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Global, regional, and national burdens of type 1 and type 2 diabetes mellitus in adolescents from 1990 to 2021, with forecasts to 2030: a systematic analysis of the global burden of disease study 2021

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Abstract

Background Adolescent diabetes is one of the major public health problems worldwide. This study aims to estimate the burden of type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) in adolescents from 1990 to 2021, and to predict diabetes prevalence through 2030.

Methods We extracted epidemiologic data from the Global Burden of Disease (GBD) on T1DM and T2DM among adolescents aged 10–24 years in 204 countries and territories worldwide. This study calculated the age-standardized prevalence rate (ASPR) and age-standardized DALY rate (ASDR) in adolescents based on the world standard population for cross-country comparisons. Average annual percentage changes (AAPC) in age-standardized rate were calculated by linkage point regression. Correlation analyses were used to identify the relationship between age-standardized rate and sociodemographic index (SDI). The Bayesian age-period-cohort (BAPC) model was used to predict changes in the diabetes prevalence among adolescents from 2022 to 2030.

Results In 2021, 3.4 million adolescents were living with T1DM, with an ASPR of 180.96 (95% CI 180.77–181.15), and 14.6 million were living with T2DM, with ASPR of 1190.73 (1190.13–1191.34). As national and territory SDI levels rise, the prevalence rate of T1DM increases ($r = 0.44$, $p < 0.01$), and the prevalence rate of T2DM decreases ($r = -0.18$, $p < 0.01$). Compared with males, females had a greater age-standardized prevalence of T1DM (185.49 [185.21–185.76] vs. 176.66 [176.39–176.92]), whereas males had a greater ASPR of T2DM than females did (1241.45 [1240.58–1242.31] vs. 1138.24 [1137.40–1139.09]). This study found a negative correlation between the SDI and the ASDR for both T1DM ($r = -0.51$, $p < 0.01$) and T2DM ($r = -0.62$, $p < 0.01$) in adolescents. For T2DM patients, 32.84% of DALYs were attributed to high BMI, which increased by 40.78% during the study period. By 2030, 3.7 million people are projected to have T1DM, and 14.6 million are projected to have T2DM.

Conclusions Among adolescents, the burden of T1DM and T2DM is increasing and varies by region, sex, and SDI. Therefore, targeted interventions based on regional features are needed to prevent and control adolescent diabetes. Moreover, more efforts are needed to control climate change and obesity to reduce the adolescent diabetes burden.

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Keywords Diabetes mellitus, Adolescent, Disease burden

Background

Diabetes mellitus is one of the most common and fastest-growing diseases worldwide [1]. Prolonged diabetes mellitus can lead to dysfunction and failure of various organs, particularly the eyes, kidneys, nerves, heart, and blood vessels [2]. According to the International Diabetes Federation, an estimated 537 million people worldwide will have diabetes mellitus in 2021, and this number is projected to increase to 784 million by 2045 [3].

In the adolescent population, T1DM is the most common form of diabetes mellitus [4]. The median age at diagnosis is 12 years, and its incidence peaks during adolescence [5, 6]. Furthermore, owing to rising rates of childhood obesity, adolescents in many countries are increasingly being diagnosed with T2DM. It has been estimated that T2DM accounts for approximately 32% of the incidence of diabetes in the same age group of adolescents [7]. More importantly, increasing evidence indicates that diabetes diagnosed at a younger age poses a greater risk, leading to the premature development of multimorbidity, with adverse effects on quality of life and long-term outcomes, increasing the possibility of future public health [8, 9]. For example, the Emerging Risk Factors Collaboration study suggested that for every decade of diabetes onset at an earlier age, the average life expectancy is reduced by 3–4 years [10].

Studies have reported the global burden of disease for T1DM patients aged 10–24 years and T2DM patients aged 15–39 years [11, 12]. However, studies that comprehensively capture long-term trends in T1DM and T2DM in adolescents and compare variations in different types of diabetes by region, sex, and level of SDI are lacking. In addition, the newly released GBD 2021 updates data on the burden of diabetes via an improved methodological framework, which means that previous reports may underestimate the burden of diabetes [13, 14].

Accurate data on the prevalence, DALY, and risk factors for diabetes in adolescents are essential for formulating public health policies. Therefore, this study aims to comprehensively assess and compare the disease burden and epidemic trends of T1DM and T2DM among adolescents in different regions and sexes by providing age-standardized rates and to project the prevalence trends up to the year 2030. This will help different countries and regions estimate current and future resource needs and formulate policies.

Methods

Data sources and study population

The data were obtained from the GBD 2021 published by the Institute for Health Metrics and Evaluation. GBD 2021 reports estimates value and 95% uncertainty interval (UI) of incidence, prevalence, years lived with disability (YLD), years of life lost (YLL), and disability-adjusted life years (DALY) associated with 371 diseases and injuries for 204 countries and territories, by sex and age, for the years 1990–2021. The introduction and estimation methodology of GBD 2021 has been described in detail in a previous Global Burden of Disease Study [15].

To be more closely related to adolescent growth and a popular understanding of this life stage and to facilitate the broadening of investments across a broader range of settings, this study defines adolescents as those aged 10–24 years [16]. Since GDB 2021 assumes that all diabetes cases under 15 years of age are T1DM, data on T2DM for this study did not include the 10–14-year-old group. We extracted the prevalence, YLL, YLD, DALY, and DALY due to different risk factors for T1DM in individuals aged 10–24 years and T2DM in individuals aged 15–24 years by diabetes type and sex for 204 countries and territories from the Global Health Data Exchange (https://ghdx.healthdata.org/gbd-results-tool).

Estimates of the burden of disease in diabetes

The reference case for diabetes was defined as an individual with a fasting glucose concentration of 7 mmol/L (126 mg/dL) or higher or who used insulin or diabetes medications. The GBD 2021 Diabetes Collaborators used the hierarchical Bayesian meta-regression modeling tool DisMod-MR 2.1 to calculate estimates of the prevalence of diabetes by age, sex, and year from 1990 to 2021. YLL are the product of the number of deaths and standard life expectancy at each age of death, and YLD are the product of the prevalence of each sequela and their corresponding disability weights. DALY was the sum of YLL and YLD. Meta-analyses were performed according to the comparative risk assessment methodology to quantify the association between each risk factor and diabetes, and the burden of risk attribution for DALY was estimated based on the population attributable fraction.

