BMC Public Health

RESEARCH

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Burden of type 2 diabetes and its relationship with human development index in Asian countries: Global Burden of Disease Study in 2019

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Abstract

Background The mounting burden of type 2 diabetes is a major concern in healthcare systems worldwide. The purpose of this study is to investigate Burden of type 2 diabetes and its relationship with human development index in Asian countries.

Methods All accessible data from the 2019 Global Burden of Disease study were used to estimate the diabetes mellitus type 2 prevalence, mortality and disability-adjusted life years and diabetes mellitus type 2 in Asia from 1990 to 2019. We estimated all-cause and cause-specific mortality, years of life lost (YLLs), years lived with disability (YLDs), disability-adjusted life-years (DALYs) and attributable risk.

Results The results indicated that the human development index (HID) was positively and significantly correlated with the incidence of type 2 diabetes in men ($r=0.481$, $P<0.05$) and women ($r=0.414$, $P<0.05$, but the correlation between death and the HDI was not significant in men and women ($P>0.05$). The highest share of DALY risk factors in men (12093.2 per 100000) and in women (7122.4 per 100000) was related to behavioral factors. According to the results, air pollution, high fasting plasma glucose, and dietary risks are the main risk factors associated with the burden of type 2 diabetes in women and men, respectively.

Conclusion Given that the burden of type 2 diabetes is escalating in Asia and the burden of disease can be largely controlled by managing its risk factors, the disease management program in different countries, especially in countries with high prevalence and high burden could be reduced by making policies.

Keywords Incidence, Mortality, Prevalence, Burden, Diabetes mellitus, HDI, Asia

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Introduction

Diabetes is one of the top 10 leading causes of death worldwide, accounting for more than 80% of all non-communicable disease (NCDs) deaths, along with cardiovascular disease, cancer and respiratory diseases [1]. In diabetic patients, the risk of all-cause death is 2–3 times higher. Diabetes is associated with increased mortality from infection, cardiovascular disease, stroke, chronic kidney disease, chronic liver disease, and cancer [2].

Diabetes imposes a heavy global burden on public health as well as socio-economic development. Although the prevalence of this disease is beginning to decline in some countries, it has taken an upturn in recent decades in most developed and developing countries [3, 4]. To date, the International Diabetes Federation (IDF) estimated that 451 million adults worldwide suffered from diabetes in 2017, which is projected to increase to 693 million by 2045 unless effective prevention methods are adopted [5].

Despite considerable investment in clinical care and pharmaceutical research, the burden of diabetes is on rise. This surge has exceeded population growth and aging [6].

Diabetes prevalence is increasing in Asia [7]. The alarming increase in diabetes prevalence in Asia can be explained by several factors, such as lower body mass index (BMI) with higher adiposity and younger age of onset of diabetes [8, 9]. Another important factor in the high prevalence of diabetes in Asia is the presence of the most populous countries, China and India. These two countries have the highest number of diabetic patients in the world, thus contributing to the major share of the worldwide diabetes prevalence [10]. The major increase in diabetes prevalence in developing countries has occurred due to rapid and ongoing socioeconomic transitions and is likely to lead to further increases [11] (2).

A socioeconomic gradient in the prevalence of type 2 diabetes (T2D) has been observed in high-income countries, and this gradient appears to persist despite improvements in health systems and national wealth. In addition, the educational gradient in diabetes prevalence has increased in some countries [12].

In patients with T2D, socioeconomic status influences individual capabilities, community or neighborhood support, health-related behaviors, access to care, and the care process at different levels [13]. In fact, low SES patients are more likely to report barriers to diabetes care such as access to care, cost, poor health status, and disability [14, 15]. Meanwhile, socioeconomic inequalities continue to affect health care coverage and access to or use of health care [16].

Another factor that influences the prevalence and incidence of diabetes is the Human Development Index (HDI) [17, 18]. This index is used as a measure of the level of economic and social development of countries and includes three main dimensions: life expectancy, education, and income [19].

The aim of this study is to investigate the burden of type 2 diabetes and its association with the Human Development Index in Asian countries.

Design and method

Study design, setting, and population

This is a correlational analytical study that aims to explore the burden of type 2 diabetes in Asia from 1990 to 2019. All the data used in this research were made available to the public at https://ghdx.healthdata.org/gbd-results-tool. Data were extracted using Global Burden of Disease (GBD) results. These data including mortality and incidence estimates for all age and sex groups. For some indices, the percentage change between 1990 and 2019 was reported. The estimation process within the Global Burden of Disease (GBD) framework involves a meticulous approach to identify various data sources that are relevant to each disease or injury. These sources include censuses, household surveys, civil and vital statistics registries, disease registries, health service usage records, air pollution monitoring, satellite imagery, disease notifications, and other pertinent sources. The identification of these data types was carried out through a systematic review of published studies, searches of government and international organization websites, examination of published reports, extraction from primary data sources such as demographic and health surveys, and contributions of datasets from GBD collaborators. The comprehensive methodology of GBD 2019, has been explained in previous studies [20, 21]. More detailed information on the data inputs used in the GBD study can be found at http://ghdx.healthdata.org/gbd-2019/data-input-sources.

Case definition

The reference case definition for type 2 diabetes was fasting plasma glucose (FPG) ≥ 126 mg/dL (7 mmol/L), or being treated with medication or insulin for type 2 diabetes. A list of alternative case definitions has been previously reported [21]. In 20% of the available articles, diabetes estimates were based on the type present, and the diagnostic criteria in articles that reported type 2 diabetes separately were not sufficiently precise. Therefore, type 2 diabetes estimates were used from 1990 to 2019 by subtracting type 1 diabetes estimates from the combined diabetes estimates for each age, sex, and location [21].

DALY, YLL and YLD

DALY is a type of health gap index that calculates the years of life lost, either due to premature death or due to non-fatal diseases. This index was defined and used in the GBD and Injuries Study to calculate the burden

of diseases [22]. The years of life lost due to premature death index, developed by the World Health Organization in the burden of diseases study, can be used to identify and prioritize the causes of premature deaths. This index takes into account not only the number of deaths but also the age of the deceased at the time of death, and the younger the age of the deceased at the time of death, the higher the number of years of life lost. The lost years of life are the years, lost due to premature death, that a person could have had a useful life [22]. It refers to the years a person suffered from a disability due to an illness [22].

