup>d</sup> Model 1: unadjusted

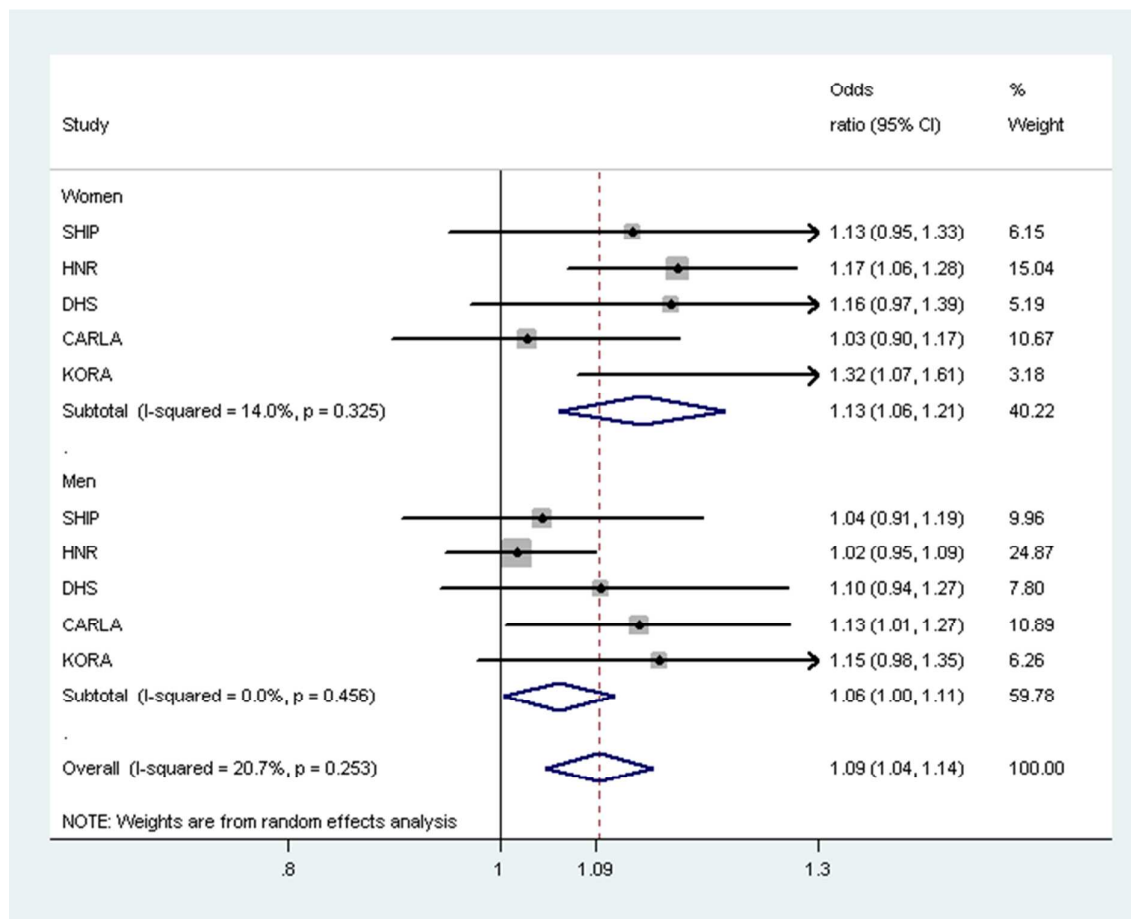
<sup>e</sup> Model 2: adjusted by age

<sup>f</sup> Model 3: adjusted by age, social class, employment status, neighborhood unemployment rate, marital status

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

<sup>h</sup> 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<sup>a, b, c, d</sup>**



<sup>a</sup> Odds Ratios and 95% Confidence Intervals derived from Study-Stratified Two-Level Mixed Effects Logistic Regression Models

<sup>b</sup> Adjusted for Age, Employment Status, Marital Status and Neighborhood Unemployment Rate

<sup>c</sup> 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

<sup>d</sup> Heterogeneity tested via Q-statistic and I<sup>2</sup>-index

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**Declaration of Competing Interests**

Nothing to declare.

For peer review only

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3 **Data sharing statement**  
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**Patient consent**

Obtained.