Statistical analyses

Descriptive analyses were used to describe the burden of diabetes in adolescents globally from 1990 to 2021 by sex, age group, and region. Age-standardized rates (per 100,000) and 95% confidence intervals (CI) were calculated based on the world standard population reported in the Global Burden of Disease Study 2019. The average annual percentage change (AAPC) in the incidence of diabetes and DALY in adolescents from 2019 to 2021 was calculated via linkage-point regression to identify the magnitude and direction of temporal trends in changes in the burden of diabetes globally and across 204 countries and regions. The linkage-point regression model is based on the Monte Carlo replacement test to determine the number and location of link points and the corresponding p value, and the overall asymptotic significance level is maintained through a Bonferroni correction, to describe continuous changes of disease burden [17]. The disease burden associated with diabetes was evaluated via the DALY rate, and the associations between disease burden and the SDI were analyzed via Pearson linear correlation. In this study, we used the BAPC model, with well-calibrated probabilistic predictions, to predict future disease burden in adolescents with diabetes [18, 19]. The Bayesian inference in age-period-cohort model method treats all unknown parameters as random with appropriate prior distributions, which are usually predicted using a smoothing prior and second-order random walk. The BAPC model uses Integrated Nested Laplace Approximation the posterior marginal distributions directly avoiding any Markov Chain Monte Carlo sampling techniques and therefore also mixing and convergence issues. All the statistical analyses were performed via the Joinpoint regression program (version 5.2.0), R (version 4.3.0), and Python (version 3.0). A p value <0.05 was considered significant.

Results

Prevalence of diabetes in adolescents

In 2021, the global prevalence of T1DM among adolescents was 3.4 million, with ASPR of 180.96 (95% CI 180.77–181.15) (Additional file 1: Table S1). The global prevalence of T2DM was 14.6 million, with ASPR of 1190.73 (1190.13–1191.34). At the regional level, high-income North America (445.31 [443.77–446.85]) presented the highest ASPR of T1DM. Notably, eight of the ten countries with the highest prevalence rates were from Western Europe (Finland: 1181.7 [1159.68–1203.72], Malta: 633.61 [572.15–695.06], Italy: 602.97 [597.86–608.07], Ireland: 601.76 [586.44–617.07], Norway: 552.26 [537.73–566.8], Sweden: 496.62 [486.29–506.95], Spain: 488.69[483.53–493.85], and Cyprus: 486.05 [456.88–515.23]), with the remaining two from high-income North America (Canada: 940.98 [933.58–948.39]) and the high-income Asia–Pacific region (Brunei: 566.46 [521.03–611.89]) (Fig. 1). The highest ASPR of T2DM was observed in Oceania (2860.11 [2839.78–2880.44]). All ten countries with the highest ASPR were from Oceania, including the Marshall Islands (6576.27 [6106.93–7045.61]), American Samoa (5811.56 [5292.49–6330.62]), Niue (5102.79 [2391.17–7814.41]), Cook Islands (5063.37 [4234.36–5892.38]), Tokelau (4650.28 [1902.16–7398.40]), Samoa (4334.66 [4129.69–4539.63]), Palau (4054.38 [3252.31–4856.46]), Nauru (3815.37 [3008.57–4622.17]), Micronesia (3297.45 [3051.75–3543.15]), and Kiribati (3120.22 [2890.25–3350.18]). Overall, there was a positive correlation between the ASPR of T1DM and the SDI at the national level ($r=0.44$, $p<0.01$) and a negative correlation between the ASPR of T2DM and the SDI at the national level ($r=-0.18$, $p<0.01$) in adolescents (Additional file 1: Fig. S1).

Sex-specific diabetes prevalence in adolescents

The ASPR of T1DM was greater in females than in males (185.49 [185.21–185.76] vs. 176.66 [176.39–176.92]) (Additional file 1: Table S2). However, the gender gap gradually narrowed, with the ratio changing from 0.83 to 0.95 between 1990 and 2021 (Fig. 2). Conversely, the ASPR of T2DM has consistently been greater in males than in females (1241.45 [1240.58–1242.31] vs. 1138.24 [1137.40–1139.09]), and this gender gap appears to be widening, with the ratio changing from 1.04 to 1.09. In 2021, for T1DM, 111 (54.4%) countries and territories reported a lower ASPR in males than in females (Additional file 1: Table S2). Notably, Haiti, Afghanistan, and Laos presented a male prevalence that was more than 50% lower than that of females. Conversely, across 93 (45.6%) countries and territories where the male prevalence exceeded that of females, Gabon, Kenya, Malawi, and Uganda stood out, with male rates surpassing female rates by more than 100%. For T2DM, 126 (61.8%) countries and territories presented a lower ASPR in males than in females. Serbia, Slovakia, Montenegro, and Croatia were highlighted, where the male prevalence was more than 80% lower than the female prevalence. In 78 (38.2%) countries and territories where male prevalence surpassed that in females, Russia, Tokelau, North Macedonia, Angola, and Canada presented male rates exceeding female rates by more than 50%.

Age-specific diabetes prevalence in adolescents

Between 1990 and 2021, the global prevalence of T1DM in adolescents increased nearly 1.5-fold across age subgroups (Fig. 3A). In contrast, the prevalence of T2DM increased at least 2.5-fold across age subgroups (Fig. 3B). The prevalence of both T1DM and T2DM was consistently greater in the 20–24-year age group than in the younger age group. In 2021, Southeast Asia, East Asia, and Oceania emerged as the super-regions with the highest prevalence of T1DM (143.28, 95% UI 104.50–188.51) and the lowest prevalence of T2DM (2517.78, 95% UI 2038.91–3081.74) among individuals aged 20–24 years (Fig. 3C, D). High-income regions presented the highest prevalence of T1DM (474.12, 95% UI 391.17–564.00), whereas Central Europe, Eastern Europe, and Central Asia presented the lowest prevalence of T2DM (352.16, 95% UI 242.06–474.30) (Additional file 1: Table S3). At