Human development index (HDI)

The Human Development Index (HDI) is an index for measuring several different criteria about countries and examines them in terms of things such as the level of health, access to education, balance between work and life, etc. This index includes three dimensions of human development: long and healthy life, knowledge and appropriate living standards.These indices are used to create a health index, an education index, and an income index, each of which has a value between 0 and 1. The geometric mean of these three indicators - that is, the cube root of the product of the indicators - is the human development index. A value above 0.800 is classified as very high, between 0.700 and 0.799 as high, 0.550 to 0.699 as medium, and below 0.550 as low [23, 24].

Statistical analysis

In this study, Pearson correlation method was used to analyze the data to investigate the correlation between the burden of type 2 diabetes and HDI. The significance level was set at $P<0.05$. Data analysis was performed using Stata software version 12 (Stata Corp, College Station, TX, USA).

Results

Asia is ranked third in the world in terms of type 2 diabetes with an incidence of 280.59 per 100,000 people, mortality of 18.06 per 100,000 people and a DALY of 836.16 per 100,000 population.

As depicted, the incidence and death of type 2 diabetes has taken an upward trend and the incidence of type 2 diabetes has risen from 146.5 per 100,000 in 1990 to 280.5 in 2019 while the death rate of the disease has climbed from 8.6 per 100,000 to 18.06 in 2019 (Fig. 1).

The analysis of the burden of type 2 diabetes in Asia reveals its upward trend in Asia from 1990 to 2019, so that YLD climbed from 189.3 per 100,000 in 1990 to 438.9 per 100,000 in 2019. The YLD has also risen from 213 per 100,000 in 1990 to 397.1 per 100,000 in 2019, and DALY has surged from 402.3 per 100,000 in 1990 to 836.1 per 100,000 in 2019 (Fig. 2).

The results showed that the burden of diabetes increased similarly in men and women from 1990 to 2005, and since 2005 this trend has been slightly greater in men than in women (Fig. 3).

The chart below (Fig. 4) manifests the distribution of disease burden by age and sex. As can be seen, diabetes burden has increased by aging in women and men. In men of all age groups, the burden of diabetes is higher than women. In women, the disease burden has taken a downturn at the age of 84, and in men, this downturn has appeared from the age of 89 onwards.

The results of the study showed that according to the estimated statistics, the highest incidence of type 2 diabetes in 2019 was in Bahrain (99.44 per 100,000), Qatar (835.02 per 100,000) and Brunei (697.38 per 100,000), respectively. The highest deaths of type 2 diabetes in Asia in 2019 were registered in Sri Lanka (58.29 per 100,000), Bahrain (48.53 per 100,000) and Armenia (39.14 per 100,000), respectively. The highest prevalence of type

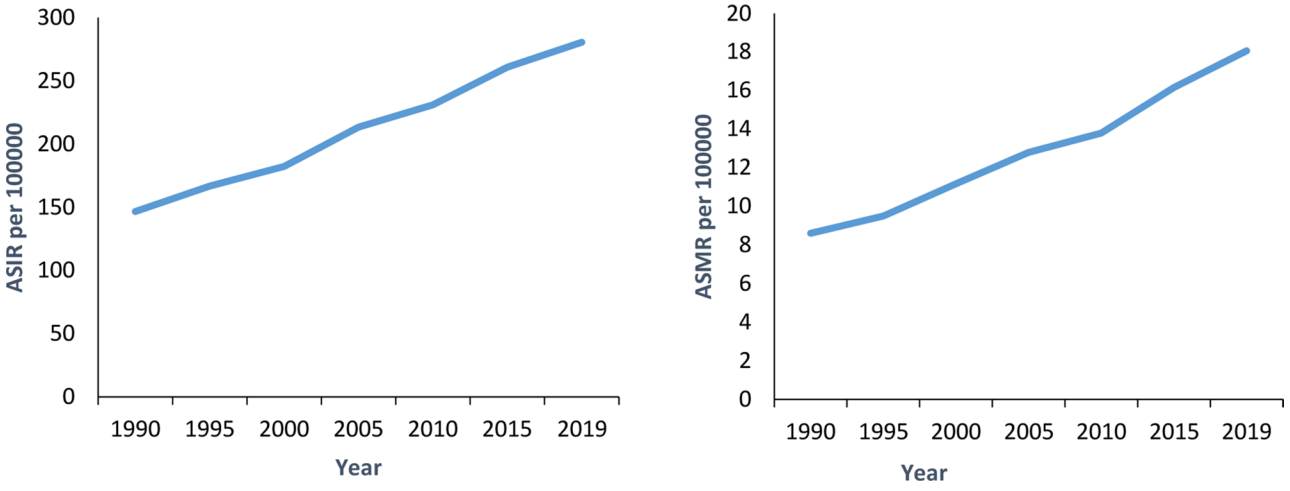

Fig. 1 Trend of ASIR and ASMR of diabetes mellitus type 2 during 1990–2019 in Asia. ASIR: Age-Standardized Incidence Rate, ASMR: Age-Standardized Mortality Rate. (Source: Global Burden of Disease 2019)

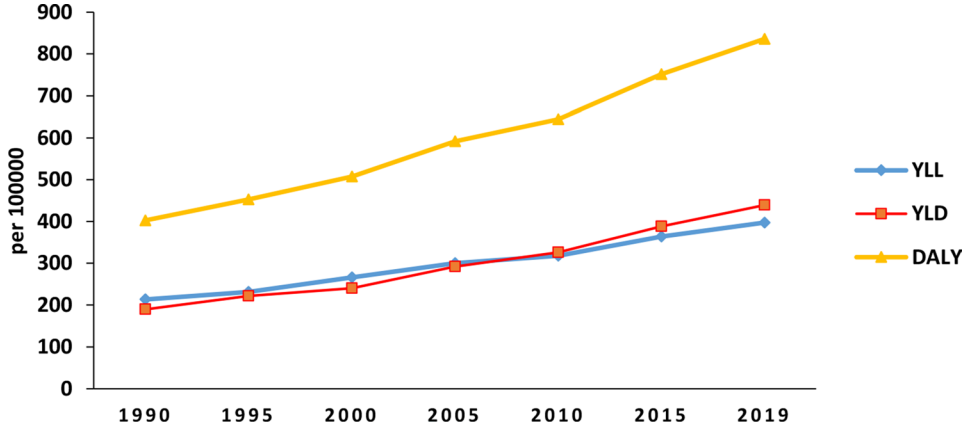

Fig. 2 Trend of DALY, YLL and YLD of diabetes mellitus type 2 during 1990–2019 in Asia. (Source: Global Burden of Disease 2019)

