Global Inequity in Diabetes 1

The role of structural racism and geographical inequity in diabetes outcomes

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Diabetes is pervasive, exponentially growing in prevalence, and outpacing most diseases globally. In this Series paper, we use new theoretical frameworks and a narrative review of existing literature to show how structural inequity (structural racism and geographical inequity) has accelerated rates of diabetes disease, morbidity, and mortality globally. We discuss how structural inequity leads to large, fixed differences in key, upstream social determinants of health, which influence downstream social determinants of health and resultant diabetes outcomes in a cascade of widening inequity. We review categories of social determinants of health with known effects on diabetes outcomes, including public awareness and policy, economic development, access to high-quality care, innovations in diabetes management, and sociocultural norms. We also provide regional perspectives, grounded in our theoretical framework, to highlight prominent, real-world challenges.

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Introduction

Globally, the number of people with diabetes is projected to surpass 1 billion people by 2050.[1] In 2021, the global burden of diabetes was estimated to be 529 million people (95% uncertainty intervals [UI] 500–564), yielding a global age-standardised prevalence of 6·1% (95% UI 5·8–6·5).[1] In 2050, estimates are expected to more than double to 1·31 billion people (1·22–1·39), yielding a global age-standardised prevalence of 9·8% (9·4–10·2), or approximately one in ten people.[1] In 2021, 96·0% (95% UI 95·1–96·8%) of the total global diabetes cases were estimated to be due to type 2 diabetes (approximately 508 million people), with type 1 diabetes accounting for the remaining cases (approximately 21 million people).[1] Gestational diabetes and hyperglycaemia during pregnancy add to the global burden, with more than 20 million women affected worldwide, 7 million of whom were living in southeast Asia in 2021.[2] Rates of type 1 and type 2 diabetes in young people (up to age 25 years) are also rising globally, leading to an exponential generational increase in diabetes.[1,3–5]

Extensive evidence shows that diabetes is associated with high morbidity and mortality, and is one of the major causes of blindness, kidney failure, heart attacks, strokes, lower limb amputations, and premature mortality worldwide.[6–10] Globally, in 2021, there were 37·8 million (95% UI 35·4–40·2) total diabetes-related years of life lost due to premature mortality and 41·4 million (29·5–55·4) years lived with disability, for a total of 79·2 million (67·8–92·5) disability-adjusted life-years, mostly driven by type 2 diabetes in adults.[1] In paediatric populations, acute events such as diabetic ketoacidosis and severe hypoglycaemia remain major causes of death in many parts of the world; in 2021, average life expectancy after a diagnosis of type 1 diabetes ranged from 13 years for a 10-year old child in a low-income country to 65 years for a 10-year old child in a high-income country (HIC).[11]

Importantly, global diabetes burden is further exacerbated by large-scale inequities in diabetes prevalence, morbidity, and mortality.[12–15] Prevalence of type 1 and type 2 diabetes in both adult and paediatric populations is increasing disproportionately among minoritised groups, and in low-income and middle-income countries (LMICs) versus HICs.[2,5,10,11,16–21] By 2045, three of four adults with diabetes will be from a LMIC,[16,18] with anticipated large global effects on premature morbidity and mortality given that less than 10% of people with diabetes in LMICs currently receive guideline-based comprehensive diabetes care.[22] According to the Global Burden of Disease (GBD) Study 2021,[1] the highest age-standardised total diabetes prevalence by super region in 2021 was 9·3% (95% UI 8·7–9·9) in north Africa and the Middle East and 12·3% (11·5–13·0) in Oceania. Within HICs, such as the USA, adult and paediatric prevalence of diabetes in minoritised groups (eg, non-Hispanic American Indians and Alaska Natives, non-Hispanic Black Americans, Hispanic Americans, and Asian Americans) is nearly 1·5 times higher than in non-Hispanic White groups.[3,21,23] In the Northern Territory of Australia, diabetes prevalence increased from 14·4% (95% CI 13·9–14·9) in 2013 to 17·0% (16·5–17·5) in 2019 among Aboriginal populations, with diabetes prevalence in adults increasing to 39·5% (37·9–41·1) in the Central Australian region.[24] The disproportionate effects of diabetes equate to lower quality of life. As of 2021, 52·2% (95% UI 25·5–71·8) of type 2 diabetes disability-adjusted life-years were attributed to high BMI, rising by 24·3% (18·5–30·4) since 1990, with the highest increase in south Asia (58·0% [44·0–75·4]), central sub-Saharan Africa (48·8% [35·8–61·2]), and east Asia (45·7% [33·5–57·3]).[1]

Global inequity in diabetes prevalence proliferates into disproportionate effects on premature morbidity and

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mortality in LMICs, as well as in marginalised and minoritised populations in HICs. As of 2019, diabetes-related mortality rates and disability-adjusted life-years were nearly double in LMICs compared with HICs.[18] Furthermore, despite an overall decrease in global death rates from non-communicable diseases since 2000,[25] cardiovascular disease, mortality, and all-cause mortality in people with diabetes were nearly three times higher in low-income countries than in middle-income countries and HICs in 2019.[26] In the USA, wide inequity still remains; for example, in 2017, deaths due to diabetes among non-Hispanic White individuals accounted for 2·5% of total deaths, compared with 5·8% among non-Hispanic American Indian or Alaska Native individuals.[23] In individuals younger than 25 years, 16 300 diabetes-related deaths occurred in 2019 globally, with the majority due to type 1 diabetes (73·7%), and 15 900 (97·5%) of which occurred in LMICs.[27] The COVID-19 pandemic amplified diabetes inequities globally, with people with diabetes being 50% more likely to experience severe infection and twice as likely to die compared with people without diabetes, especially if they were from minoritised groups.[10,12,28–31] Overall, minoritised status and geographical location predict major adverse outcomes and inequities in diabetes prevalence, morbidity, and mortality.

In this first Series paper, we narratively review how structural racism and geographical inequity lead to clinical consequences in diabetes, and how global inequity is fuelling the diabetes crisis. We present theoretical frameworks that link social and medical factors in diabetes and discuss the effects of structural inequity (structural racism experienced by minoritised groups and geographical inequity experienced by LMICs) on diabetes outcomes. We then highlight regional, real-world challenges that show how the cascade of inequity affects the full spectrum of diabetes, from diagnosis to complications. In the second paper in this Series,[32] we describe recommended strategies and action plans to address global inequity in diabetes, and provide real-world examples that translate theory into practice. In the third paper in this Series,[33] we review the mechanisms of diabetes inequity within and between minoritised groups in the USA, including in youth.