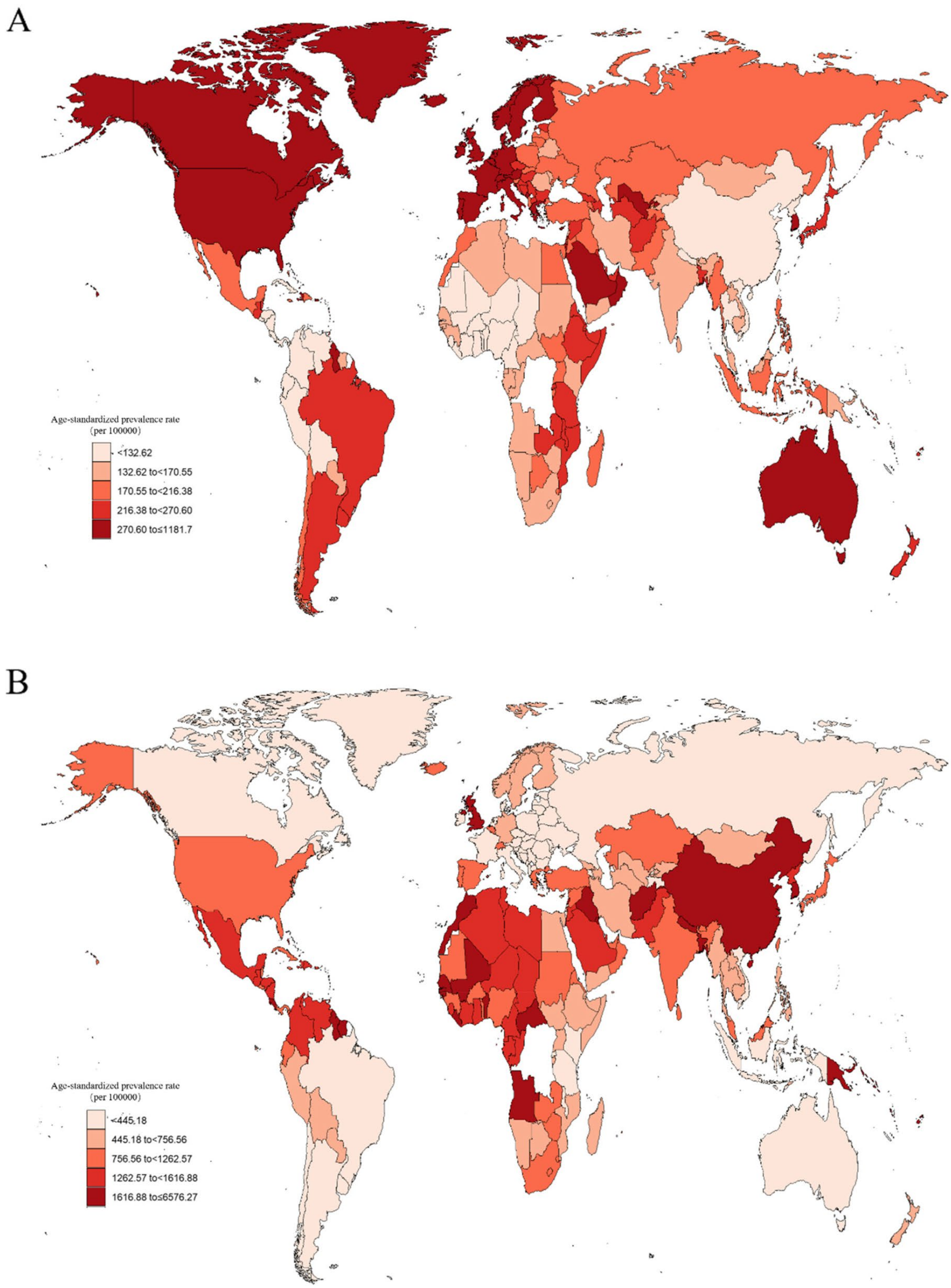

Fig. 1 Age-standardized prevalence rate of type 1 and type 2 diabetes mellitus among adolescents in 2021. **A** Type 1 diabetes mellitus. **B** Type 2 diabetes mellitus

