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Type 2 diabetes complications in ethnic minority compared with European host populations: a systematic review and meta-analysis

Joline W J Beulens ,[1,2,3] Felix Reichelt ,[1] Sharon Remmelzwaal,[1,2,3,4] Femke Rutters,[1,2,3] Bianca Strooij,[2,3,4] Peter Harms,[2,3,4] Ralph de Vries,[5] Marieke T Blom ,[2,3,4,6] Karien Stronks,[2,7] Mirthe Muilwijk [1,2,3]

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For numbered affiliations see end of article.

Correspondence to
Dr Mirthe Muilwijk;
m.muilwijk@amsterdamumc.nl

ABSTRACT

This systematic review and meta-analysis aimed to quantify differences in type 2 diabetes (T2D) complications between ethnic minority populations and European host populations, in both cross-sectional and prospective studies. Following Preferred Reporting Items for Systematic Review and Meta-Analyses guidelines, we searched multiple databases for studies (until July 1, 2024) with T2D complications as outcome. Studies were included if they compared ethnic minority populations to the host population and were conducted in Europe. T2D complications included mortality, macrovascular and microvascular complications and mental disorders. Risk of bias was assessed with the assessment tool for observational cohort and cross-sectional studies. Risk estimates were pooled using random effects models. From a total of 2901 references, 58 studies were included, comprising 805 to 1 230 410 individuals for the meta-analyzed complications. Compared with the host population, ethnic minority populations generally had a lower risk of all-cause mortality (RR 0.70 (95% CI 0.63; 0.77); I^2=87%)) and macrovascular complications (RR 0.72 (95% CI 0.58; 0.88); I^2=88%). South Asians, however, showed comparable risks for most macrovascular complications and a slighthly higher risk of major adverse cardiovascular events. Increased risks for microvascular complications, nephropathy and retinopathy were observed (eg, in prospective studies RR 1.50 (95% CI 1.14; 1.96); I^2=86% for nephropathy). No ethnic differences were observed for mental disorders. Ethnic minority populations with T2D in Europe are generally at reduced risk of all-cause mortality and macrovascular complications, but at higher risk of nephropathy and retinopathy. Our findings may help to further identify high-risk populations and to develop guidelines and future interventions. PROSPERO registration number:PROSPERO 2022 CRD42022366854.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Ethnic minority populations within Europe are at a two to six times higher risk of type 2 diabetes (T2D), compared with their host populations.
⇒ The intricate interplay of socioeconomic, genetic, developmental, environmental and lifestyle factors likely contribute to these ethnic differences.

WHAT THIS STUDY ADDS

⇒ Compared with the European host population, ethnic minority populations generally had a lower risk of all-cause mortality and macrovascular complications.
⇒ Increased risks for microvascular complications, nephropathy and retinopathy were observed among ethnic minority populations.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Future studies may investigate how healthcare professionals differentiate in the care provided to various ethnic groups and how this relates to the development of T2D complications.

INTRODUCTION

Type 2 diabetes (T2D) represents a persistent global health challenge, with its global prevalence projected to rise from 8.8% in 2017 to 9.9% by 2045.[1] T2D may lead to both macrovascular and microvascular complications, including cardiovascular disease (CVD), retinopathy and nephropathy.[2] Individuals with T2D are also at increased risk of mental disorders, with the prevalence of depression being two to three times greater compared with those without T2D.[3]

Ethnic minority populations within Europe are at a two to six times higher risk of T2D, compared with their host populations.[4 5] The intricate interplay of socioeconomic, genetic, developmental, environmental and lifestyle factors likely contribute to these ethnic differences.[6 7] Individuals from ethnic minority backgrounds often experience lower socioeconomic status and more frequently reside in deprived neighborhoods, with less options for physical activity, healthy food, social support and healthcare resources.[8] Furthermore, psychosocial factors such as heightened stress

and depression that potentially stem from discrimination and adverse social circumstances, may further exacerbate the risk of T2D in these populations.

Several studies from the USA reported higher risks of T2D complications among ethnic minority compared with host populations.[7] Additionally, reviews reported higher risks of T2D complications and mortality among ethnic minorities compared with host populations, although Lanting *et al* showed that most ethnic differences disappear after adjustment for risk factors including smoking, socioeconomic status and body mass index.[4 9] Moreover, a meta-analysis by Ezzatvar *et al* reported limited ethnic differences in T2D-related complications and all-cause mortality.[10] Notably, that meta-analysis included mostly studies from the USA and New Zealand, with only one European study included. Findings may differ by continents, since both healthcare systems and the composition of the population remarkably differ. Intriguingly, certain European studies have contradicted the expected trend as observed in the USA, demonstrating lower all-cause mortality risks among ethnic minority populations with T2D compared with their European counterparts.[11 12] To comprehensively address this knowledge gap, this systematic review and meta-analysis aimed to quantify ethnic differences in T2D complications between ethnic minorities and European host populations, in both cross-sectional and prospective studies in Europe.

METHODS

This review adheres to the Preferred Reporting Items for Systematic Review and Meta-Analyses (www.prisma-statement.org).[13] The meta-analysis protocol was preregistered with the International Prospective Register of Systematic Reviews (PROSPERO; CRD42022366854) before commencement of the study.

Patient and public involvement

A patient board was involved in the design and dissemination plans of our research.