Methods

Search strategy and selection criteria

We searched PubMed and Embase for articles published in English from Jan 1, 2003, to March 31, 2023, using the terms "race", "racism", "structural racism", "equity", "inequity", "racial inequity", "structural inequity", "minoritized", "geographic inequity", "ethnicity", "low income country/countries", "middle income country/countries", "low and middle income country/countries", "high income country/countries", "global", "global burden", "complications", "retinopathy", "neuropathy", "nephropathy", "cardiovascular disease", "amputations", "morbidity", "mortality", "death", "disability-adjusted life years (DALYs)", "children", "youth", "young adults", "adults", "women", "lifecourse", "pregnancy", "gestational", "hyperglycemia in pregnancy", "social", "social factors", "social determinants of health", "socioecological model", and "conceptual framework/model" in combination with "diabetes". We reviewed articles resulting from these searches and their references, and selected those relevant to the topic of this Series paper. We also reviewed data from the GBD Study 2021, which was in press at the time of writing.

We made purposeful efforts in literature searches to be cognisant of over-representing articles from HICs, given the inherent and systemic bias in publications.[34–36] When available, we used data banks such as the International Diabetes Federation atlas[37] and the Institute for Health Metrics and Evaluation GBD 2019 database[38] to calculate rates of disease. Nevertheless, we found a disproportionate number of published articles that were either from HICs, or written by authors from HICs or majority groups. Moreover, when including publications or data from LMICs or minoritised groups, key data were often missing, culminating in under-representation and imbalance in data availability and reporting. As such, any scoping review of this literature and its reporting would be biased, as there are known inequity issues in published literature.[34–36] Thus, although we used rigorous methods to retrieve and synthesise available evidence in a systematic manner, we elected to perform a narrative review, using our expertise to contextualise and frame the literature equitably.

Definitions

In this Series, we use a common set of definitions to standardise language throughout the papers (table). We have tried to be specific when speaking about inequity, whether by race, ethnicity, geography, Indigeneity, or migration status. However, because these terms and groupings are imperfect, we acknowledge that no adequate way exists in which we can or should categorise people.[42] Individuals, communities, countries, and regions are complex and non-homogenous, and we will never be able to capture their complexity.[46,50] Thus, in this Series, we use such groupings only for the purpose of clarity. All author groups have contributed their thought leadership to the definitions we have used, although we all recognise their relative inadequacy.

Key concepts and frameworks

Hundreds of articles report consistent associations between structural racism, geographical inequity, and poor physical and mental health in people with diabetes.[12,46,49,51–53] The way that structural inequity affects the pathways between upstream and downstream social determinants of health are complex and operate in multilayered ways. Moreover, the impacts of structural inequity accumulate over time and can affect generational trajectories of health.[54] For example, structural inequity can lead to differences in upstream resources, such as money, power, knowledge, prestige, and beneficial social connections, which have enduring associations with downstream factors, such as socioeconomic status and resultant diabetes.[39] Additionally, institutional and cultural racism can affect diabetes through stigma, stereotypes, prejudice, and discrimination, perpetuating inequitable physical and mental health outcomes.[40]

For this Series, we created several theoretical frameworks to illustrate how structural inequity causes global inequity in diabetes outcomes. These frameworks are based on heavily researched and well established models that theorise how social factors and structural inequity affect health, such as WHO's conceptual framework for action on social determinants of health,[39] the social–ecological model,[50,55] Phelan and Link's theory of fundamental causes,[47] and William and Mohammed's framework for the study of racism and health.[40]

Our framework (figure 1) shows how a cascade of widening inequity in diabetes occurs, stemming from structural inequity that leads to large and fixed differences in key, upstream social determinants of health (eg, socioeconomic position, availability of resources, and access to opportunities for development), and results in unequal and unjust experience of downstream social determinants of health (eg, access to high-quality care, education, housing, and food systems), which causes inequity in diabetes outcomes (figure 1). In this cascade of widening inequity, divergent trajectories of health are created on the basis of upstream inequity, and, over time, the achievement of advantageous outcomes becomes increasingly difficult for people experiencing inequity. In figure 2, we present another framework, which focuses on downstream social determinants of health that have known effects on diabetes outcomes, and include public awareness and policy, economic development, access to high-quality care, innovations in diabetes management, and sociocultural norms.

Although biology has often been considered an individual factor in models of social determinants of health, we did not include it as its own category in the conceptual frameworks, because emerging research suggests that long-standing structural and social inequity interacts with biological factors to cause poor outcomes in minoritised populations, rather than representing underlying genetic predisposition.[56–59] The weathering effect explains how early health deterioration, such as development of diabetes and its complications, can result from cumulative exposure to adversity from social, economic, and political forces, which increases vulnerability to adverse physiological outcomes in minoritised populations.[56] The mechanisms of the weathering effect are best understood with the allostatic load model, which outlines the physiological costs of chronic or repetitive exposure to stress.[57] In minoritised populations, cumulative biological burdens on the body from physical and emotional stress due to continued perceived discrimination and social inequity can lead to high catecholamine and cortisol concentrations and physiological tipping points in glucose concentrations, blood pressure, cholesterol

	Definition	Justification for use
Inequity	The preventable differences in health outcomes closely linked to social, economic, and environmental conditions[39–43]	Negative effects on health outcomes due to known unfair or unjust treatment, experiences, and circumstances[43]
Minoritised	Groups of people who have been historically marginalised and treated unequally or unjustly[12]	Wealth of literature on large scale social and biological effects of minoritisation on outcomes[44]
Race	Social construct established for government classification systems of race and ethnicity[12,41,45]	Alignment with published literature, global organisations, and governments for data tracking and description
Structural racism	The totality of ways in which societies foster racial discrimination, through mutually reinforcing systems of housing, education, employment, earnings, benefits, credit, media, health care, and criminal justice, and its influences on health[12,40,46,47]	Racism is multilevel and includes systems in society that extend beyond individual overt discrimination or implicit bias to inequalities, exerting large downstream effects on health
Geographical inequity	Differences in world position, development, resources, and access between low-income and middle-income countries and high-income countries[48]	The economic development of these countries is a result of historical and continued effects of global colonialism and xenophobia on country and regional development, including the perpetuation of income status across countries;[12,49] categorisation will evolve as changes in economic development and definitions occur
Structural inequity	The effects of structural racism and geographical inequity combined	Connoting the structural, pervasive, deeply rooted, and continuous force that affects how all social determinants of health affect equity in outcomes[12,46]