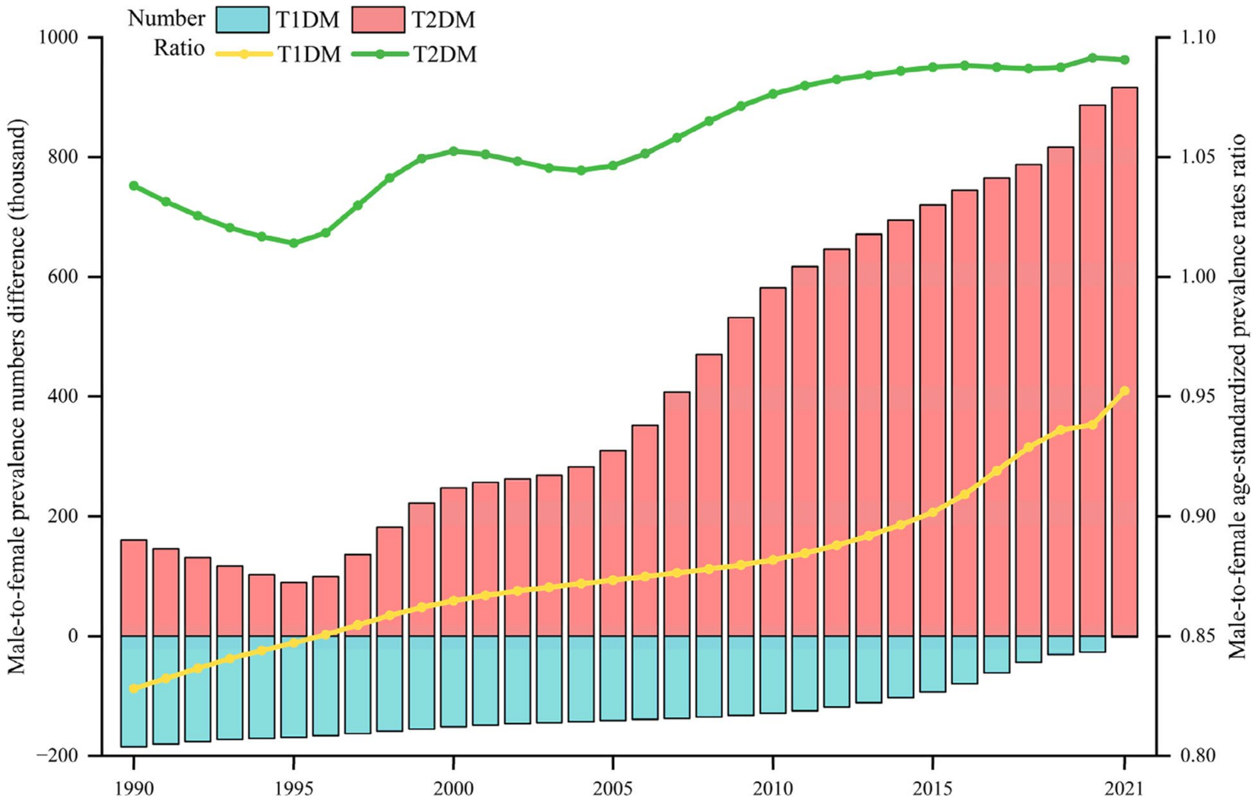

Fig. 2 Male-to-female prevalence numbers difference and age-standardized prevalence rates ratio for diabetes mellitus among adolescents from 1990 to 2021

the national and territory levels, Finland (10–14 years: 859.03 [819.91–900.44], 15–19 years: 1213.00 [1157.52–1263.33], 20–24 years: 1520.33 [1449.39–1589.08]) reported the highest prevalence of T1DM across all age groups, and the Marshall Islands (15–19 years: 3191.55 [2524.55–3897.96], 20–24 years: 10,173.62 [8283.51–12,498.11]) had the highest prevalence of T2DM across all age groups.

Adolescent diabetes burden: YLL, YLD, and DALY

Among adolescents, there were 735,700 (95% UI 667,187–802,876) total diabetes-related YLL and 937,222 (601,628–1,419,383) YLD, yielding 1,672,923 (1,325,093–2,141,723) DALY due to diabetes in 2021. T2DM constituted 43.0% of YLL, 81.2% of YLDs, and 64.9% of DALY (Additional file 1: Fig. S2). The ASDR for T1DM was 31.45 (95% CI 31.37–31.53), age-standardized YLL rate of 22.12 (22.06–22.19) and age-standardized YLD rate of 9.33 (9.29–9.37) (Additional file 1: Tables S4, S6–S7). For T2DM patients, the ASDR was 87.97 (87.81–88.14), with age-standardized YLL rate of 25.92 (25.83–26.01) and age-standardized YLD rate of 62.05 (61.92–62.19) (Additional file 1: Tables S5–S7). Regionally, the highest ASDR for T1DM was 63.76 (62.30–65.22) in the Caribbean, whereas Oceania reported the highest ASDR for T2DM at 256.89 (250.69–263.09) (Additional file 1: Fig. S3). Among 204 countries and territories, 39 (19.12%) had an ASDR for T1DM greater than 50 per 100,000, and 20 (9.80%) had an ASDR for T2DM greater than 200 per 100,000 (Additional file 1: Fig. S4).

From 1990 to 2021, the ASDR for T1DM decreased by 6.69% (6.67–6.70%). However, it is important to note that three regions (high-income North America, Tropical Latin America, and Central Asia) experienced increases in DALY rates of more than 10%. The ASDR for T2DM increased by 76.78% (76.94–76.63%). Five regions (high-income North America, East Asia, high-income Asia Pacific, North Africa, the Middle East, and Western Europe) had DALY rates that increased by more than 100%. A comparison of ASDR with SDI in the same region from 1990 to 2021 revealed an overall negative correlation between DALY and SDI (T1DM: $r= -0.51$, $p<0.01$; T2DM: $r= -0.62$, $p<0.01$) (Fig. 4). However, there are some epidemiological differences at the regional level. For example, ASDR of T1DM and T2DM consistently increased with increasing SDI in Oceania. Similar patterns were observed between the ASDR and SDI at