Search strategy

Systematic searches were conducted in PubMed, Embase.com, CINAHL (Ebsco), APA PsycInfo (Ebsco) and Web of Science (Core Collection) from inception to July 1, 2024, in collaboration with a medical information specialist. The following terms were used (including synonyms and closely related words) as index terms or free-text words: "Type 2 diabetes," "Transients and Migrants," "Ethnicity," "Ethnic differences," "Europe." No terms for complications were added, to reduce the risk of missing types of complications. The search was not restricted by language. Duplicate articles were systematically removed. The references of the identified articles and the meta-analysis by Ezzatvar *et al*[10] were searched for relevant publications (snowballing). The full search strategies are available in online supplemental file 1.

Selection process

Two independent reviewers (FReichelt and MM) screened titles and abstracts for eligibility, with disagreements resolved through consensus with a third reviewer (SR). Studies were included if they met the following criteria: (1) included adult (>18 years) participants with T2D; (2) compared at least one specified ethnic minority group with the host population regarding T2D complications; (3) were conducted in Europe; (4) the full report was written in English. Studies were excluded if (1) results were not presented according to ethnic group; (2) the study focused on specific populations (eg, pregnant women or hospital patients); or (3) publication types other than original studies (eg, case reports, case series) were employed. In cases where multiple publications used the same data source, the article with the most thorough presentation of data was included.

Any T2D-related complication was considered as an outcome. Outcomes analyzed included all-cause mortality (including cause-specific: CVD and cancer mortality), macrovascular (coronary heart disease (CHD), heart failure, myocardial infarction (MI), stroke and peripheral and artery disease (PAD)), microvascular (retinopathy, maculopathy, nephropathy, neuropathy, foot ulcer and amputation) and mental complications (depression, cognitive impairment and increased emotional distress). Additionally, study outcomes were grouped into microvascular outcomes, macrovascular outcomes and major adverse cardiovascular events (MACE), defined as the composite endpoint of MI, stroke and cardiovascular death.[14 15]

Data assessment

Methodological quality was independently evaluated by two reviewers (FReichelt and MM or SR) using the assessment tool for observational cohort and cross-sectional studies developed by Thomas *et al*[16] and adapted by Gao *et al*.[17] Discrepancies were resolved through discussions with a third reviewer (MM or SR). The tool, comprising 19 items across eight domains (study design, blinding, representativeness with regard to selection bias, representativeness with regard to withdrawals/dropouts, confounders, data collection, data analysis and reporting), was used to assign an overall rating to each study based on component ratings. High methodological quality was granted to studies with no "weak" ratings and at least three "strong" ratings; moderate to those with one "weak" rating or fewer than three "strong" ratings; and low to those with two or more "weak" ratings.

Data extraction

The following key characteristics from each included study were extracted:

1. Study characteristics: first author name, publication year, study location, sample size, number of participants per ethnic group, follow-up duration and data source.

2. Participant information: sex, age and number of events.
3. Ethnicity assessment details: self-reported, extracted from primary case records, nationality based or other administrative staff observation.
4. Statistical analysis and study results by ethnicity: consideration of confounders, study outcomes and main results including ORs or HRs with corresponding 95% CIs were extracted from the manuscripts (n=40) or calculated based on reported data (n=12). In cases where presented data were insufficient for the calculation of ORs/HRs with 95% CIs, authors were contacted to obtain additional information (n=1).

Synthesis of results

Ethnic group classifications were predominantly based on geographical origin, aligning with the definition of the International Diabetes Federation (IDF) and Meeks *et al*.[5 18] IDF geographical region categories included South Asian, Sub-Saharan African, Middle Eastern and North African, South and Central American and Western Pacific. In this meta-analysis, *South Asian* included individuals of Pakistani, Indian, Bangladeshi, Sri Lankan or South-Asian Surinamese descent. *Sub-Saharan African* comprised those identified as "African descendant," Sub-Saharan African, African-Caribbean, Afro-Caribbean, African Surinamese, "Negroid" or "Black Caribbean." *Middle Eastern and North African* included individuals of Turkish, Moroccan, North African, Maghrebian, Syrian, Iraqi, Iranian, Lebanese or "Other Middle Eastern" origin. *South and Central American* encompassed those identified as "Latin American." *Western Pacific* included individuals of Chinese and Mongoloid descent. Additionally, a general ethnic minority group was created to encompass categories that did not align with a specific IDF geographical region but were also not considered of European ethnicity.

Studies were meta-analyzed stratified by study design (cross-sectional or prospective) when either two or more cross-sectional or two or more prospective studies investigated the same T2D complication. Retrospective, case–control and prevalence-based studies were grouped together with the cross-sectional studies and all labeled as "cross-sectional," since the majority of these studies were of cross-sectional nature. HRs or OR and relative risks (RRs) were considered as equivalent measures of risk. In a sensitivity analysis, we meta-analyzed these effect measures separately. A random effects model was employed. Estimates that were stratified by severity of complication (eg, for retinopathy) and estimates reported for multiple measures/questionnaires evaluating the same outcome were first pooled using a fixed effects model. Heterogeneity across studies was assessed using the heterogeneity index (I^2). Publication bias was assessed using a funnel plot to visually inspect asymmetry and Egger's test was used to statistically evaluate the presence of bias. Sensitivity analyses were performed by excluding studies with weak quality ratings. To account for temporal trends, we stratified our analyses according to time period (before and since 2015). Analyses were conducted in R V.4.0.3, using the Metafor and Meta packages. Study outcomes with only one study available were qualitatively described.