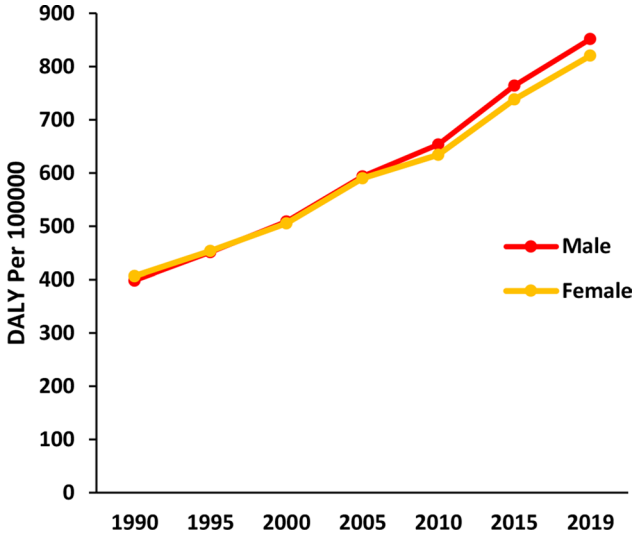

Fig. 3 Trend of DALY of diabetes mellitus type 2 during 1990–2019 in Asia by sex. (Source: Global Burden of Disease 2019)

2 diabetes was also reported in Bahrain (12965.2 per 100,000) and Georgia (11382.4 per 100000), respectively (Table 1).

According to type 2 diabetes statistics in Asia in 2019, the highest YLL index was reported in Bahrain (1133.19 per 100,000), Sri Lanka (1132.1 per 100000), respectively. The highest YLD of type 2 diabetes was related to Sri Lanka (1043.85 per 100000) and Bahrain (1027.242 per 100000), respectively, and the highest DALY was reported in Sri Lanka (2175.96 per 100000) and Bahrain (2175.46 per 100000) (Table 2).

The analysis of the global distribution of type 2 diabetes based on the level of development suggested that the highest DALY of type 2 diabetes is related to high SDI regions, which accounts for 24% of the DALY of type 2 diabetes in the world. The highest incidence of type 2 diabetes (28% of the total global incidence of type 2 diabetes) is also related to high SDI regions and the highest reported death of this disease (25% of the total deaths related to type 2 diabetes in the world) is reported middle SDI regions (Fig. 5).

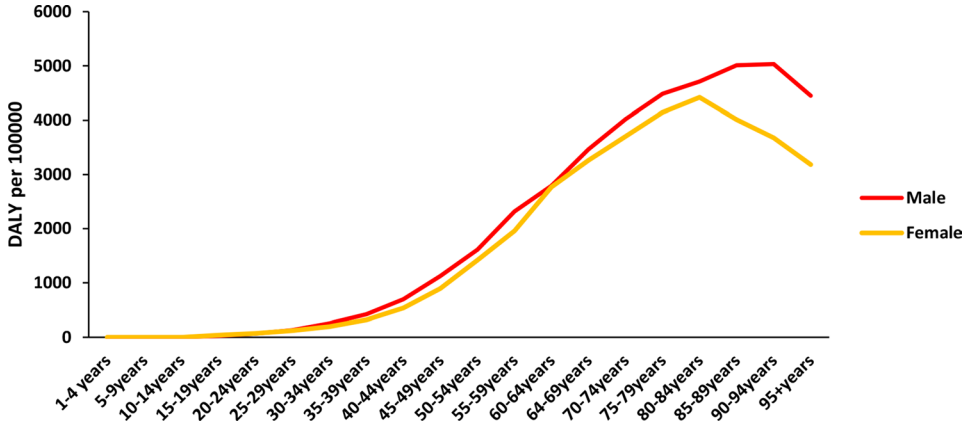

Fig. 4 Trend of DALY of diabetes mellitus type 2 in Asia by sexes and age. (Source: Global Burden of Disease 2019)

Table 1 Incidence, death and prevalence of type 2 diabetes, according to sex in Asian countries. (source: Global Burden of Disease 2019)