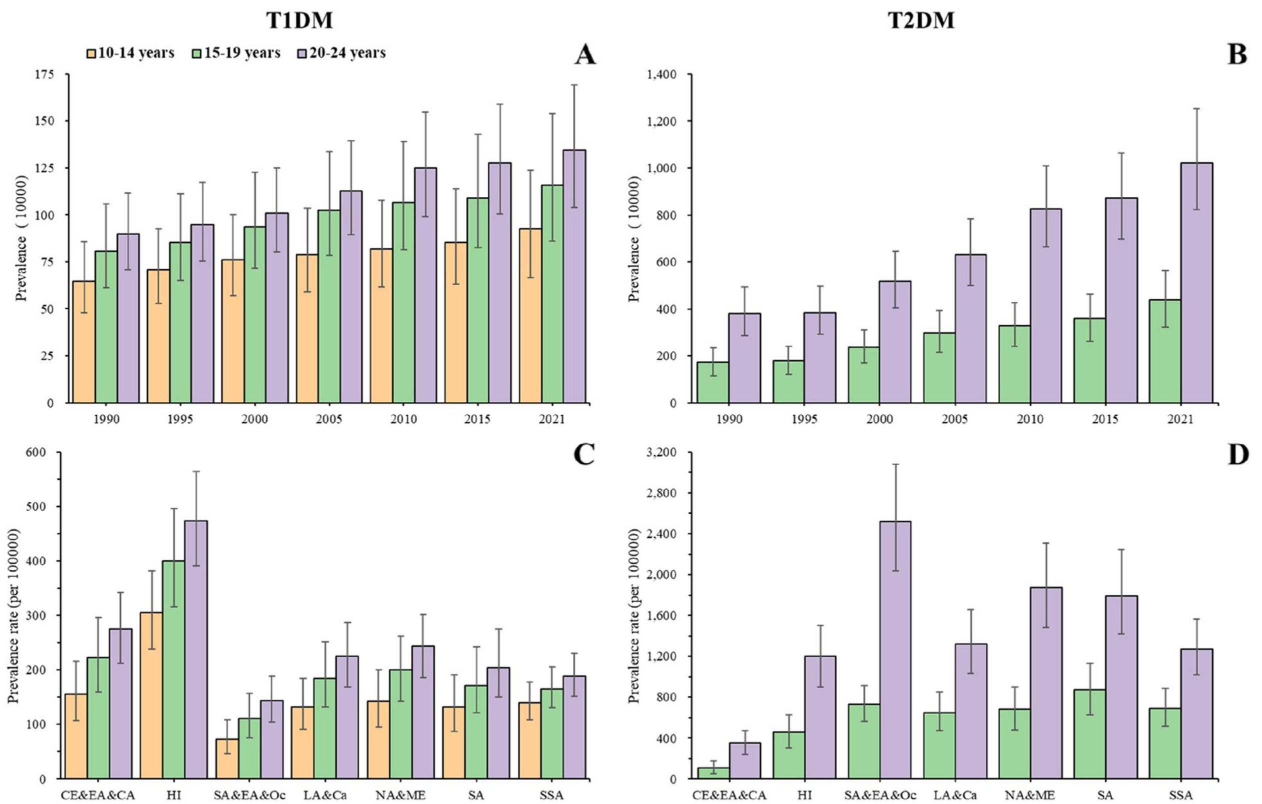

Fig. 3 Global prevalence of type 1 and type 2 diabetes in adolescents by age, 1990–2021 and by GBD super-region, 2021. **A** Global prevalence of T1DM by age, 1990–2021. **B** Global prevalence of T2DM by age, 1990–2021. **C** Prevalence of T1DM by GBD super-region, 2021. **D** Prevalence of T2DM by GBD super-region, 2021. CE&EE&CA: Central Europe, Eastern Europe, and Central Asia; HI: high-income; SA&EA&Oc: Southeast Asia, East Asia, and Oceania; LA&Ca: Latin America and Caribbean; NA&ME: North Africa and Middle East; SA: South Asia; SSA: Sub-Saharan Africa

the national level for T1DM and T2DM (Additional file 1: Fig. S5).

Adolescent diabetes mellitus risk factors

In 2021, DALY associated with T1DM were attributed to two main risk factors: low temperature (2.47%, 95%UI [1.56–3.61]) and high temperature (2.33% [0.78–4.19]) (Fig. 5). For T2DM, DALY was attributed to three risk factors: low temperature (0.79% [0.45–1.26]), high temperature (0.99% [0.38–1.79]), and high BMI (32.84% [17.38–43.70]). However, the contributions of these risk factors varied significantly across regions. In countries with high SDI, low temperature had a greater impact on the burden of T1DM (2.67% vs. 1.99%) and a smaller impact on the burden of T2DM (0.53% vs. 0.90%). High temperature had the smallest impact on the burden of both T1DM and T2DM (TID: 0.60% vs. 2.33%; T2DM: 0.53% vs. 0.90%). High BMI had the greatest impact on the burden of T2DM (48.16% vs. 23.16%). From 1990 to 2021, the proportion of DALY attributable to low temperature decreased for both T1DM and T2DM patients by 25.78% (16.97–34.38) and 47.04% (39.12–55.48), respectively (Additional file 1: Table S8). Conversely, the proportion of DALY attributable to high temperatures increased for both T1DM and T2DM, by 41.13% (27.69–55.65) and 18.94% (27.69–55.65), respectively. Additionally, high BMI as the proportion of DALY associated with T2DM increased by 40.78% (29.44–57.62), highlighting that BMI is a significant risk factor for T2DM among adolescents globally.

Adolescent diabetes mellitus prevalence over time: 1990–2021 and forecasts to 2030

Between 1990 and 2021, the ASPR of T1DM in adolescents increased by 19.53% (95% CI 19.50–19.56), from 151.39 (151.20–151.59) to 180.96 (180.77–181.15) (Additional file 1: Table S9). The ASPR of T2DM increased by 118.19% (118.12–118.26%), from 545.73 (545.28–546.18) to 1190.73 (1190.13–1191.34). The prevalence of T1DM and T2DM increased more rapidly in high-SDI areas than in lower-SDI regions, with increases of more than 37.4% for T1DM and 132.85% for T2DM. In 204 countries and territories, 26 (12.7%) reported an increase in the ASPR of T1DM of more than 50%, whereas 29 reported