RESULTS

Description of included studies

The literature search yielded a total of 4932 references (figure 1). After removing duplicates, 2,901 references remained. Title and abstract screening led to 163 potentially eligible articles. Full-text screening led to a final selection of 58 articles (online supplemental file 2), of which 49 could be included in the quantitative synthesis. The other nine articles describe outcomes that are not reported in any of the other articles and are described qualitatively. Main reasons for exclusion were: no ethnic subgroups included (n=33), no T2D complications as outcome (n=27), not in Europe (n=16) or review (n=10). Snowballing did not yield additional articles.

Study characteristics

The majority of included studies were cross-sectional (n=35 including retrospective (n=7), case–control (n=2) or prevalence-based (n=1) designs) or prospective designs (n=22; online supplemental file 3), one study included both a retrospective and a prospective cohort. Studies were predominantly conducted in the UK (n=41), the Netherlands (n=8) and Sweden (n=5). The included studies comprised a total of 805–1 230 410 individuals for foot problems in cross-sectional studies and all-cause mortality in prospective studies, respectively. Studies mainly included people of South Asian and Sub-Saharan African ethnicity. Phenotypic characteristics of the included participants in the studies are shown in online supplemental file 4.

Risk of bias

Six studies were categorized as weak, mainly due to weak scores on the confounding and data collection domains, 28 studies as moderate and 24 as strong (table 1).

Synthesis of findings

Mortality

All-cause mortality risk was consistently lower among ethnic minority compared with European host populations (RR=0.70 (95% CI=0.63; 0.77); I^2=87%; n=10 studies; figure 2a). This is consistent with a study by Chudasama *et al*, which reported higher mortality rates among European than ethnic minority populations after a first non-fatal CVD event. However, nuances emerged in cause-specific mortality. CVD mortality was generally lower among ethnic minority compared with European host populations (RR=0.65 (95% CI=0.52; 0.81); I^2=85%; n=7, (online supplemental file 5), with the exception of South Asian populations (RR=0.96 (95% CI=0.68; 1.34); I^2=86%). Ethnic minority populations, particularly South

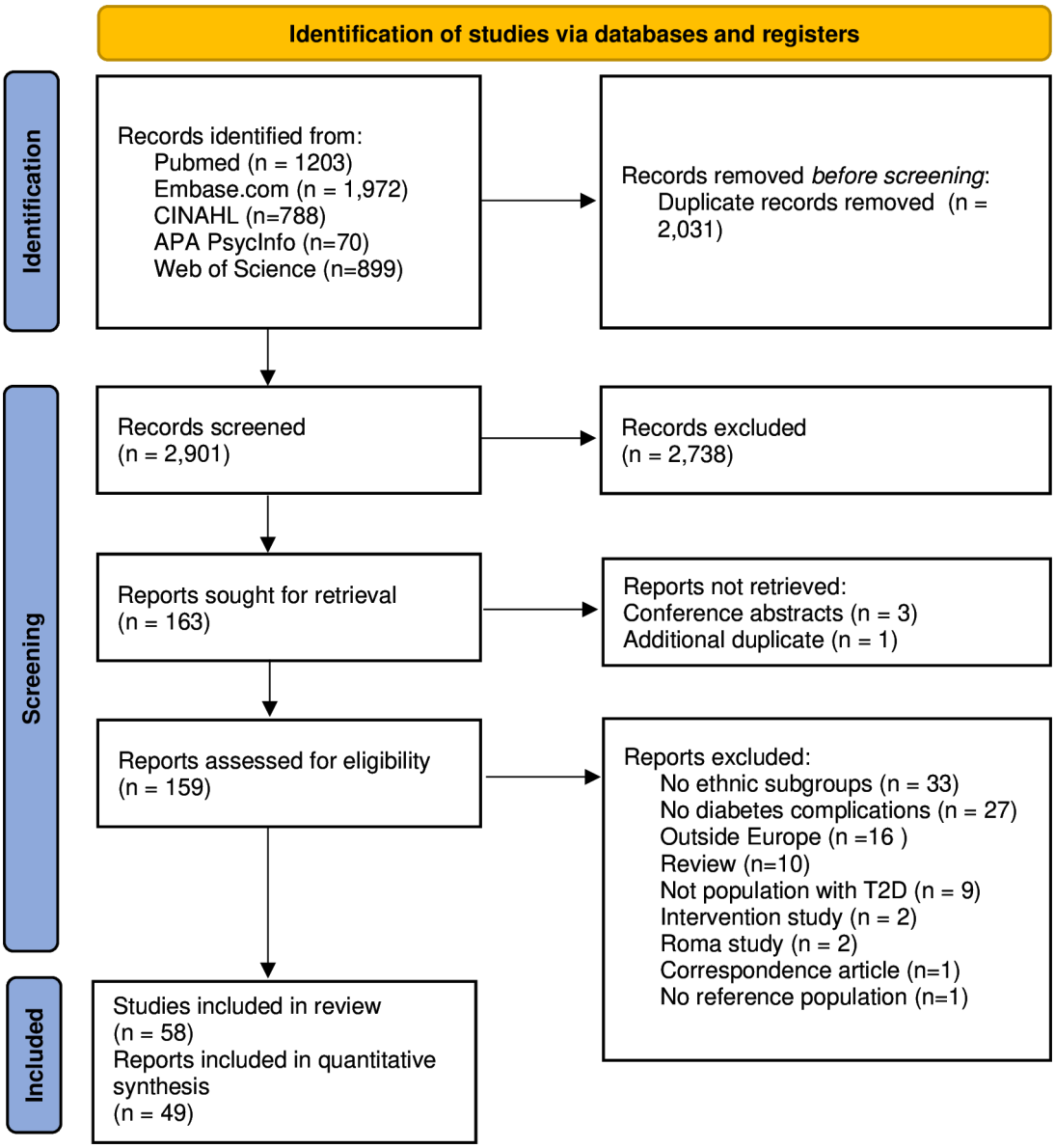

Figure 1 Preferred Reporting Items for Systematic Review and Meta-Analyses flow diagram of study selection.