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**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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For peer review only

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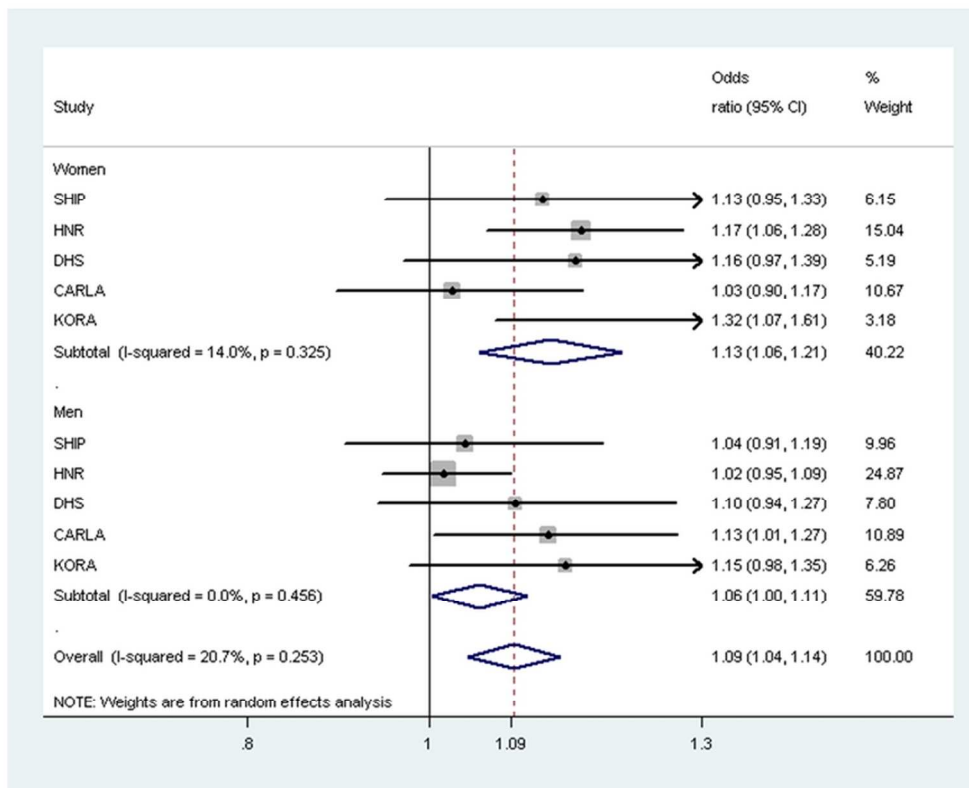
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Figure 1: Meta Analysis of Five Logistic Regressions of Type 2 Diabetes Mellitus for the Social Class Score (Range: 2-14 Points) in Women and Men <sup>a, b, c, d</sup>



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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 <sub>A</sub>	MOR	V <sub>A</sub>	MOR	V <sub>A</sub>	MOR	V <sub>A</sub>	MOR
<b>Model 1</b>	0.16 (0.10)	1.47	0.08 (0.07)	1.31	0.00 (0.00)	1.00	0.04 (0.03)	1.20
<b>Model 2</b>	0.15 (0.10)	1.45	0.07 (0.06)	1.30	0.00 (0.00)	1.00	0.02 (0.02)	1.15
<b>Model 3</b>	0.15 (0.10)	1.45	0.07 (0.06)	1.29	0.00 (0.00)	1.00	0.02 (0.02)	1.13
<b>Model 4</b>	0.14 (0.09)	1.42	0.08 (0.07)	1.32	0.00 (0.00)	1.00	0.00 (0.01)	1.05
<b>Model 5</b>	0.08 (0.09)	1.32	0.07 (0.06)	1.29	0.00 (0.00)	1.00	0.00 (0.00)	1.00

<sup>d</sup> Model 1: unadjusted

<sup>e</sup> Model 2: adjusted by age

<sup>f</sup> Model 3: adjusted by age, social class, employment status, marital status

<sup>f</sup> Model 4: adjusted by age, social class, employment status, marital status, neighborhood unemployment rate

<sup>g</sup> 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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			

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
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://www.strobe-statement.org).