Table: Definitions

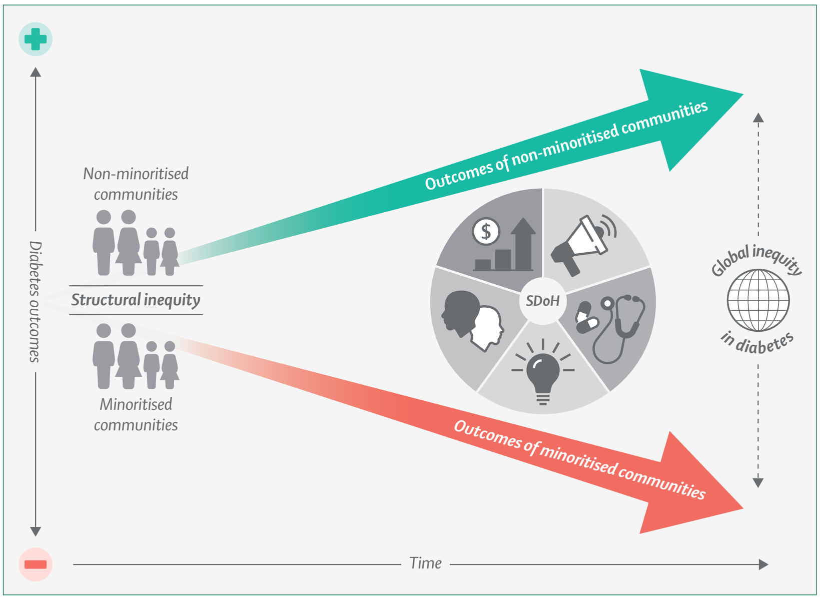

Figure 1: Cascade of widening inequity in diabetes stemming from structural inequity
SDoH=social determinants of health.

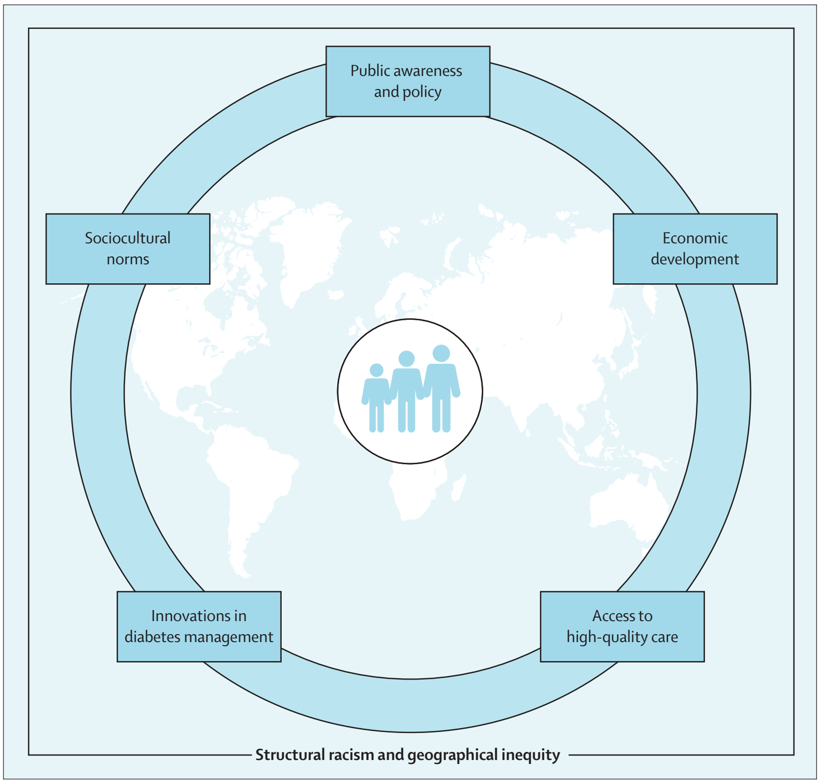

Figure 2: **Conceptual framework depicting the effects of structural inequity on social determinants of health and global diabetes outcomes across the lifespan**
Social determinants of health are identified on the basis of a wealth of evidence of their effects on diabetes. These social determinants of health are closely interconnected and often bidirectional; their commonality is observed globally and their impact can be seen across the lifespan. Structural inequity (structural racism and geographical inequity) serves as the backdrop to acknowledge its pervasive negative effects on social determinants of health and diabetes outcomes.

concentrations, and weight regulation, which are associated with worsening chronic disease and premature mortality.[57–59] At chronically high levels, these physiological stress pathways are shown to trigger changes at the genetic and epigenetic levels, which increase vulnerability to adverse effects not only in individuals, but also future offspring.[56,57] Thus, instead of connoting genetic predisposition or biology as a cause of health outcomes, the allostatic load model suggests that chronic stress due to perceived discrimination and inequity mediates the relationship between biological risk and health outcomes such that, without chronic stress, adverse outcomes might not occur.[56–58]

Social determinants of health and diabetes outcomes

The social determinants of health are the conditions that influence individuals and groups where they work, play, and live.[39] A deeper understanding is needed of how social determinants of health can negatively influence diabetes outcomes to reduce global inequity in diabetes. We use key literature and narrative synthesis to discuss in more depth how downstream social determinants of health affect clinical diabetes outcomes (figure 3).

Public awareness and policy

Public awareness of the global burden of diabetes is tantamount to developing policy that supports efforts at curbing diabetes rates and modifying existing inequity in structural determinants of diabetes (figure 3).[10,14,39,40,47,60] Databases that use global health data including from LMICs, such as the Global Burden of Disease Studies 2019 and 2021,[1,18] and the International Diabetes Federation atlas[16] have been used to raise public awareness of diabetes outcomes globally, helping to inform calls to action on screening, awareness, and reduction of diabetes and obesity. Raised awareness of global diabetes burden has also paved the way for organisations such as WHO and UN to address existing structural inequity in the factors that most closely affect socioeconomic status and resultant outcomes, through the creation of new global policy efforts that bring together multisectoral private–public collaborations and funding.[10,60–62] Such efforts hold potential to reduce large-scale structural inequity in diabetes in LMICs and minoritised groups.[10,16,18]