Asians, had a lower risk of cancer mortality (RR=0.67 (95% CI=0.54; 0.82); I^2=80%; online supplemental file 6). Finally, one study, Wright *et al*,[19] reported lower risks of mortality from respiratory and digestive diseases among South Asians and Sub-Saharan Africans, compared with Europeans. A study by Wilmot *et al* reported on ethnic differences in mortality and/or admission to the intensive care unit among people with T2D and a COVID-19 infection. They reported increased risks for people of Asian and black ethnicity in the UK, but decreased risks for people of Afro-Carribbean, Middle Eastern and North African or Asian ethnicity in France.

Macrovascular complications

We observed an overall lower risk of macrovascular complications among ethnic minority, compared with European host populations in prospective studies (RR=0.72 (95% CI=0.58; 0.88); I^2=89%; n=10; figure 2b). The subgroup analyses consistently support this lower risk across ethnic minority populations, with the exception of South Asians (RR=1.09 (95% CI=0.86; 1.38); I^2=88%). Cross-sectional studies confirm these findings for Sub-Saharan African, compared with European host populations (RR=0.66 (95% CI=0.46; 0.95); I^2=69%), but not for other populations (overall RR=0.94 (95% CI=0.79; 1.13); I^2=86%) (online supplemental file 7). One study evaluated second CVD events,[11] reporting lower risks among ethnic minority compared with European host populations.

Major adverse cardiovascular events

In prospective studies, the risk of MACE paralleled that of macrovascular complications, since included studies largely overlapped (RR=0.65 (95% CI=0.48; 0.88); I^2=89%; online supplemental file 8). However, South Asian populations were at somewhat higher risk of MACE compared with European host populations 1.18 (95%

Table 1 Quality assessment

Author	Year	SD	BL	RSB	RWD	CF	DC	DA	RP	Overall
Prospective studies										
Abbott, CA	2005	M	NA	S	NA	S	M	S	S	Strong
Adler, AI	1998	M	NA	S	W	S	M	S	S	Moderate
Bellary, S	2010	M	NA	W	W	S	M	S	S	Weak
Benhalima, K[a]	2011	M	NA	S	W	W	M	W	S	Weak
Bennet, L[a]	2021	M	NA	M	S	S	M	S	S	Strong
Bennet, L[b]	2021	M	NA	S	NA	S	M	S	S	Strong
Chandie Shaw, PK	2006	M	NA	W	M	M	W	M	S	Weak
Chaturvedi, N	1996	M	NA	M	W	S	M	S	S	Moderate
Davis, T	2014	M	NA	S	M	S	M	S	S	Strong
Gurudas, S	2021	M	NA	S	NA	S	M	S	S	Strong
Hopkins, R	2024	M	NA	S	NA	S	S	S	S	Strong
Iyen, B	2022	M	NA	S	NA	S	M	S	S	Strong
Malawana, M	2018	M	NA	S	W	M	M	S	S	Moderate
Mathur, R	2017	M	NA	S	NA	S	M	S	S	Strong
Mathur, R	2018	M	NA	S	NA	S	M	S	S	Strong
Muilwijk, M	2019	M	NA	M	NA	S	M	S	S	Strong
Nieuwenhuijse, EA	2023	M	NA	M	NA	M	M	M	S	Moderate
Nugawela, M	2021	M	NA	S	NA	S	M	S	S	Strong
Rawshani, A	2016	M	NA	S	NA	S	M	S	S	Strong
Remsing, S	2022	M	NA	S	NA	S	M	S	S	Strong
Tillin, T	2006	M	NA	M	NA	S	W	S	S	Moderate
Wright, A	2017	M	NA	M	NA	M	S	S	S	Moderate
Cross-sectional studies										
Abbott, CA	2010	M	NA	S	NA	S	M	S	S	Strong
Abbott, CA	2011	M	NA	S	NA	M	M	S	S	Strong
Abubakari, AR	2013	M	NA	M	NA	M	S	M	S	Moderate
Ali, S	2009	M	NA	S	NA	S	S	S	S	Strong
Amin, A	2017	M	NA	W	NA	S	M	S	S	Moderate
Armengol, G	2021	M	NA	S	NA	S	M	S	S	Strong
Aujla, N	2009	M	NA	W	NA	S	S	S	S	Moderate
Aujla, N	2010	M	NA	W	NA	S	S	S	S	Moderate
Benhalima, K[b]	2011	M	NA	S	NA	S	W	M	S	Moderate
Bennet, L	2013	M	NA	M	NA	M	M	S	S	Moderate
Carey, IM	2023	M	NA	S	NA	M	M	M	S	Moderate
Chandie Shaw, PK	2002	M	NA	S	NA	S	W	M	S	Moderate
Chowdhury, T	2006	M	NA	S	NA	W	W	W	S	Weak
Chudasama, YV	2023	M	NA	S	NA	M	M	S	S	Strong
Coles, B	2021	M	NA	S	S	S	M	S	S	Strong
Dijkstra, S	2002	M	NA	M	NA	M	W	M	S	Moderate
Dixon, A	2006	M	NA	M	NA	S	W	S	S	Moderate
Dreyer, G	2009	M	NA	M	NA	M	M	S	S	Strong
Hermans, M	2020	M	NA	M	NA	W	W	W	W	Weak
Holman, N	2012	M	NA	S	NA	M	M	M	S	Moderate
Kristensen, JK	2007	M	NA	S	NA	W	M	S	S	Moderate