Asian countries	ASIR per 100,000			ASMR per 100,000			ASPR per 100,000		
	Both	Female	Male	Both	Female	Male	Both	Female	Male
Afghanistan	252.19	286.79	219.34	11.31	17.53	5.41	3630.64	4292.02	**3002.86**
Armenia	330.71	357.87	301.60	39.14	45.49	32.35	7135.14	7950.43	**6261.27**
Azerbaijan	298.60	321.02	276.19	19.00	20.96	17.05	5487.96	6063.51	**4912.98**
Bahrain	996.44	838.62	1092.41	48.53	53.64	45.42	12965.21	11185.74	**14047.21**
Bangladesh	211.51	211.25	211.78	19.24	19.86	18.60	4055.30	4015.50	**4096.17**
Bhutan	231.61	223.49	239.08	19.47	20.44	18.58	4262.95	4163.72	**4354.28**
Brunei	697.38	578.96	804.97	37.19	35.03	39.15	10462.12	8916.10	**11866.85**
Cambodia	262.54	269.82	254.99	20.19	22.95	17.32	4232.05	4511.81	**3942.01**
China	262.88	260.00	265.66	11.84	12.22	11.48	6328.79	6013.81	**6631.91**
Georgia	378.98	364.24	395.03	20.58	19.23	22.03	11382.43	10787.74	**12015.69**
India	302.48	282.13	321.81	18.62	18.61	18.62	5885.54	5526.91	**6226.23**
Indonesia	243.46	238.91	247.93	38.03	39.23	36.85	3883.71	3850.95	**3915.88**
Iran	345.78	363.72	328.40	16.83	18.48	15.24	5972.88	6269.08	**5685.93**
Iraq	344.32	356.38	332.82	21.46	21.57	21.35	5532.81	5865.38	**5215.95**
Israel	277.37	283.38	271.31	27.86	29.42	26.28	5529.40	5771.61	**5285.01**
Japan	241.67	198.36	287.24	6.68	6.66	6.71	6856.60	5736.02	**8035.62**
Jordan	330.17	282.34	371.90	17.19	17.45	16.97	5088.19	4347.66	**5734.28**
Kazakhstan	311.37	360.07	259.53	13.25	16.43	9.87	6165.86	7553.27	**4688.86**
Kuwait	544.82	464.66	614.30	8.01	6.28	9.50	8489.24	6980.27	**9796.91**
Kyrgyzstan	140.92	147.57	134.12	4.50	5.00	3.99	2632.69	2897.48	**2362.22**
Lao People's Democratic Republic	272.72	287.25	258.35	20.11	23.34	16.91	4292.50	4589.11	**3998.95**
Lebanon	390.89	377.22	404.99	15.86	12.48	19.34	7756.97	7630.34	**7887.66**
Malaysia	332.82	342.42	323.87	10.33	11.19	9.52	5797.03	6009.54	**5598.80**
Maldives	231.55	223.90	236.60	9.71	10.09	9.46	3604.10	3671.05	**3559.86**
Mongolia	104.08	100.80	107.46	3.35	2.51	4.21	1838.69	1876.62	**1799.73**
Myanmar	330.53	366.80	291.40	38.16	36.16	40.31	5328.96	6108.49	**4487.86**
Nepal	223.39	208.84	239.37	10.67	10.02	11.38	4440.84	3999.12	**4925.85**
Oman	325.51	277.27	352.10	14.00	17.43	12.11	4205.32	3931.67	**4356.21**
Pakistan	220.89	221.09	220.71	20.07	22.55	17.70	3769.04	3684.39	**3849.53**
Philippines	209.58	230.81	188.93	23.22	23.68	22.77	3259.78	3725.18	**2807.26**
Qatar	835.02	728.73	871.18	11.71	14.99	10.60	9575.36	8439.28	**9961.89**
Saudi Arabia	473.53	428.65	505.54	7.83	6.92	8.48	6958.35	6307.34	**7422.83**
Singapore	359.14	293.07	422.35	3.09	3.20	2.98	7709.25	6455.36	**8908.74**
Sri Lanka	623.22	634.32	611.35	58.29	60.89	55.52	10741.96	11405.11	**10032.97**
Syrian Arab Republic	356.36	356.51	356.21	11.03	11.44	10.60	6255.85	6063.12	**6458.83**
Tajikistan	230.40	236.98	223.96	15.58	15.47	15.67	3736.81	3912.98	**3564.50**
Thailand	359.84	363.20	356.30	26.16	29.16	23.00	6777.48	6917.31	**6630.75**
Timor-Leste	198.75	193.68	203.70	13.18	15.87	10.56	3191.07	3107.28	**3272.91**
Turkey	317.49	317.94	317.05	23.15	27.03	19.34	5672.28	5811.62	**5535.82**
Turkmenistan	216.98	224.26	210.00	12.99	14.17	11.85	4195.66	4654.96	**3755.60**
United Arab Emirates	691.00	537.01	749.05	13.33	9.71	14.70	7782.55	6362.53	**8317.85**
Uzbekistan	254.98	249.62	260.36	21.35	22.19	20.51	4104.89	4176.41	**4033.11**
Viet Nam	290.98	302.98	278.76	28.78	34.42	23.03	4514.43	4891.28	**4130.66**
Yemen	154.06	159.29	148.95	5.14	6.23	4.08	2347.71	2430.65	**2266.62**
Republic of Korea	242.22	245.65	238.75	23.62	24.02	23.23	5263.27	5525.12	**4998.80**
Democratic People's Republic of Korea	242.22	245.65	238.75	14.69	18.34	11.01	5263.27	5525.12	**4998.80**

**ASPR: Age-Standardized Prevalence Rate, ASIR: Age-Standardized Incidence Rate, ASMR: Age-Standardized Mortality Rate

Table 2 Distribution of YLL, YLD and DALY Diabetes mellitus type 2 in 2019 by country in Asia. (source: Global Burden of Disease 2019)