Economic development

Economic development in individuals has direct implications for advancement in societal position, education, and access to improved infrastructure, all of which promote beneficial diabetes outcomes (figure 3).[10,39,49,60,63–65] As a first sign of progress in this area, funding for diabetes has more than quadrupled from US$10 billion in 1996, to $41 billion in 2019, due to overall increased development in LMICs.[66,67] Additionally, the World Bank, WHO, UN, and philanthropic organisations have started the process of bridging funding gaps in LMICs, by fostering international coalitions that provide grants and opportunities to support general and health-specific infrastructure.[60] Nevertheless, opportunities for economic development must be provided equitably such that marginalised and minoritised populations can access them. Decolonising aid must be done to ensure equitable distribution of resources. Examples of decolonising aid include acknowledging marginalisation and paying reparations for historical injustices,[68,69] writing off international debt to erase centuries of unfair entrenched lending and borrowing systems,[68,69] investing in the creation of Indigenous expertise while valuing existing Indigenous knowledge,[70] and balancing funding decisions between scalability and local value.[71]

Access to high-quality care

High-quality care is a basic human right that not only affects diabetes, but also other social and long-term outcomes (figure 3).[10,14,39,41,72] Although access to high-quality diabetes care is outlined as a standard of care in

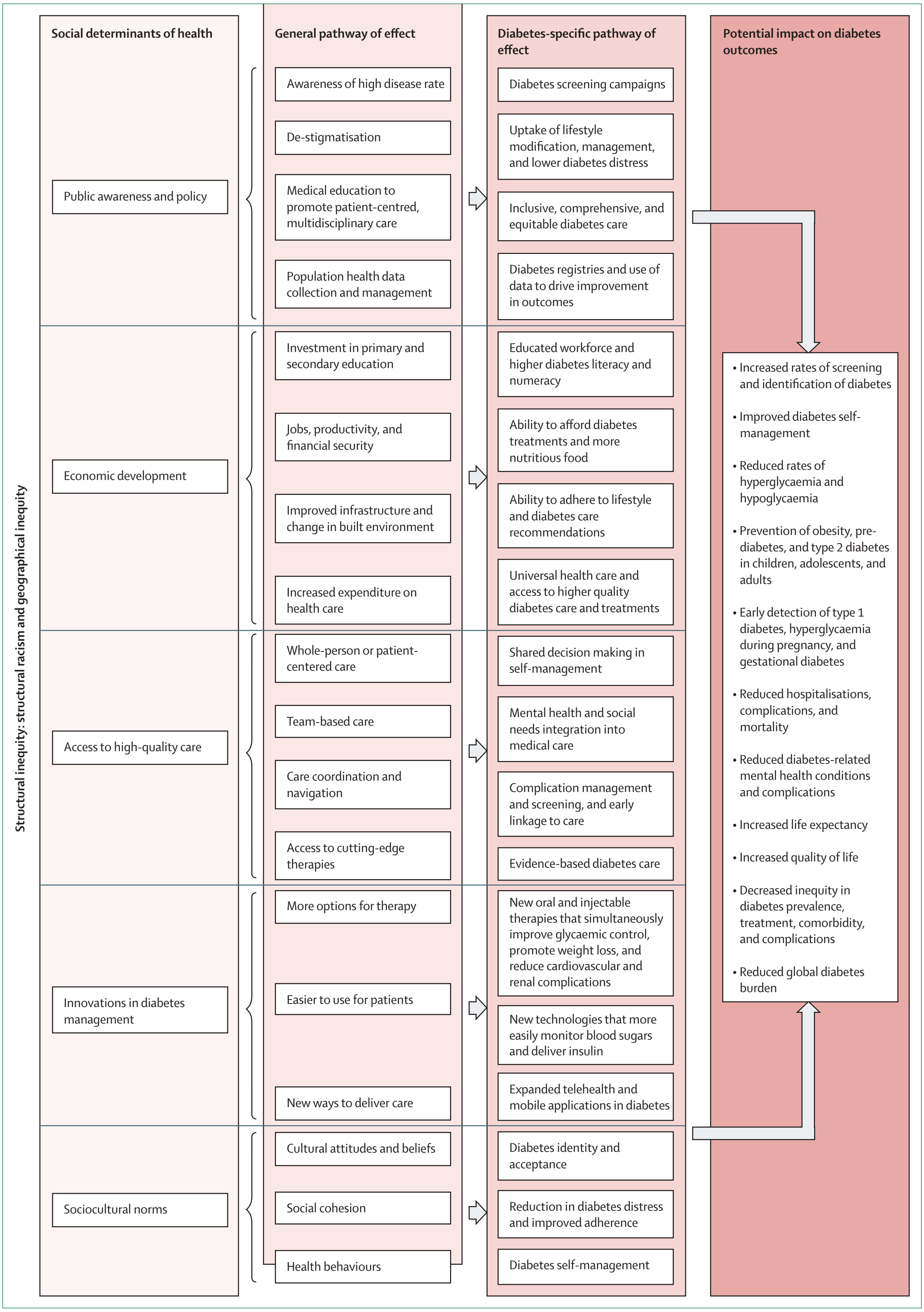

***Figure 3:* Social determinants of health and diabetes outcomes**
All pathways are negatively affected by structural inequity.

many professional society guidelines, it is rarely fully implemented.[73–78] Global evaluation by WHO has shown a scarcity of trained health staff to deliver high-quality diabetes prevention and management worldwide, with higher staff and training shortages since the COVID-19 pandemic.[79,80] As a result, the WHO Global Diabetes Compact, established in 2021, has set forth goals to improve integration of evidence-based diabetes care and training into primary care settings, as an overall effort to increase universal health-care coverage for people with diabetes.[60,61]

Additionally, access to essential medicines,[81] such as life-sustaining and affordable insulin, is part of high-quality care and greatly contributes to global inequities in diabetes, especially for type 1 diabetes.[82] Due to the cost and scarcity of insulin, the difference in remaining life expectancy of a child with type 1 diabetes diagnosed at age 10 years compared with a child without type 1 diabetes is 11 years in HICs and 47 years in low-income countries.[11] Furthermore, the high cost of insulin has been shown to be the leading cause of diabetic ketoacidosis in urban settings in HICs.[83] Because of its foundational importance, insulin is now an essential target of the WHO Global Diabetes Compact, which has vowed to improve access to diabetes diagnostics, medicines, and health products in LMICs.[60,61,84] In the USA, legislation has been recently passed to cap the monthly cost of insulin at $35 per month to improve affordability and accessibility.[85]