Continued

Table 1 Continued

Author	Year	SD	BL	RSB	RWD	CF	DC	DA	RP	Overall
Malik, M	2015	M	NA	S	S	S	S	S	S	Strong
Mathur, R	2020	M	NA	S	NA	M	M	S	S	Strong
Mehta, R	2011	M	NA	S	NA	S	M	S	S	Strong
Moulton, Calum D	2016	M	NA	M	NA	M	M	M	S	Moderate
Owusu Adjah, E	2018	M	NA	M	NA	M	M	M	S	Moderate
Pouwer, F	2010	M	NA	W	NA	M	M	M	S	Moderate
Pouwer, F	2013	M	NA	M	NA	M	M	S	M	Moderate
Raymond, N	2009	M	NA	M	NA	S	M	S	S	Moderate
Riffi, A	2012	M	NA	M	NA	W	W	M	S	Weak
Sivaprasad, S	2012	M	NA	S	NA	M	M	S	S	Strong
Tahrani, A	2017	M	NA	M	NA	S	M	M	S	Moderate
Taloyan, M	2012	M	NA	M	NA	M	M	S	S	Moderate
Tran, A	2011	M	NA	M	NA	S	M	M	S	Moderate
Weijers, R	1997	M	NA	M	NA	M	M	M	S	Moderate
Wilmot, EG*	2023	M	NA	M	NA	M	M	M	S	Moderate

Methodological quality rating per study of the studies included. For this method, an adapted review protocol by Thomas *et al*[16] was used.
*This work was funded by the Amsterdam Public Health, Amsterdam, The Netherlands, Strategic Research Call 2021, Postdoc Fellowship.
CF, confounding; DA, data analysis; DC, data collection; M, moderate; NA, not applicable; RP, reporting; RSB, representativeness—selection bias; RWD, representativeness—withdrawal; S, strong; SD, study design; W, weak.

CI=1.00; 1.39); I^2=28%; online supplemental file 8). Cross-sectional studies only showed a lower RR of MACE among Sub-Saharan African compared with European host populations (RR=0.57 (95% CI=0.49; 0.67); I^2=0%; online supplemental file 9). However, after excluding a weak study in sensitivity analyses, South Asian populations showed also a lower RR for MACE (RR=0.98 (95% CI=0.67; 1.42); I^2=90% and RR=0.72 (95% CI=0.65; 0.79); I^2=0%, respectively).

Myocardial infarction

Two prospective studies assessed MI, both included South Asian and Sub-Saharan African individuals.

South Asians did not show a risk difference (RR=1.11 (95% CI=0.97; 1.27); I^2=0%), while Sub-Saharan Africans had a statistically significant lower risk (RR=0.53 (95% CI=0.42; 0.66); I^2=0%; online supplemental file 10). The cross-sectional studies support the findings from the prospective studies, but the two identified studies both included different ethnic groups. No ethnic differences between Middle Eastern and North African populations and European host populations were identified by Kristensen *et al*, while both South Asians and Sub-Saharan Africans had a lower RR of MI than European host populations according to Owusu *et al* (online supplemental file 11).

Stroke

In prospective studies (n=2), no statistically significant differences in stroke risk emerged (RR=1.08 (95% CI=0.91 to 1.28); I^2=64%; online supplemental file 12). Conversely, the six cross-sectional studies showed a lower RR among ethnic minorities compared with European host populations (RR=0.69 (95% CI=0.57 to 0.83); I^2=22%; online supplemental file 13).

Heart failure

Two cross-sectional studies compared South Asian and Sub-Saharan African with European host populations (online supplemental file 14). RRs were lower among ethnic minority populations (RR=0.81 and 0.31 (95% CIs=0.71; 0.93 and 0.24; 0.41); I^2=0%; for South Asians and Sub-Saharan Africans, respectively).

Coronary heart disease

The cross-sectional studies (n=7) showed a higher RR of CHD among South Asian, compared with European host populations (RR=1.84 (95% CI=1.14; 2.97); I^2=87%), but no differences were observed for any of the other ethnic groups (overall RR=1.22 (95% CI=0.71; 2.12); I^2=83%; online supplemental file 15).

Peripheral and artery disease

Across four cross-sectional studies, no statistically significant differences between ethnic minority and European host populations were found for PAD (RR=0.85 (95% CI=0.54; 1.33); I^2=60%; online supplemental file 16). One prospective study, Davis *et al*,[12] was identified, which reported lower risks for both African Caribbeans and Asian Indians compared with European host populations.

Microvascular complications

In prospective studies, no overall differences in risk of microvascular complications emerged (RR=1.14 (95%