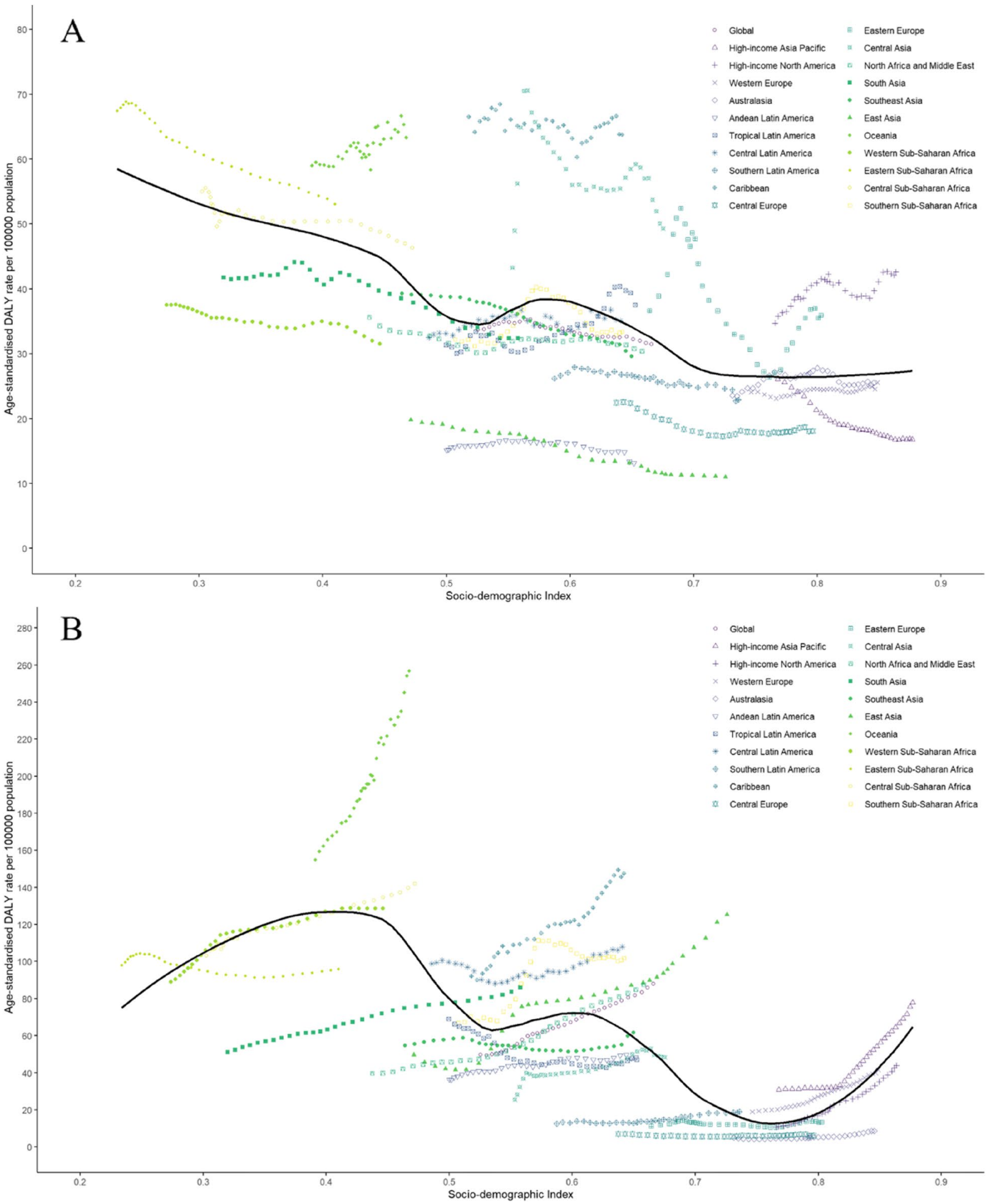

Fig. 4 Age-standardized DALY rates for type 1 and type 2 diabetes mellitus for 21 GBD regions by sociodemographic index, 1990–2021. **A** Type 1 diabetes mellitus. **B** Type 2 diabetes mellitus

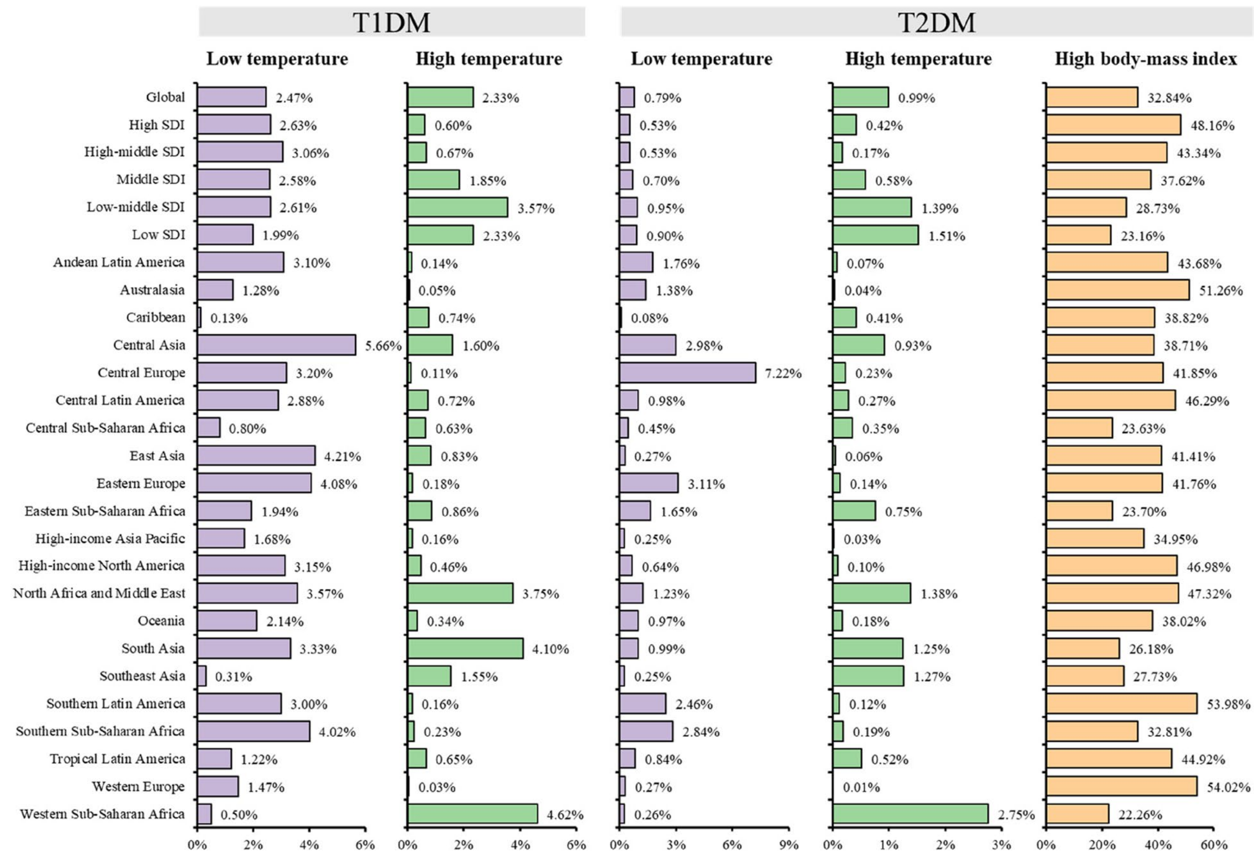

Fig. 5 The proportion of DALY attributable to risk factors for type 1 and 2 diabetes mellitus in adolescents, by Global Burden of Disease regions, 2021

a decrease of more than 10%. For T2DM, the ASPR increased by more than 200% in 23 countries (11.3%) and decreased by more than 25% in 15 countries (7.36%).

This study used the BAPC model to predict trends in the prevalence of diabetes in adolescents after 2021. The results indicate that between 2021 and 2030, the ASPR of T1DM in adolescents is projected to increase by 2.68%, from 180.96 to 185.80 (Fig. 6). Additionally, the ASPR of T2DM is projected to increase by 33.84%, from 1190.73 to 1593.73. Correspondingly, the number of adolescents with T1DM is expected to increase by 0.3 million people, from 3.4 million to 3.7 million, whereas the number of those with T2DM is projected to increase by 6.3 million, from 14.6 million to 20.9 million.