Innovations in diabetes management

Recent innovations in diabetes treatment and management have provided more options for care, which are easier and more efficacious, offering potential to improve adoption, reach, effectiveness, and outcomes. New oral and injectable therapies have shown benefits in reducing cardiovascular and renal complications, offering hope for curbing long-term morbidity and mortality in diabetes. Additionally, new technologies (eg, insulin pumps and continuous glucose monitors, smart insulin pens, and telehealth) have made insulin administration easier, glycaemic control more achievable, and have expanded access to care. Nevertheless, these and other innovations in diabetes management are less accessible to minoritised populations, whether in HICs or LMICs, which widens the disparity in outcomes (figure 3).[73,76–78] In the UK and USA, large studies in children, young adults, and adults have shown inequity in insulin pump and continuous glucose monitoring use among minoritised groups, with less than half of people of Hispanic or non-Hispanic Black, Asian, and mixed race or ethnicity using diabetes technology compared with non-Hispanic White groups.[86–91] For type 2 diabetes, a study of adults from more than 160 primary care clinics in the UK showed that Black individuals were 50% less likely than White individuals to be prescribed newer therapeutics, such as SGLT2 inhibitors and GLP-1 receptor agonists,[92] with similar results found in a study done in the USA.[93]

In LMICs, focus on coverage and dissemination of essential medications and supplies has impeded the ability to incorporate treatment innovations into diabetes care, inadvertently creating lead time gaps in entry of new drugs to some populations.[84,94] For example, metformin and sulfonylurea oral medications are still not available in several countries in the sub-Saharan region, according to WHO's 2021 report on the selection and use of essential medicines.[95,96] Additionally, although the use of mobile phones in sub-Saharan African countries has increased from 5–10% in 2000, to 80–90% in 2015, internet use was less than 25% across all regions as of 2015, limiting the ability to use new therapeutics and modalities that rely on the internet for comprehensive care.[49]

Sociocultural norms

Sociocultural norms are a result of historical, geopolitical, economic, and cultural forces, which are influenced by structural racism and geographical inequity, and can greatly affect diabetes outcomes (figure 3).[53] In line with WHO and other frameworks,[39,40,47] cultural attitudes and beliefs, social cohesion, and health behaviours can have large impacts on diabetes self-management, which is a cornerstone of diabetes care.[10,73,75–78,97] Sociocultural norms can also greatly affect mental health, and exacerbate mental health disorders that are common in diabetes, such as depression, anxiety, post-traumatic stress disorder, chronic stress, and diabetes-related distress, which can affect diabetes self-management, access to diabetes care in a timely manner, and longevity.[10,12–14,97,98] Acknowledging and incorporating sociocultural norms into diabetes care paradigms and programmes might improve patient–provider therapeutic relationships, diabetes self-management, and outcomes; however, historical lack of focus and training of medical providers on these issues remains common.[10,12–14,97,98]

Regional perspectives on inequity in diabetes

As global diabetes data become more readily available through collaborations such as the Non-communicable Disease Risk Factor Collaboration,[99] the GBD Studies,[1,27,38,100] and the International Diabetes Federation atlas,[37] it is becoming increasingly evident that large regional and country-level variations in diabetes prevalence, morbidity, and mortality exist. Importantly, although more data on LMICs and minoritised populations are being added to these large global databases, difficult-to-measure local influences and factors might continue to be excluded, despite their large effects on minoritised and marginalised populations. Additionally, global measures of disease and morbidity might not accurately capture important differences within and between geographical regions. For this reason, we chose to include regional perspectives on inequity in diabetes from two LMIC and two HIC regions as examples from which we can learn about on-the-ground challenges. The sections reporting on LMICs underscore shared challenges of all LMICs, while highlighting region-specific issues in the face of large, upcoming demographic transitions. The sections reporting on HICs highlight salient issues of minoritised and Indigenous populations that remain from long-standing perpetuation of structural inequity, and serve as harbingers to future HICs.

Sub-Saharan Africa

Diabetes poses a major risk to sub-Saharan Africa. In 2021, the International Diabetes Federation estimated that 23·6 million people (95% UI 15·0–29·8) in the region were living with diabetes, with a projected increase to 54·9 million people (34·8–69·7) by 2045.[16] Diabetes-related morbidity is high, with pooled multicountry estimates of diabetic nephropathy of 35·3% (95% CI 27·5–43·1) in studies published between 1997 and 2017,[101] and diabetes-related amputations of 36·9% (32·9–40·8) in studies published between 1999 and 2020.[102] Meta-analyses of diabetic retinopathy prevalence confined to sub-Saharan Africa are limited, but one, which included north as well as sub-Saharan Africa, reported a pooled multicountry prevalence of 32% (28–36) in studies published between 2000 and 2020.[103] With approximately 306 000 deaths, sub-Saharan Africa ranks fourth in the number of deaths under age 60 years due to diabetes;[37] however, this number is probably underestimated, due to a paucity of data and challenges with accurately recording the cause of death in the region.[104] Diabetes also has a substantial impact on health expenditure in the subcontinent. In 2015, the estimated economic burden of diabetes in sub-Saharan Africa was US$19·55 billion in adults aged 20–79 years, representing 1·2% of gross domestic product, which is projected to increase to 1·4–1·7% in 2030, if sustainable development goals of reduction in premature diabetes-related mortality and stabilisation of the age-standardised prevalence of diabetes are not achieved.[67]

Much of the inequity in diabetes management in sub-Saharan African countries is associated with their low-income and middle-income status, which results in a scarcity of financial and human resources. Avoidable, systematic disparities driven by economic, social, and cultural barriers are common in sub-Saharan Africa. These disparities exist across all levels, with fewer people attaining treatment goals than in HICs, but also between countries in the subcontinent, and even within individual countries.[105] Urban residence is associated with increased diabetes prevalence, reflecting lifestyle changes and increased obesity associated with urbanisation.[106–109] Despite this heightened prevalence, some diabetes-related outcomes are better in people living in urban areas than those living in rural areas, probably because of superior access to diagnostic and therapeutic services.[110–113] Socioeconomic status follows a similar pattern, with people with higher socioeconomic status having higher diabetes prevalence and better adherence to self-care activities.[106,112–116] Food insecurity, another indicator of inequity, is prevalent in some people with diabetes in sub-Saharan Africa, and has been associated with both higher diabetes prevalence and poorer outcomes in sub-Saharan Africa.[117–119] Food insecurity is associated with poorer adherence to diabetes self-care activities,[120] and selecting a healthy diet is difficult when reliable access to food of any type is variable.