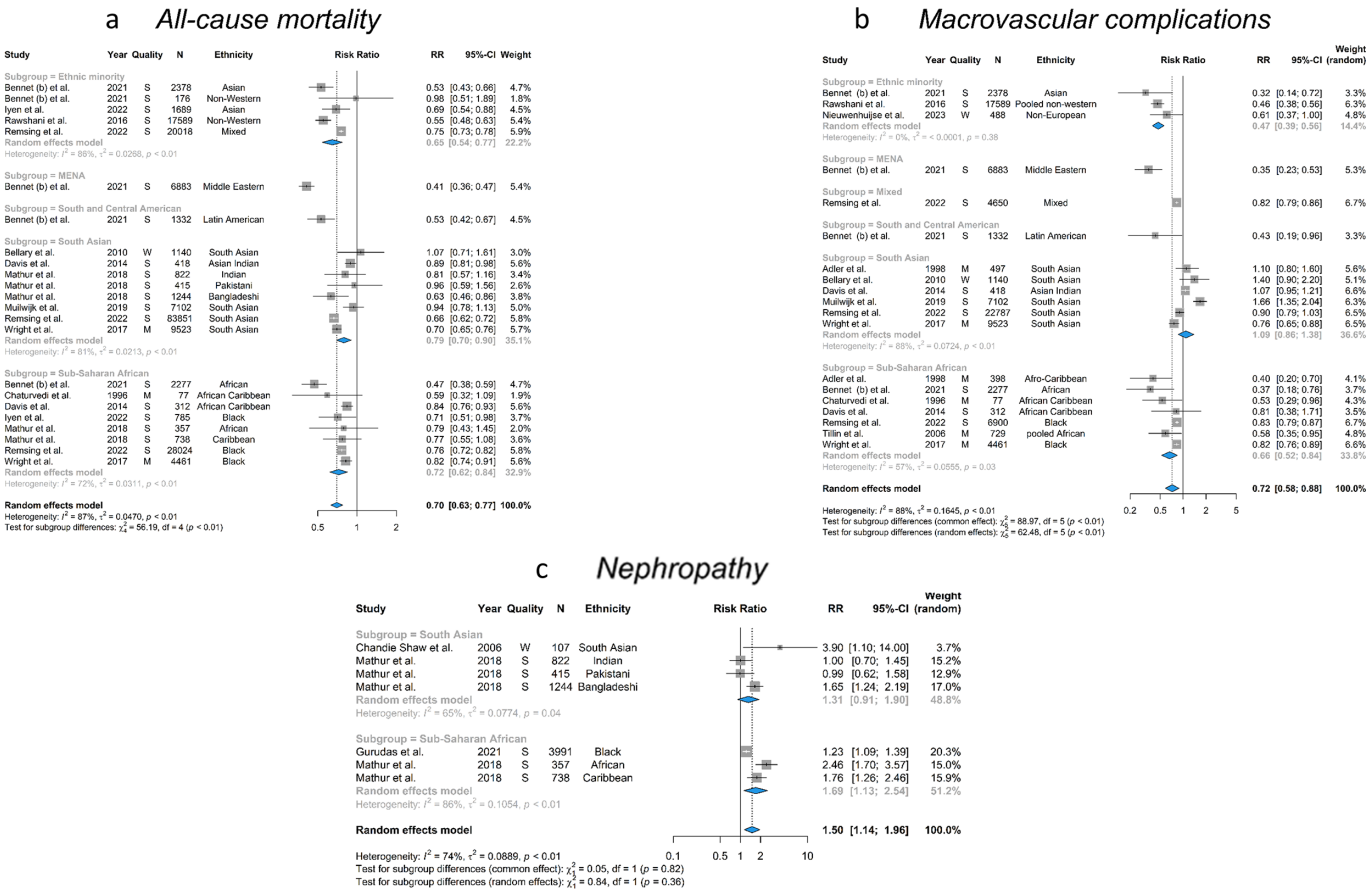

Figure 2 Forest plots of the estimated risk ratios among ethnic minority vs host populations, for (a) all-cause mortality, (b) macrovascular complications and (c) nephropathy, in prospective studies. Studies were meta-analyzed all together and by geographical region (subgroups). "Ethnicity" specifies the included participants in the study, terms are used according to the original terminology in the articles and might be outdated. M, medium; N, number of participants; RR, risk ratio; S, strong; W, weak.

CI=0.98; 1.33); I^2=81%, n=8; online supplemental file 17). However, increased risks were observed for nephropathy and retinopathy (figure 2c and online supplemental file 18). Cross-sectional studies showed a higher RR among ethnic minority, compared with European host populations (overall RR=1.21 (95% CI=1.02; 1.45); I^2=94%; n=18; online supplemental file 19), primarily driven by elevated RRs among South Asians (RR 1.53 (95% CI=0.97; 2.39); I^2=92%).

Nephropathy

In three prospective studies, RR for nephropathy among South Asian and Sub-Saharan African compared with European host populations were 1.31 and 1.69 (95% CI=0.91; 1.90 and 1.13; 2.54), I^2=65 and 86% for South Asian and Sub-Saharan African populations, respectively (figure 2c). These findings were partially inconsistent with 10 cross-sectional studies showing a higher RR only among South Asians (RR=2.46 (95% CI=1.19; 5.12); I^2=74%), but no statistically significant differences for other ethnic groups (online supplemental file 20).

Retinopathy

Two prospective studies including South Asian, Sub-Saharan African and other ethnic minority populations showed a slightly higher overall risk (RR=1.05 (95% CI=1.00; 1.09); I^2=74%; online supplemental file 18). Cross-sectional studies (n=8) found consistently higher RRs for ethnic minority populations (overall RR=1.24 (95% CI=1.06; 1.44); I^2=97%; online supplemental file 21). Findings were comparable for severe retinopathy (online supplemental files 22 and 23).

Maculopathy

In two cross-sectional studies, higher RRs of maculopathy were observed among South Asian compared with European host populations (RR=1.94 (95% CI=1.68; 2.23); I^2=0%; online supplemental file 24). Sivaprasad *et al* also included other ethnic groups and reported a higher prevalence of maculopathy among African Caribbeans, but lower prevalence of maculopathy among other ethnic minority populations.