Asian countries	YLL			YLD			DALY		
	Both	Female	Male	Both	Female	Male	Both	Female	Male
Afghanistan	309.74	485.61	142.81	270.32	322.01	221.25	580.06	807.62	**364.06**
Armenia	815.99	895.56	730.70	649.80	736.52	556.85	1465.79	1632.08	**1287.55**
Azerbaijan	482.83	513.25	452.44	482.78	541.67	423.95	965.62	1054.93	**876.39**
Bahrain	1133.19	1150.96	1122.38	1042.27	922.26	1115.24	2175.46	2073.22	**2237.62**
Bangladesh	358.05	381.96	333.49	330.09	320.03	340.42	688.14	701.99	**673.91**
Bhutan	382.90	403.08	364.32	349.95	338.80	360.22	732.85	741.88	**724.54**
Brunei	913.66	803.08	1014.13	813.30	707.22	909.69	1726.96	1510.30	**1923.82**
Cambodia	485.56	522.62	447.14	372.70	398.01	346.46	858.26	920.63	**793.60**
China	234.65	230.15	238.99	440.52	419.59	460.66	675.18	649.74	**699.65**
Georgia	709.92	667.80	755.75	862.34	806.04	922.30	1274.34	1162.76	**1393.15**
India	401.27	392.77	409.34	462.54	433.69	489.94	863.81	826.45	**899.29**
Indonesia	1029.99	1043.26	1016.95	340.66	334.27	346.94	1370.65	1377.53	**1363.90**
Iran	337.21	358.03	317.05	512.70	540.44	485.82	849.91	898.47	**802.87**
Iraq	519.08	512.05	525.78	431.09	462.85	400.83	950.17	974.90	**926.61**
Israel	404.53	378.89	430.41	418.06	437.61	398.33	822.59	816.50	**828.74**
Japan	91.95	74.13	110.70	587.57	502.99	676.56	679.52	577.13	**787.26**
Jordan	367.70	351.81	381.56	376.64	337.79	410.54	744.34	689.60	**792.11**
Kazakhstan	292.14	340.76	240.37	542.93	675.92	401.35	835.07	1016.68	**641.73**
Kuwait	158.38	123.19	188.87	644.20	535.82	738.12	802.57	659.01	**926.98**
Kyrgyzstan	120.00	126.28	113.59	225.67	252.49	198.28	345.67	378.77	**311.87**
Lao People's Democratic Republic	509.10	568.52	450.29	373.99	397.36	350.87	883.09	965.88	**801.16**
Lebanon	295.10	234.75	357.39	704.19	698.33	710.23	999.29	933.08	**1067.62**
Malaysia	240.15	248.84	232.04	485.90	505.59	467.53	726.05	754.43	**699.57**
Maldives	205.62	204.52	206.34	307.80	315.80	302.52	513.42	520.31	**508.86**
Mongolia	101.21	67.94	135.39	155.04	161.51	148.39	256.25	229.44	**283.78**
Myanmar	910.39	799.43	1030.11	472.36	540.33	399.01	1382.75	1339.77	**1429.13**
Nepal	212.39	169.22	259.79	363.47	323.09	407.80	575.86	492.31	**667.59**
Oman	323.69	398.33	282.53	317.50	307.88	322.81	641.19	706.20	**605.34**
Pakistan	493.02	554.28	434.76	323.63	306.28	340.14	816.65	860.56	**774.90**
Philippines	583.46	541.27	624.48	288.47	329.18	248.89	871.93	870.46	**873.37**
Qatar	283.29	340.17	263.93	718.42	649.68	741.80	1001.71	989.86	**1005.74**
Saudi Arabia	223.81	200.07	240.75	463.38	421.88	492.99	687.20	621.95	**733.75**
Singapore	56.21	52.54	59.72	615.45	502.84	723.18	671.66	555.37	**782.90**
Sri Lanka	1132.10	1099.45	1167.02	1043.85	1100.65	983.13	2175.96	2200.10	**2150.15**
Syrian Arab Republic	246.48	251.53	241.15	504.46	491.34	518.28	750.94	742.87	**759.43**
Tajikistan	427.62	418.23	436.82	319.35	338.94	300.20	746.98	757.17	**737.02**
Thailand	569.27	587.99	549.62	619.50	629.34	609.17	1188.77	1217.33	**1158.80**
Timor-Leste	304.26	360.36	249.48	284.30	275.01	293.37	588.56	635.37	**542.84**
Turkey	430.82	464.56	397.77	516.44	547.09	486.43	947.26	1011.65	**884.20**
Turkmenistan	366.85	388.51	346.10	360.15	407.10	315.16	727.00	795.61	**661.26**
United Arab Emirates	407.00	272.24	457.81	544.55	454.56	578.48	951.56	726.80	**1036.28**
Uzbekistan	582.87	590.94	574.77	353.86	364.69	342.98	936.72	955.62	**917.75**
Viet Nam	594.24	642.30	545.30	409.88	444.72	374.40	1004.12	1087.01	**919.70**
Yemen	124.45	151.34	98.16	182.43	190.38	174.66	306.88	341.72	**272.81**
Republic of Korea	394.50	334.01	453.73	589.32	570.96	607.30	983.82	904.96	**1061.03**
Democratic People's Republic of Korea	335.86	387.77	283.43	420.48	449.33	391.34	756.34	837.10	**674.77**

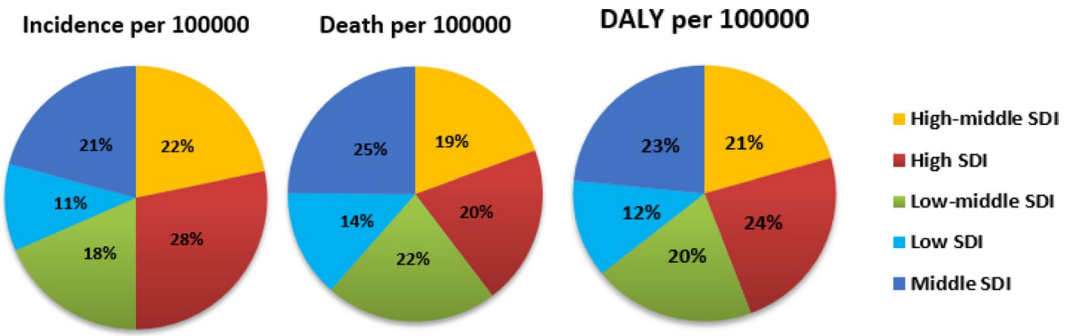

Fig. 5 Distribution of Incidence, Death and DALY of diabetes mellitus type 2 by SDI level. (Source: Global Burden of Disease 2019)

In examining the relationship between HDI and the incidence and death of type 2 diabetes in Asia, the results revealed that the incidence of type 2 diabetes in men ($r=0.481$, $P<0.05$) and women ($r=0.414$, $P<0.05$) was positively and significantly correlated with HDI, while the observed correlation between death and HDI in women and men was not significant ($P>0.05$) (Fig. 6).

shows the association between the burden of type 2 diabetes and HDI in Asia in 2019. As can be seen, there is a positive and significant correlation between YLD and HDI ($r=0.541$, $P<0.05$). The results demonstrated that the relationship of DALY and YLD with HDI was not significant ($P>0.05$) (Fig. 7).

Figure 8 shows the distribution of risk factors for type 2 diabetes by age group in Asia in 2019. As is shown, in all age groups, metabolic factors have the largest share in all three indices of DALY, YLD and YLL in type 2 diabetes and aging reinforces the impact of all three factors (metabolic, environmental and behavioral) on DALY, YLL, and YLD (Fig. 8).

In examining the risk factors associated with the burden of disease in women and men in Asia, the results showed that High Body Mass Index and Dietary Risks were the highest risk factors associated with the burden of type 2 diabetes in women and men, respectively (Fig. 9).

Discussion

According to the results, the highest incidence of diabetes is related to Sri Lanka (21175.96 per 100000) and Bahrain (21175.46 per 100000). The results also demonstrate the positive and significant correlation between the incidence of type 2 diabetes in men ($r=0.481$, $P<0.05$) and women ($r=0.414$, $P<0.05$) and HDI. A positive and significant correlation was observed between YLD and HDI ($r=0.541$, $P<0.05$). As suggested by the results, the highest prevalence of type 2 diabetes in Asia is related to Bahrain (12965.2 per 100,000) and Georgia (11382.4 per 100000). The results showed that High Body Mass Index and Dietary Risks were the highest risk factors associated with the burden of type 2 diabetes in women and men, respectively.