Discussion

To enhance the availability of comprehensive and high-quality data for improving care for adolescent diabetes patients, we conducted an analysis of the global burden of diabetes in adolescents. The study findings indicate that the global prevalence of T1DM and T2DM in adolescents increased from 1990 to 2021. During this period, there was a decrease in DALY for T1DM patients but a significant increase in DALY for T2DM patients. In the adolescent population, T1DM was more prevalent in females, whereas T2DM was more prevalent in males. Meanwhile, ASDR for T1DM and T2DM in adolescents increased with decreasing national and regional SDI levels. In addition, we also found that high BMI was the most significant risk factor for adolescent diabetes. These findings emphasize the pressing need for government intervention to enhance diabetes management and address the global burden of diabetes in the adolescent population.

Sex differences in the prevalence of T1DM and T2DM among adolescents

According to epidemiological studies, there are sex differences in the prevalence of different types of adolescent diabetes, which aligns with our findings [20, 21]. Our study revealed that T1DM was more prevalent in adolescent females than in males, whereas T2DM was more prevalent in adolescent males than in females. The differences in diabetes susceptibility between sexes can be attributed to biological disparities, culture, lifestyle,

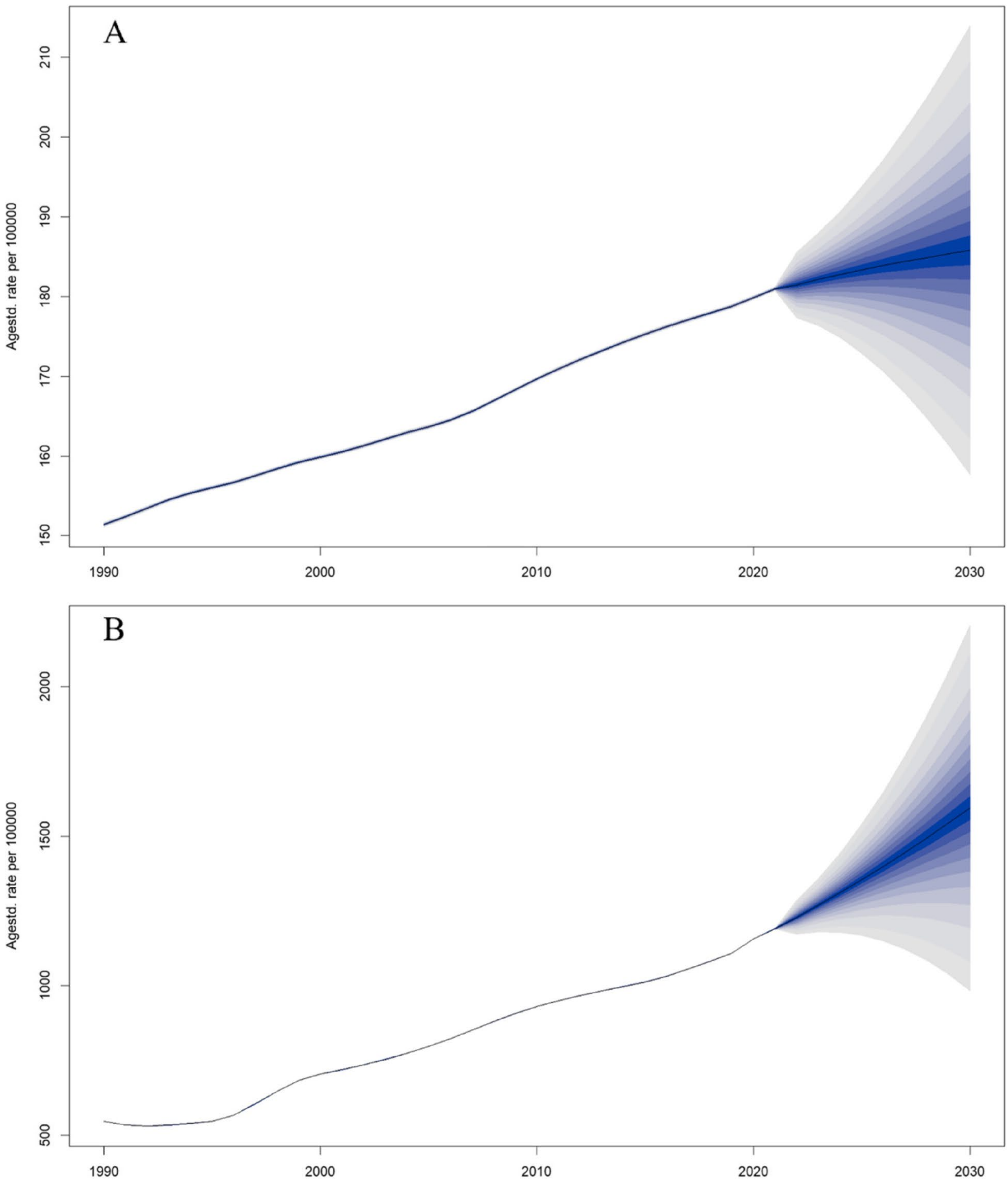

Fig. 6 Age-standardized prevalence of type 1 and type 2 diabetes mellitus from 1990 through 2030 forecasts. **A** Type 1 diabetes mellitus. **B** Type 2 diabetes mellitus

environment, and socioeconomic status [22, 23]. For example, during puberty, females are more susceptible to T1DM because of the influence of sex hormones, making them more likely than males of the same age to develop this condition [24]. While most studies suggest that diabetes is usually more prevalent in males than in females, it is crucial to note that, compared with diabetic males, diabetic females face a 6% higher risk of cancer [25], 27% higher risk of stroke [26], 58% higher risk of coronary heart disease, and 13% higher risk of all-cause mortality [27]. As a result, there is an urgent need for high-quality research on sex differences in diabetes and further consideration of sex-specific prevention and treatment strategies to enable both sexes to lead healthy lives in the future [28].

Relationships between the SDI and DALY among adolescent diabetes mellitus patients

Despite some exceptions, we discovered an overall negative correlation between the ASDR and the SDI in adolescents with T1DM and those with T2DM. These findings align with those of previous clinical studies, which indicated that low socioeconomic status is linked to a higher incidence of diabetes and its complications, poorer outcomes, and lower quality of care [29–32]. Socioeconomic status influences various aspects of diabetes management, such as the quality of healthcare, availability of community resources, access to diabetes-related knowledge, exercise, and diet [29]. Importantly, the disparities in socioeconomic status experienced during adolescence can have long-term effects in adulthood. This implies that customizing interventions for low-SDI areas and socially disadvantaged groups will have a positive impact on diabetes care and significantly help reduce the burden of diabetes in adolescents. Therefore, there is a need to strengthen international cooperation with low-SDI regions, increase investment in health resources, and improve access to health services to improve the health of the adolescent population.