Neuropathy

No statistically significant differences between ethnic minority populations and European host populations

were observed for neuropathy (overall RR=0.97 (95% CI=0.77; 1.23), I^2=89%; n=7 cross-sectional studies; online supplemental file 25).

Foot problems and amputations

Two cross-sectional studies, both of weak quality, found no statistically significant differences between ethnic minorities and European host populations for T2D-related foot problems (online supplemental file 26). A few other studies were identified on foot problems but could not be pooled: In Abbott *et al*'s[20] prospective study on foot ulcers, both Indians and African Caribbeans had lower risks compared with European host populations. Kristensen *et al* reported no statistical differences in amputation prevalence among Turkish compared with European host populations. Holman *et al*, however, reported a negative correlation of lower limb amputations in the population from Asian and black ethnicity.

Infections

Carey *et al*, reported no ethnic differences in risk of infections among people with T2D compared with those without T2D. The study included participants of European South Asian, black and mixed/other ethnicity. A study by Hopkins *et al* reported higher risks of COVID-19 hospitalization, but lower risks of pneumonia hospitalization among people of black and South Asian ethnicity.

Mental complications

For depression, no statistically significant differences were found among ethnic minority compared with European host populations in four cross-sectional studies (RR=0.85 (95% CI=0.53; 1.36); I^2=83%; online supplemental file 27). Other mental complications were evaluated in, at most, one study per ethnic group. Moulton *et al* and Pouwer *et al* reported slightly higher RRs for cognitive impairment and increased emotional distress among ethnic minority populations, although the results were not statistically significant due to small sample sizes. Taloyan *et al* evaluated loss of sexual desire and reported an increased prevalence among Assyrians/Syrians compared with European host populations.

Sleep

Amin *et al* considered sleep apnea in South Asian compared with European host populations, with higher prevalences of sleep apnea among Europeans, potentially explained by higher adiposity levels.

Hypoglycemia

Malawana *et al* reported an increased risk of hypoglycemia among black Caribbean populations prescribed insulins, while people of Bangladeshi ethnicity prescribed insulins had a lower risk of hypoglycemia compared with the European host population. In those prescribed sulfonylurea, higher risks of hypoglycemia were observed for people of black Caribbean, black African and Indian ethnicity compared with the European host population.

Publication bias

No evidence for publication bias was observed, as funnel plots did not reveal significant asymmetry, and Egger's test confirmed the absence of publication bias (p value>0.05; online supplemental files 28–38).

Temporal trends

Sensitivity analyses with stratification of studies before and after 2015 did not reveal any temporal trends.

DISCUSSION

This systematic review and meta-analysis quantified the differences in risk of T2D complications in ethnic minority populations residing in Europe, compared with their host populations. The results revealed diverse patterns of risk for T2D complications across ethnic groups. Noteworthy is the consistent lower risk of all-cause mortality among ethnic minority compared with European host populations, primarily driven by reduced CVD and cancer mortality. We found a general trend of lower risks for macrovascular complications, but not for South Asian populations. Our study also suggests higher risks of both nephropathy and retinopathy among specific ethnic subgroups compared with European host populations. No differences between ethnic minority and European host populations were observed for mental disorders.

Our study showed that the risk of all-cause mortality is nearly one-and-a-half times lower among ethnic minority compared with European host populations. This contrasts with the meta-analysis by Ezzatvar *et al*, which identified a two-fold higher all-cause mortality risk for Māori, compared with White host populations, and no differences in all-cause mortality risks for any other ethnic groups.[10] It is important to note that the study by Ezzatvar *et al*[10] included only one study from Europe, while all other included studies were conducted in North America and New Zealand. Moreover, only one of the ethnic minority populations overlapped with those in our study (Sub-Saharan African/black). Contextual factors vary considerably between continents, contributing to the observed differences in direction of the association. In particular, there are larger inequalities in care in the USA than in Europe.[21] Most studies included in our meta-analysis were conducted in the UK or the Netherlands, where access to basic healthcare services is common. Examining cause-specific mortality further delineates that the lower risk of all-cause mortality among ethnic minorities compared with European host populations may be driven by the lower risks of cancer and CVD.[19 22–24]

Risk of macrovascular complications was lower among most ethnic minority populations compared with host populations. South Asians, however, showed comparable risks for most macrovascular complications and slightly higher risk of MACE. Moreover, cross-sectional studies suggested an almost twofold higher risk of CHD among South Asians compared with host populations, aligning

with the high risk for both T2D and CVD described in the literature.[5 25] This may partly be explained by the high susceptibility to central obesity among South Asians.[26] Explanations for the lower risk of all-cause mortality and macrovascular disease among ethnic minorities compared with European host populations may be multifactorial, involving genetics, biological responses to medication and behavioral attitudes. First, Wright *et al* suggested that the prevalence of risk factors such as smoking, hypertension and obesity may be lower, while the exposure to glucose-lowering medication may be higher among ethnic minority compared with European host populations.[19] This aligns with observations of Mathur *et al*, who reported better or equivalent cardiometabolic profiles among ethnic minority compared with European host populations at the time of diagnosis, along with a shorter time until initiation of antidiabetic treatment.[27] Second, it is plausible that physicians, aware of the increased T2D risk in ethnic minority populations, initiate treatment early in the course of T2D among ethnic minority but not among host populations. Our study did not assess whether ethnic groups received similar quality of care. Lower risks may for instance stem from heightened awareness among both ethnic minority populations and their physicians regarding the elevated T2D risk prevalent from a young age within these communities.[5] Some studies suggest temporal changes in ethnic differences in T2D risk, since a study in 1996 reported two to four times higher all-cause mortality risks among ethnic minority populations compared with individuals born in the UK.[28] We did not find indications of such a trend, and excluded this study because of an inappropriate study design, as it used death certificates to establish T2D diagnosis. Importantly, variations in risk of macrovascular complications were evident across subgroups and type of complications. Sub-Saharan Africans consistently had reduced risks, supporting the notion of a lower cardiovascular burden among this group, due to better cardiometabolic profiles.[27 29]