The World Bank estimated a domestic general government health expenditure of 2·0% in sub-Saharan Africa in 2019, compared with 7·7% in HICs.[121] In 2019, there were 2·9 physicians and 18·3 nurses and midwives per 10 000 population is sub-Saharan Africa, compared with 33·4 physicians and 114·9 nurses and midwives per 10 000 population in HICs.[122] Availability of therapeutic agents is also sub-optimal—although metformin was available in the public health care sector in 39 of 48 sub-Saharan African countries in 2021, access to other essential diabetes medications was still low, with sulfonylureas available in 23 countries and insulin available in 32 of them.[95,96,123] Pooled analysis from nationally representative population-based studies done in 12 sub-Saharan African countries between 2005 and 2015 estimated that 27% of people with diabetes had been told their diabetes diagnosis, 25% were taking oral hypoglycaemic agents, and 11% were taking insulin.[105] These findings are in contrast to the US National Health and Nutrition Examination Survey, in which, between 2013 and 2016, 74% of people with diabetes had been told of their diabetes diagnosis and 94% of people with diagnosed diabetes were linked to diabetes care.[124]

Several countries have made substantial strides in developing government-funded universal health-care models, which reduce fragmentation of care and out-of-pocket expenses; however, access to diabetes care and diabetes outcomes still vary substantially between and within sub-Saharan African countries.[125] Meta-analyses have estimated pooled prevalence of glycaemic control at 27% (95% CI 24–30) from studies in north and sub-Saharan Africa published between 2000 and 2020,[103] and 30% (28–33) from studies in sub-Saharan Africa published between 2012 and 2022.[126] However, country estimates ranged from as low as 8·1% in Uganda in 2019, to 52·0% in Nigeria in 2011.[103] Similarly, prevalence of complications varied both between and within countries. Studies from Lesotho, Kenya, Cameroon, and Senegal reported a prevalence of diabetic nephropathy of less than 10%, whereas prevalence higher than 30% was reported in studies from Sudan, Democratic Republic of the Congo, Malawi, Zimbabwe, Botswana, Uganda, and South Africa. Meanwhile, studies in Ethiopia, Ghana, Nigeria, and Tanzania have reported variable prevalence of diabetic nephropathy.[103] Prevalence of peripheral neuropathy was lowest in a 2010 study from Eritrea (4·0%) and highest in a 2018 study from Nigeria (83·0%), whereas prevalence of diabetic retinopathy ranged from 4·7% in Lesotho in a study published in 2018, to 82·6% in a 2017 study from Sudan.[103] Prevalence of diabetic foot ulcers ranged from 0·4% in a 2015 Ethiopian study to 21·2% in 2017 Ethiopian study, and peripheral arterial disease ranged from 4·7% in a 2011 multisite study in Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria to 52·5% in a 2012 study from Nigeria.[103]

Sub-saharan African countries range in their economic development and resources, resulting in variable rates of diabetes outcomes. Constrained economic resources in LMICs in sub-Saharan Africa have contributed to underinvestment in health-care systems and an inability to provide universal diagnostic and therapeutic services for people with diabetes. Equity could be achieved through policies that promote or provide human resources for health and medication access, particularly focusing on rural areas and people in lower socioeconomic groups. Additionally, recruitment of trained health-care professionals away from these countries should be discouraged to avoid diminishing the pool of qualified health professionals providing diabetes care in the area.

South Asia

South Asia has the highest absolute numbers of people with type 2 diabetes and gestational diabetes in the world, with anticipated exponential growth in the next 30 years.[1,37] Due to these staggering statistics and given the high rates of diabetes across the lifespan, south Asian countries might offer unique insight into the adverse intergenerational factors associated with diabetes propagation and provide new targets for intervention.[127]

Diabetes in south Asia is expressed differently, with regard to associations between BMI, percentage body fat, and health outcomes, compared with classically defined diabetes in populations of European descent.[128] South Asian people with diabetes have lower BMI values than European individuals.[128,129] Additionally, diabetes affects young people more disproportionately in South Asia, even in the absence of high BMI.[130] Thus, although south Asian people who are overweight tend to develop the metabolic syndrome and diabetes, a normal weight status does not preclude them from developing the metabolic syndrome as much as it does in European populations.[130] Variability in diabetes phenotypes in the south Asian population might be under-appreciated, particularly with regard to BMI and the contribution of insulin secretion and insulin resistance. This under-appreciation could be due to literature dominated by studies on type 2 diabetes in European populations. Moreover, the evidence base evaluating various diabetes subtypes across or apart from the type 2 diabetes spectrum are evolving. Overall, a nuanced approach to subtyping and treating diabetes in south Asia is warranted to avoid missing key subpopulations of people with diabetes.

See Online for appendix

The social determinants of health might help to explain manifestations of diabetes in south Asia, tying social factors to vulnerability and health outcomes. Geographical inequity and structural racism culminating in chronic ecological stress, colonisation, famines, and wars greatly impacted development of the region, including historical poor education, low socioeconomic status, and reduced decision-making power of women.[127,131–133] Before the 2000s, in some communities, mothers reduced their food intake in late pregnancy because they believed that it could facilitate easy delivery.[134] Women living in rural areas also did heavy physical work at home and outdoor manual work until late in pregnancy, which was associated with lower birthweight.[135] Although these social norms are becoming uncommon nowadays, they might have left a lasting transgenerational impact on the structure and function of the developing fetus (intrauterine programming), which might have made south Asian populations, particularly young people, more prone to diabetes.[136] In essence, a combination of low in-born capacity for resilience (smaller pancreas), excessive intrinsic load (adiposity-related insulin resistance), and rapidly increasing environmental load (rapid economic transition) might make the pancreas more prone to early failure, resulting in high rates of diabetes in young individuals with a lower BMI in south Asia.[127]

Connecting social determinants of health with biological outcomes, the paradox of the double burden of malnutrition encapsulates the metabolic and growth effects of early life undernutrition followed by overnutrition. This paradox is driven by historical multigenerational undernutrition, interacting with modern-day rapid socioeconomic and nutritional transition.[137–139] Due to the recent rapid economic development of India, diabetes has transitioned from predominantly affecting residents living in affluent areas to becoming more common in residents living in rural areas and urban slums.[140]