Risk factors for T1DM and T2DM among adolescents

We found that high BMI is the most significant risk factor for T2DM in adolescents. For adolescents, progressive weight gain increases the likelihood of being diagnosed with diabetes [33]. Moreover, obesity exacerbates the adverse outcomes associated with diabetes and acts as a mediating variable between other risk factors and diabetes [34–36]. Although the mechanisms linking obesity to insulin resistance and T2DM have been well studied [37], obesity in adolescents has tripled globally since 1990 [38]. While GBD data do not reflect the impact of BMI on T1DM, a systematic review has shown that high BMI is associated with an increased risk of T1DM [39]. Therefore, the government should strengthen health education for adolescents to control the increase in obesity rates, promote the adoption of healthy dietary and living habits, actively engage in physical exercise and outdoor activities, and carry out regular screening of obese adolescents. Additionally, both low and high temperatures significantly contribute to the adolescent diabetes burden, particularly in low-SDI countries and those with T1DM. High temperatures may lead to abnormal thermoregulatory capacity and cause changes in glucose tolerance thereby increasing the risk of diabetes [40]. Low temperature may contribute to diabetes risk through indirect mechanisms, including dietary, physical activity, and socioeconomic disparities [41, 42]. This additional discussion highlights the need for future research to further explore and disentangle these factors to better understand their role in the observed associations.

Strengths and limitations of this study

Compared with previous studies, we conducted a more comprehensive and specific analysis of adolescent diabetes categorized by diabetes type. This study compared differences in the burdens of T1DM and T2DM in adolescents across region and sex by calculating age-standardized rate and projected the ASPR and number of people with diabetes in adolescents from 2022 to 2030. However, this study has several limitations. Despite the critical review and criteria for methodological differences established by the GBD study, the burden of diabetes among adolescents in countries with low levels of SDI may have been underestimated. This could be attributed to disparities in regional economic development and limitations of existing studies. Additionally, the GBD study identified risk factors based on a literature review and therefore could not include all known risk factors, which would have resulted in an overrepresentation of attribution to existing risk factors. Lastly, the GBD considers all diabetics under the age of 15 as havingT1DM. This assumption may result in an overestimation of the burden of T1DM and an underestimation of T2DM in the study's findings.

Conclusions

The prevalence of T1DM and T2DM in adolescents has been increasing since 1990, with significant differences by region, sex, and SDI level. Although the burden of diabetes in adolescents has declined among those with T1DM, it continues to increase among those with T2DM. In addition, controlling obesity remains a major challenge in the prevention and management of diabetes in adolescents.

Abbreviations

AAPC	Average annual percentage change
ASDR	Age-standardized DALY rate
ASPR	Age-standardized prevalence rate
BAPC	Bayesian age-period-cohort
CI	Confidence intervals
DALY	Disability-adjusted life years
GBD	Global Burden of Disease
SDI	Sociodemographic index
T1DM	Type 1 diabetes mellitus

T2DM	Type 2 diabetes mellitus
UI	Uncertainty interval
YLD	Years lived with disability
YLL	Years of life lost

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12916-025-03890-w.

Additional file 1. Fig. S1 Age-standardized prevalence rates for type 1 and type 2 diabetes mellitus among adolescents for 204 countries and territories by sociodemographic index, 2021. Fig. S2 Composition of DALY counts, YLD counts, and YLL counts for adolescent total diabetes in 2021. Fig. S3 Age-standardized DALY rates per 100,000 population for type 1 and type 2 diabetes among adolescents in 21 Global Burden of Disease regions, 2021. Fig. S4 Age-standardized DALY rates among adolescents per 100,000 population for type 1 diabetes and type 2 diabetes in 2021. Fig. S5 Age-standardized DALY rates for type 1 and type 2 diabetes mellitus among adolescents for 204 countries and territories by sociodemographic index, 2021. Table S1 Prevalence count and age-standardized prevalence rate of type 1 and type 2 diabetes mellitus among adolescents in 21 GBD regions and 204 countries and territories, 2021. Table S2 Male and female age-standardized prevalence rate, and sex ratio of age-standardized prevalence rate of type 1 and type 2 diabetes mellitus among adolescents in 21 GBD regions, and 204 countries and territories, 2021. Table S3 Age specific prevalence rate of type 1 and type 2 diabetes mellitus in adolescents per 100,000 population in 21 GBD regions and 204 countries and territories, 2021. Table S4 Age-standardized DALY rate per 100,000 population and the corresponding percentage change and average annual percentage changes of type 1 diabetes in adolescents in 21 GBD regions, and 204 countries and territories, 1990 to 2021. Table S5 Age-standardized DALY rate per 100,000 population and the corresponding percentage change and average annual percentage changes of type 2 diabetes in adolescents in 21 GBD regions, and 204 countries and territories, 1990 to 2021. Table S6 Age-standardized YLD rate and average annual percentage changes of type 1 and type 2 diabetes mellitus in adolescents per 100,000 population in 21 GBD regions, and 204 countries and territories, between 1990 and 2021. Table S7 Age-standardized YLL rate and average annual percentage changes of type 1 and type 2 diabetes mellitus in adolescents per 100,000 population in 21 GBD regions, and 204 countries and territories, between 1990 and 2021. Table S8 Percentage change in the proportion of adolescents with type 1 and type 2 diabetes mellitus DALY attributable to risk factors between 1990 and 2021 for diabetes globally, in 5 SDI regions and 21 Global Burden of Disease regions. Table S9 Global age-standardized prevalence of type 1 and type 2 diabetes mellitus in adolescents, 1990 to 2021.

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Authors' contributions
X.C. contributed to the study design, data analysis, and drafting and editing of the manuscript. L.Z. contributed to the study design, funding acquisition, review and editing of the manuscript. W.C contributed to the study design, funding acquisition, revising of manuscript. All authors read and approved the final manuscript.

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Data availability
The data used for analyses are publicly available at https://ghdx.healthdata.org/gbd-results-tool.

Declarations

Ethics approval and consent to participate
Ethical approval and informed consent were waived because the GBD is publicly available and no identifiable information was included in the analyses.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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