Diabetes is a significant global public health issue [25]. The projected increase in diabetes prevalence from 1995 to 2025 is estimated to be 42% in developed countries and 170% in developing countries [26]. Managing diabetes necessitates lifelong medical care to prevent secondary complications. Effective diabetes control involves a combination of therapeutic and preventive strategies, considering biological and behavioral health factors, the responsiveness of health services, and socioeconomic conditions. This approach requires a comprehensive understanding of the incidence, mortality, and burden of the disease in each country [27].

In this study, the results indicated that the incidence, mortality, and burden of type 2 diabetes increased in Asia from 1990 to 2019.

The upward trend in diabetes incidence in this study was consistent with some other reports around the world. Lin et al. demonstrated that the global incidence of diabetes rose significantly from 1990 to 2017 [28]. Additionally, both the study by Lin et al. and the World Health Organization report indicated that the mortality rate associated with diabetes has increased worldwide, which is consistent with the current findings [28].

The rising incidence of diabetes is often linked to the increased prevalence of high-risk behaviors, including obesity, physical inactivity, and poor dietary choices [29].

The prevalence of obesity and the proportion of energy intake from fat have risen over time, and the aging population may also contribute to the increase in diabetes rates. Another factor influencing the rise in diabetes incidence is the advancement of diagnostic methods. With enhanced diabetes screening techniques and heightened public awareness, participation in screening programs has increased, resulting in the identification of more diabetes cases. Furthermore, studies indicate that the percentage of individuals with undiagnosed diabetes has declined over time. Lifestyle interventions, such as increased physical activity and healthier diets, can lead to a reduction in diabetes prevalence [30–34].

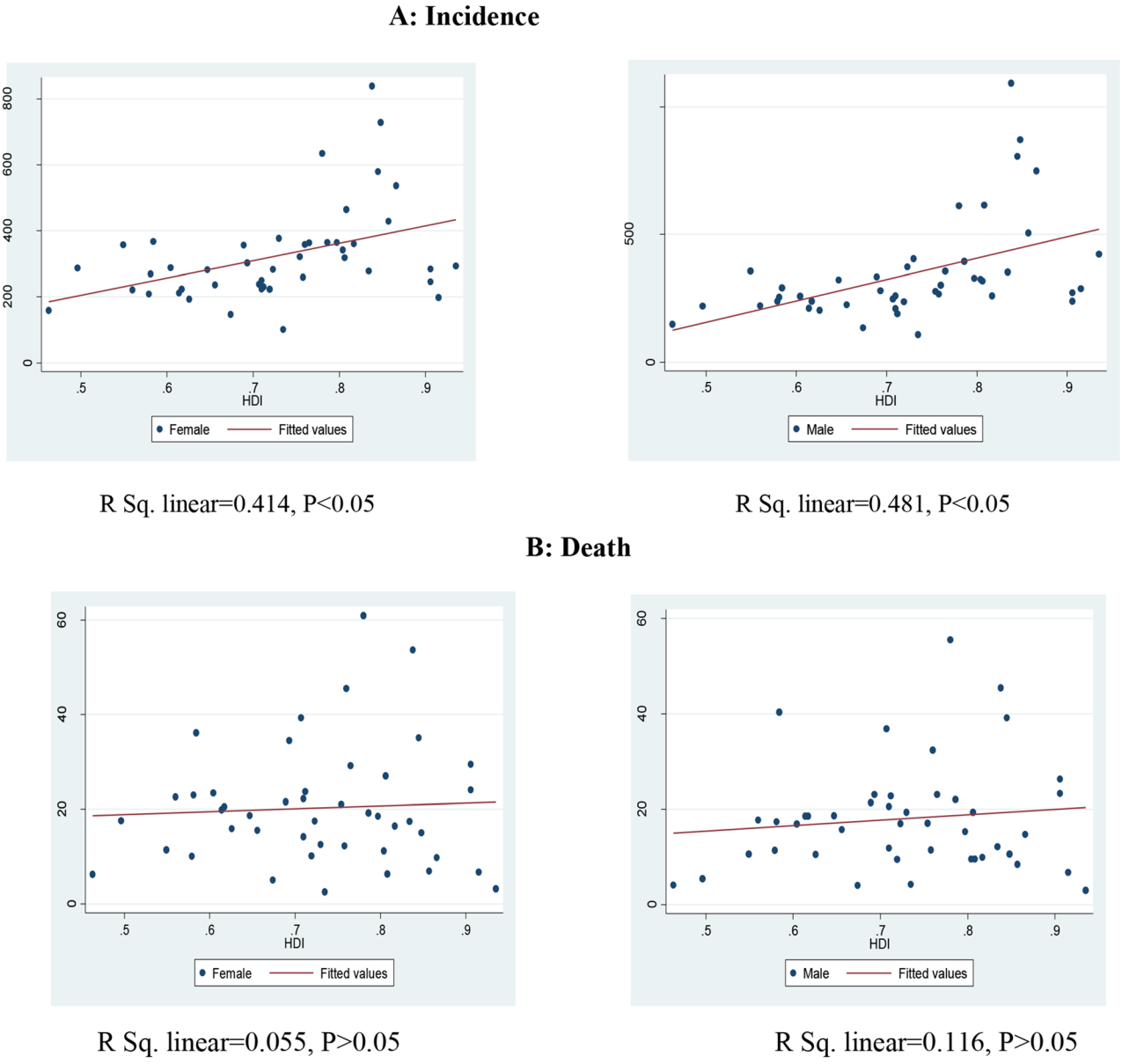

Fig. 6 Correlation of HDI with **A**: Incidence, **B**: Death of diabetes mellitus type 2 in Asia in 2019

In examining the risk factors associated with the burden of disease in both women and men, the results indicated that a high body mass index and dietary risks are the most significant contributors to the burden of type 2 diabetes in both genders.

Approximately 90% of individuals with type 2 diabetes are overweight or obese. This suggests a direct correlation between obesity and the onset of diabetes. Obesity can induce metabolic changes that elevate the risk of developing diabetes. The accumulation of fat in the liver can hinder insulin production and result in elevated blood sugar levels [35, 36].