The legacy of chronic undernutrition in south Asia has affected several generations and is observed across the lifespan, starting from birth.[127,141] Between 1830 and 1980, Indian people and other south Asian populations did not show an increase in mean height, whereas Europeans gained up to 15 cm.[142] Additionally, a study showed that babies born to mothers from the Indian subcontinent (India, Bangladesh, and Bangladeshi migrants in the UK) had lower birthweights than babies born to mothers of European ancestry, despite a similar genetic score for birthweight (appendix).[143] By contrast, from 1980 to current day, there has been a 5 cm gain in mean height and a rise in prevalence of overweight and obesity in Indian children compared with their parents.[144–146] Diabetes in adolescents and young people in India is on the rise,[144,147] and has been shown to be associated with earlier need for insulin therapy and development of retinopathy, which is alarming given the vast number of individuals at risk in the south Asian region.[148]

Lifestyle changes accompanying the rapid economic transition include increased intake of high glycaemic and unhealthy foods; presence of environmental endocrine disruptors,[149] such as bisphenol A, dioxins, and polyfluoroalkyl substances (which can eventually increase the risk of obesity and cancer, cause cognitive dysfunction, and interfere with reproductive health); and increase in psycho-social stressors generated by the modern, rapid, and competitive ecosystem.[150] Moreover, energy dense foods such as rice, cooking oil, and fatty savoury snacks are far cheaper than healthy foods such as vegetables, fish, and fruits, which can increase the likelihood of overweight and obesity in individuals with a low income.[151–153] Consanguinity, inbreeding, and endogamy continue to be common in south Asia, with differences existing by region, state, and community;[154] these practices have crucial roles in influencing diabetes phenotypes through enrichment of multiple alleles.[154]

Although still evolving, some cohort studies have shown associations of some south Asian diabetes subtypes with distinct genetic profiles compared with those of European descent.[155,156] Moreover, several physiological studies have observed that Indian people have lower muscle mass, smaller visceral organs, and a higher fat mass for a given weight than European individuals.[127,138,157] The combination of these factors can result in diabetes characterised by low insulin secretion, but higher insulin resistance than that observed in European individuals with diabetes and a similar BMI.[129] Another expression of diabetes might be evidenced in a physiological study, which showed that some individuals with a very low BMI (<19 kg/m²) and no evidence of pancreatic disease or islet cell-related autoimmunity can have a severe insulin secretory defect.[158] Deeper investigation is needed to distinguish diabetes and its subtypes in south Asia, but data so far are compelling to prompt further research.

In summary, historical and sustained geographical inequity and structural racism have led to varied economic development and large-scale multigenerational nutritional inequity across the life course in south Asian people, resulting in high prevalence of diabetes. Such inequity will need new solutions to break the cycle of transgenerational fetal programming of diabetes, which includes prevention strategies starting in the preconception phase to influence outcomes in later life.[159,160]

Australia

Australian Aboriginal peoples have lived in Australia for more than 60 000 years, and are one of the world's oldest living cultures.[161] Australian Aboriginal and Torres Strait Islander peoples continue to sustain a very strong and diverse culture, with more than 160 Indigenous languages spoken in Australia and strong connections to country and cultural practices continuing.[162] Similar to other Indigenous peoples globally, Aboriginal and Torres Strait Islander peoples in Australia experience a disproportionately high burden of type 2 diabetes and related conditions, resulting in more than three times higher rates than the general Australian population, with nearly 40% prevalence in the most remote and disadvantaged regions of central and northern Australia.[24,163]

The decreasing age of diagnosis with each new generation has been of great concern in the Aboriginal population, such that rates of youth-onset type 2 diabetes are among the highest reported globally.[20,163] The youngest reported age of type 2 diabetes diagnosis was 4 years in a study done across northern Australia,[20] and the highest prevalence was 3·1% among adolescents and women aged 15–24 years in Central Australia.[20] Prevalence of type 2 diabetes among Aboriginal and Torres Strait Islander peoples of all ages has been consistently reported to be higher in girls and women than in boys and men.[20,24] The high prevalence of youth-onset type 2 diabetes among female individuals contributes to very high prevalence of pregestational diabetes in pregnancy, with rates as high as 8·4% among pregnant Aboriginal women in Central Australia.[164] Similarly to south Asian communities, the high prevalence of hyperglycaemia in pregnancy has probably contributed to the intergenerational escalation of the diabetes epidemic among Aboriginal and Torres Strait Islander communities, with possible contributions from epigenetics, genetics, social determinants of health, and traditional diabetes risk factors.

As a result of the cascade of widening diabetes inequity, Australian Aboriginal and Torres Strait Islander communities experience high and premature morbidity and mortality from type 2 diabetes and its complications.[165,166] In the Northern Territory, 27% of the population identify as Aboriginal peoples, and experience the greatest socioeconomic disadvantage, as well as the highest rates of diabetes, end-stage kidney disease, and mortality nationally.[24,162,165,166] In 2021, diabetes-related mortality and hospitalisation rates were more than four times higher among Aboriginal and Torres Strait Islander peoples than non-Indigenous Australians.[165,167] The median age of death was 62·5 years for Aboriginal and Torres Strait Islander peoples, compared with 82·2 years for the general Australian population, with cardiovascular disease and diabetes among the two leading causes of death.[165] Young age of diabetes onset and persistent high glycaemic concentrations contribute to excess risk of complications.[20,168] For Aboriginal and Torres Strait Islander female individuals nationally and for all Aboriginal peoples in the Northern Territory, diabetes remains the leading cause of death.[165]

The impacts of colonisation are high and still affect Aboriginal and Torres Strait Islander peoples today in a number of ways. Transgenerational trauma has been passed down through generations with ongoing impacts on all aspects of life—eg, loss of culture, loss of identity, the stolen generation, and forced displacement from country. Transgenerational trauma probably contributes to increased diabetes risk through several mechanisms, including poor mental health and wellbeing, and social determinants of health including structural, community-level, and individual-level racism.[169] Aboriginal and Torres Strait Islander peoples have many competing factors that might affect their diabetes care. Food insecurity and the high cost of fresh food remain substantial barriers to healthy diets, particularly in remote communities, where the average cost of a Healthy Food Basket in 2021 was 52% higher than in the average district centre supermarkets.[170] Additionally, a healthy diet was reported to require 38·7% of household disposable income in remote communities, and is thus not affordable for most households.[171] Sugar intake is also high, with sales data from remote stores showing a purchase of free sugars per MJ total energy of 2·6 times the WHO recommendation of 10% for the prevention of dental disease and overweight and obesity.[172] A food system now dominated by highly processed, convenient, unhealthy foods and drinks high in sugar, saturated fat, and salt, a scarcity of resources to afford healthy foods, and inadequate housing greatly impede efforts at diabetes self-management and treatment.[173,174] Nevertheless, women described that their connections to the land and cultural identity were important enablers of healthier lifestyles in this challenging context.[175] Improving diabetes care is near to impossible when all the aforementioned factors (racism, food insecurity, high cost of food, and household crowding) can affect Aboriginal women with diabetes trying to care for themselves and their families. Hence, it is crucial to incorporate community-led design of diabetes prevention and management programmes to enhance such key enablers of success.