Our analysis revealed no overall differences in microvascular complications across ethnic groups. However, closer examination showed elevated risks for retinopathy and nephropathy among ethnic minority compared with European host populations, ranging from slightly higher to one-and-a-half times higher risks. These studies mainly included people of South Asian and Sub-Saharan African ethnicity. Future studies should examine whether these observations are consistent in other ethnic minority populations. Limited evidence for neuropathy was found, necessitating more high-quality studies. Yet, some studies suggest higher risks of painful diabetic neuropathy among South Asians.[20] Higher risks for nephropathy may be attributed to a higher prevalence of comorbidities, including hypertension (mainly among Sub-Saharan African populations), metabolic syndrome and chronic hepatitis B infections, as people with these comorbidities may have a more rapid decline of kidney function than people with T2D alone.[30–33] The increased risk of nephropathy and retinopathy may also be influenced by factors such as the stage of T2D progression at diagnosis and healthcare system disparities. Discrepancies in monitoring and prescriptions were reported for Sub-Saharan African and Asian compared with European individuals, although studies show conflicting results.[27 34] Despite these conflicting reports, ethnic minority populations in Europe generally exhibit lower glycemic control,[35 36] which may explain an increased risk of microvascular complications.[37] Our analysis did not find statistically significant differences in the prevalence of depression among ethnic minority, compared with European host populations. Importantly, methodological variations in assessing depression may affect study outcomes. Although not statistically significant, a lower prevalence of depression among South Asians compared with the European host population was observed with the WHO-5 model, but opposite findings were reported with the Center for Epidemiologic Studies Depression scale (CES-D), due to low agreement between both scales.[38]

This study has several limitations. First, the observed high heterogeneity may stem from variations in study designs, methodologies and unmeasured confounding factors. Despite attempts to account for heterogeneity through sensitivity analyses, residual heterogeneity may still exist due to unmeasured confounding factors or differences in populations characteristics. Nonetheless, the directionality of the key findings was consistent across the subgroups, and the high heterogeneity is thus unlikely to affect our conclusions. Second, ethnic minority populations were categorized based on geographical origin, following the IDF classifications. While this approach provides a broad overview, it may oversimplify the complex diversity within ethnic minority populations. Subgroups within these broad categories may have distinct risk profiles and healthcare needs that were not captured in the analysis. Yet, data of all individual studies is made visible, with the original categories as described in the original paper displayed, which provides the opportunity to further assess the granularity within IDF regions. Third, although subgroup analyses by sex were planned, the scarcity of studies reporting findings stratified by sex withheld us from these analyses. Finally, the variation in countries where the studies were conducted, predominantly in the UK, was limited which impedes a comprehensive assessment of potential differences by host country. Additionally, most studies focused on South Asian and/or Sub-Saharan African populations, which limits our ability to draw firm conclusions regarding other ethnic groups that were less frequently studied.

In summary, ethnic minority populations in Europe are generally at reduced risk of all-cause mortality and macrovascular complications, but might be at higher risk of microvascular complications. However, heterogeneity is evident, both in the type of complication and across ethnicities. Where most ethnic minority populations are at reduced risk of macrovascular complications and MACE,

South Asians have comparable risks of most macrovascular complications and a slightly higher risk of MACE. The lower risks of adverse health outcomes among ethnic minority populations do not negate the importance of healthcare professionals remaining vigilant to potential differences in risk of T2D complications and healthcare disparities. Future studies may for instance investigate how healthcare professionals differentiate in the care provided to various ethnic groups and how this relates to the development of T2D complications.

Author affiliations
[1]Epidemiology and Data Science, de Boelelaan 1117, Amsterdam UMC, Amsterdam, The Netherlands
[2]Health Behaviours & Chronic Diseases, Amsterdam Public Health, Amsterdam, The Netherlands
[3]Diabetes & Metabolism, Amsterdam Cardiovascular Sciences, Amsterdam, The Netherlands
[4]Department of General Practice, de Boelelaan 1117, Amsterdam UMC, Amsterdam, The Netherlands
[5]Medical Library, Vrije Universiteit, Amsterdam, The Netherlands
[6]Personalized Medicine, Amsterdam Public Health, Amsterdam, The Netherlands
[7]Public and Occupational Health, Meibergdreef 9, Amsterdam UMC, Amsterdam, The Netherlands

Contributors JWJB, FRutters and MM contributed to the conceptualization and supervision. FReichelt, SR, RdV and MM contributed to the methodology and data collection. FReichelt, RdV and MM contributed to the formal analysis and visualization. JWJB, FReichelt and MM contributed to writing the original draft. JWJB, FR, SR, FRutters, BS, PH MTB, KS and MM contributed to discussions. All authors contributed to writing—review and editing. MM obtained funding for the work. MM is the guarantor of this work and takes responsibility for the accuracy of the data analysis.

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ORCID iDs
Joline W J Beulens http://orcid.org/0000-0002-6788-5232
Felix Reichelt http://orcid.org/0009-0003-0329-3806
Marieke T Blom http://orcid.org/0000-0002-8088-1105
Mirthe Muilwijk http://orcid.org/0000-0002-3686-5116

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