Obesity is a major risk factor for type 2 diabetes, and weight loss can positively impact blood sugar control while reducing the risk of developing this disease. Implementing dietary changes, increasing physical activity, and managing weight are effective strategies for preventing and controlling diabetes associated with obesity [37–39].

On the other hand, the nutritional risks associated with diabetes primarily stem from poor food choices, the consumption of processed foods, simple carbohydrates, and unhealthy fats. To prevent or manage diabetes, individuals should adopt a balanced diet that incorporates nutritious foods [40, 41].

The results of this study indicated that the highest incidence of type 2 diabetes in 2019 occurred in Bahrain, Qatar, and Brunei, respectively, while the highest

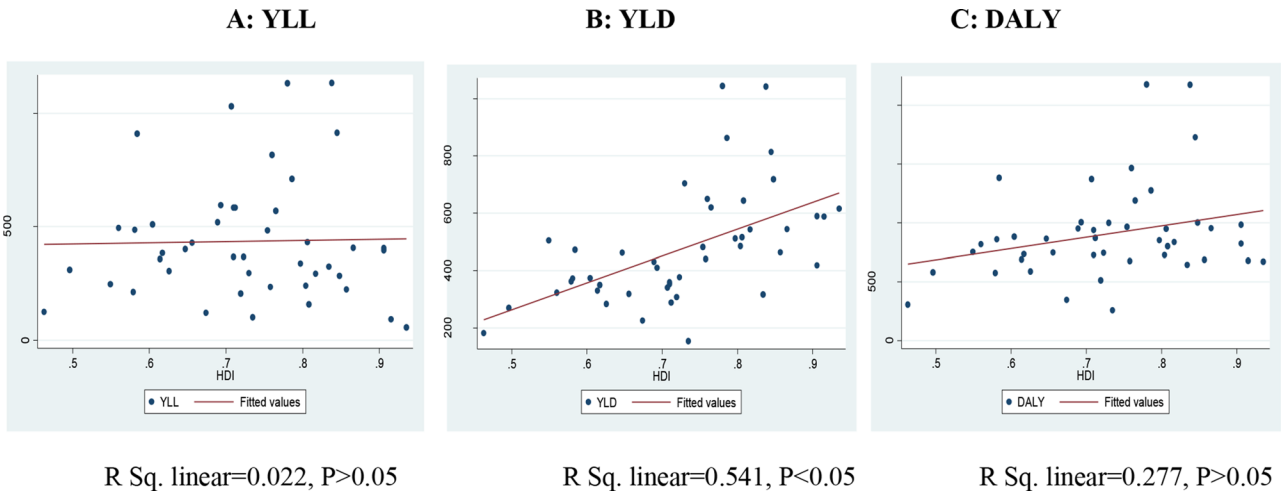

Fig. 7 Correlation of HDI with **A**: YLL, **B**: YLD, **C**: DALY of diabetes mellitus type 2 in Asia in 2019

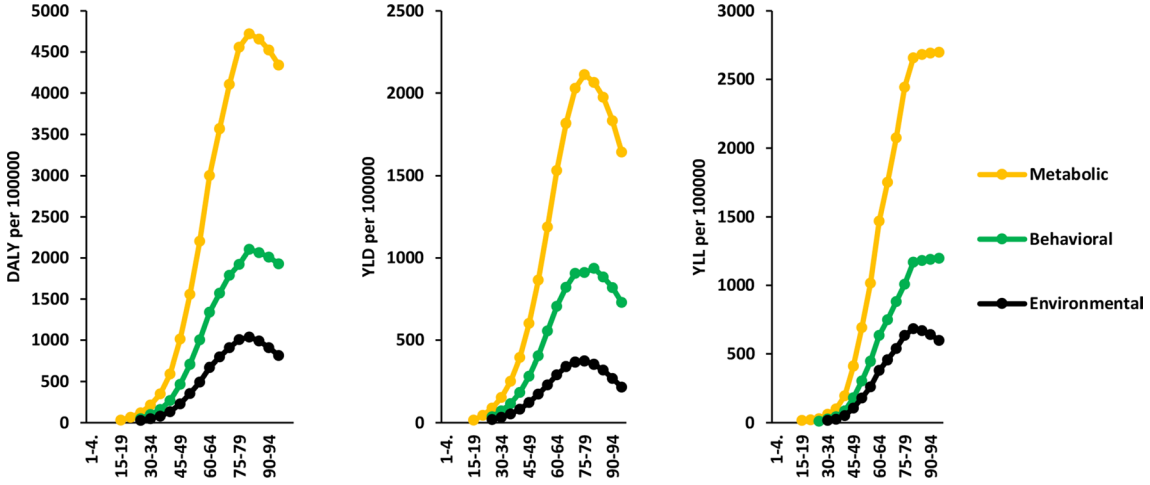

Fig. 8 Distribution of risk factor of diabetes mellitus type 2 by age group in Asia in 2019. (Source: Global Burden of Disease 2019)

mortality rates were observed in Sri Lanka, Bahrain, and Armenia.

Due to the existing demographic, social, and economic heterogeneity, varying patterns of incidence and mortality related to diabetes can be observed across different regions. Factors associated with biological conditions, such as high body mass index, socio-demographic elements like low educational attainment, regional disparities, barriers to accessing treatment, late diagnosis, and other risk factors, as well as behavioral influences, including sedentary lifestyles and unhealthy dietary habits, can contribute to the differences in diabetes incidence and mortality [42, 43].

The results of the study showed that there is a positive and significant correlation between incidence and YLD with HDI, while there was no statistically significant relationship between mortality, YLL and DALY with HDI.