In summary, adverse outcomes in Aboriginal and Torres Strait Islander peoples are likely to have stemmed from long-standing structural racism and inequity, which continue today. Misalignment of health systems with sociocultural norms and health behaviours of Aboriginal and Torres Strait Islander peoples have led to inadequate diabetes care and marginalisation of communities. Additionally, generational mistrust and experiences of racism and trauma have hampered the ability to access and use high-quality diabetes care.[169,176,177] Structural changes to health systems and new partnerships must be forged to re-engage and rebuild trust with Aboriginal and Torres Strait Islander communities. Aboriginal and Torres Strait Islander health workers, liaison officers, and interpreters should be included in health systems to advocate for communities, provide resources in Aboriginal and Torres Strait Islander languages, and enable access to high-quality medical care. Additionally, access to healthy food in remote communities must be addressed. Integrating Aboriginal and Torres Strait Islander peoples into care will help to break this intergenerational cycle of diabetes.

USA

In the USA, the distribution of social risk and resultant inequity in outcomes in diabetes is heavily weighted by an imbalance of power and access to resources, which create socioeconomic inequalities.[39] Current evidence on the relationship between structural racism and diabetes includes ten studies on governance, two on social policies, one on public policies, and one on cultural and societal values.[59] Antecedent to social determinants of health, inequitable policies and laws[39] have differentially impacted particular racial and ethnic groups and created structural inequity,[14,178–180] which reinforces, but is separate from, discriminatory beliefs, values, and distribution of resources.[46,52] The origins of structural racism in the USA can be traced down to laws that reinforced injustices against Native American and Black American communities throughout the 17–19th centuries, and continue to cause generational inequity in diabetes prevalence, morbidity, and mortality.[181–183]

For Native Americans, key examples of structural racism include the Removal Era (1820–50), during which Congress codified the Indian Removal Act, leading to widespread displacement and death of more than 4000 tribal members; the 1887 Dawes Act, which caused economic and land divestment; and the Urban Indian Relocation programme, which was initiated in 1952, and was designed to relocate Native American communities into surrounding suburbs with the intention to assimilate Native American families into White, American society.[181–183] Native Americans continue to experience the long-standing effects of historical events, exhibiting the highest rates of adult and youth-onset type 2 diabetes in the USA.[23] Strong parallels can be drawn between how structural racism and inequity affect Indigenous peoples in the USA and Australia.[180]

For Black Americans, historic events include slavery; the Black codes, enacted in 1865, and Jim Crow laws, from post-US Civil War to 1968, which limited jobs, access to jobs, health care, education, and overall economic opportunities; *Plessy v Ferguson* in 1896, which legalised segregation; and historic redlining, which encompasses the exclusionary practices codified into government policies in 1933, when the Home Owners' Loan Corporation was formed.[184] Many of these practices were enforceable under law until 1964, when the Civil Rights Act was passed, and until 1968, when the Fair Housing Act was passed, making it unlawful to practice race-based housing discrimination. Nowadays, historic redlining remains an important manifestation of structural racism in the USA, and highlights how historic events continue to influence today's health outcomes.[14,178–180,184] For example, emerging evidence shows that people living in historically redlined areas have 53·7% (95% CI 43·3–64·9; $p<0·01$) higher diabetes mortality and 66·5% (53·7–80·4; $p<0·01$) higher years of life lost than people not living in these

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areas.[179] These determinants at the neighbourhood level are affected upstream by inequity in policies, resulting in food deserts, less green space to promote physical activity, increased exposure to environmental air and water pollutants, and less safe neighbourhoods, among several other adverse risk factors.[179]

In summary, structural racism has had far-reaching generational effects on diabetes in marginalised populations in the USA by impacting upstream factors, such as laws and regulations, which lead to socioeconomic inequality and vulnerability to negative effects of social determinants of health. Although structural racism has been long-standing, social momentum stemming from the COVID-19 pandemic and the death of George Floyd has spurred efforts to not only understand the mechanisms leading to poor health, but also develop strategies across research, practice, and policy to reverse its effects.[45,184–186] Use of multisectoral approaches that target key policy areas will allow for a paradigm shift in the field of health inequity, by targeting upstream structural factors to improve population health in diabetes.

Conclusions

Diabetes prevalence, morbidity, and mortality rates are increasing exponentially, especially in LMICs and minoritised populations in HICs, threatening global health now and for generations to come. In this Series paper, we underscored important literature, proposed new theoretical frameworks, and offered regional perspectives that show how structural inequity has created and perpetuated far-reaching, trans-generational, and negative effects on diabetes outcomes globally. Public awareness and policy, economic development, access to high-quality care, innovations in diabetes treatments, and sociocultural norms are social determinants of health that have large impacts on diabetes, and should be targets for intervention to achieve equity.

The recommendations from The Lancet *Commission on Diabetes*,[10] in concert with WHO and UN Sustainable Development Goals, have provided guidelines and action plans to inform initiatives to curb global diabetes burden, and begin the process of achieving equity in diabetes care and outcomes.[61] These recommendations include multisectoral, multi-component, and integrated strategies to change the ecosystem of care, build capacity, and improve clinical practice in diabetes. Concurrently, professional societies and governmental agencies have called out inequity in diabetes and started developing clinical guidelines that incorporate screening for, and the addressing of, social determinants of health in diabetes care.[73,78,187] The effects of social determinants of health and their inequitable impact on diabetes will continue to proliferate if structural inequity is not acknowledged. The hard work of addressing and eliminating root causes of structural inequity must be encouraged to curb the current global diabetes crisis.

Contributors

SA conceptualised the Series theme and this Series paper, invited the authors, and wrote the non-regional sections. ANW and JCM wrote the sub-Saharan Africa section. CY and NT wrote the south Asia section. LM-B and SG wrote the Australia section. LEE, JAC, and RJW wrote the USA section. All authors edited the overall manuscript.

Declaration of interests

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