Factors such as poverty, limited access to health services, and low awareness of chronic diseases cause people to become aware of diabetes later and delay diagnosis. Developed countries with higher HDI levels, due to regular diabetes screening, diagnose the disease at an earlier stage, which may indicate a higher incidence than developing countries. While in developing countries the disease may not be diagnosed and the incidence of the disease may be falsely lower than its true level, developed countries usually have effective national programs for diabetes management, so people with diabetes in these countries survive better and live longer, and the prevalence and YLD of diabetes are higher due to the survival of people in these countries. Key components of diabetes self-management education include regular glucose monitoring, healthy nutrition, and physical activity. Developed countries have focused on improving the adoption of a healthy lifestyle as well as access to health care services to prevent or control diabetes and increase life expectancy. Socioeconomic status is directly related to patient survival. Therefore, patients with higher

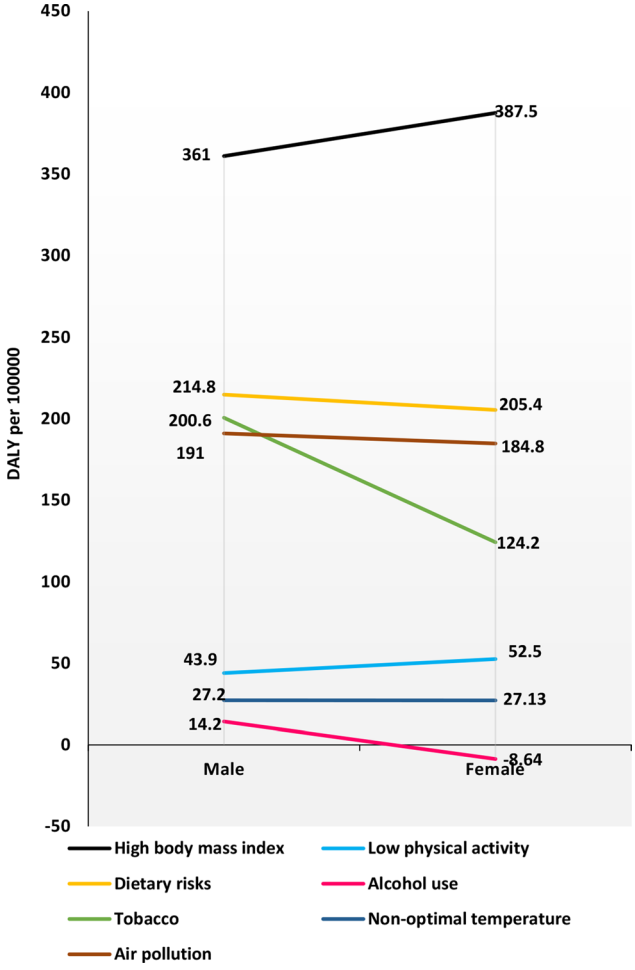

Fig. 9 Risk factors associated with the burden of type 2 diabetes. (Source: Global Burden of Disease 2019)

socioeconomic status may experience longer survival due to greater and better access to diabetes-related care and services, and therefore the YLD of diabetes is higher in these countries [17, 29].

Developed countries usually face their own challenges, which are caused by modern lifestyles and better access to health services. Developing countries also face problems such as poverty and lack of access to effective health services, which affect the control of the prevalence of diabetes. To reduce the incidence of diabetes, both developed and developing countries need effective prevention and education programs [44].

Several policies and strategies can be implemented to reduce the incidence of diabetes. Launching awareness campaigns to educate the public about the risk factors, signs and symptoms, and prevention methods of diabetes can have a significant positive impact [44, 45].

Providing practical solutions to enhance lifestyles, such as promoting regular physical activity and effective weight management, can yield positive results. Additionally, advocating for the development and implementation of public policies that address public health and mitigate the risks of diabetes are other effective strategies.

Policies and strategies designed to reduce the prevalence of diabetes and promote public health necessitate collaboration among governments, non-governmental organizations, local communities, and individuals to be effective [45, 46].

Therefore, the increasing prevalence of diabetes in Asian countries poses a significant challenge to their health systems. Preventing the rise of diabetes in these nations necessitates collaboration among governments, non-governmental organizations, local communities, and individuals. To effectively manage the disease, it is crucial to focus on preventive and educational policies. Implementing comprehensive strategies that promote lifestyle management, healthy eating, and regular physical activity can help decrease the incidence of diabetes. Additionally, there is a pressing need to enhance health infrastructure and provide effective treatment services to curb the spread of this disease.

Conclusion

This study showed the burden of type 2 diabetes in Asian countries, and its results could provide insights for prioritizing and planning health services. In light of the fact that diabetes is often increased by modifiable risk factors, governments and organizations in different countries, especially in countries with high prevalence and burden of this disease, are required to make policy, allocate medical resources and modify clinical guidelines for diabetes education to change unhealthy lifestyles, carry out effective screening of overweight and obese people to reduce the incidence of diabetes by providing solutions and adjust public lifestyle. On the other hand, because air pollution is one of the risk factors associated with the burden of diabetes, it is essential to formulate policies to reduce environmental and indoor air pollution. Thus, disease management programs and public initiatives can improve the outcome of type 2 diabetes, especially in countries where it is most needed.

Limitations

Given that the present study is based on global burden of disease data (GBD, 2019), the bias in the classification of diabetes must be taken into account. This is due to the fact that such reports rarely distinguish between type 1 and type 2 diabetes because it requires relatively complex laboratory tests to assess pancreatic function. Mortality estimated by GBD is based on diabetes certifications, which may underestimate the deaths associated with diabetes. In fact, diabetes is closely linked to the elevated risk and death of cardiovascular and cerebrovascular diseases, cancer, and infectious diseases, which can increase the rate of indirect mortality. Data from this study did not

include "chronic kidney disease due to type 2 diabetes," as this was estimated and reported separately in the GBD study. In addition, a comparison of the burden of diabetes is challenging due to the huge discrepancy in accessing health services, quality of care, and data quality between countries, and caution must be exercised in interpreting conclusions in a particular region.

Abbreviations

HDI	Human Development Index
NCDs	Non-communicable diseases
GNI	Gross national income
LEB	Life expectancy at birth
GDP	Gross domestic product
ASPR	Age-Standardized Prevalence Rate
ASIR	Age-Standardized Incidence Rate
ASMR	Age-Standardized Mortality Rate

Acknowledgements
The authors would like to thank Global Burden of Disease and their staff for their willingness to provide the data required for this research.

Author contributions
Design: E. G., and S. A. A Data Collection and/or Processing E. G., S. A. A., and A. B., Analysis or Interpretation: E. G.,S. A. A., Z. KH., V. M., and A. S., Writing: E. G.,S. A. A.,SH. H., and A. B.

Funding
No additional funding was provided for this study.

Data availability
The datasets analyzed in this study can be found from the Global Health Data Exchange (GHDx) website (http://ghdx.healthdata.org/gbd-results-tool).

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 16 July 2024 / Accepted: 23 January 2025
Published online: 31 January 2025

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