Cross-sectional Study

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Global, regional, and national burden of inguinal, femoral, and abdominal hernias: a systematic analysis of prevalence, incidence, deaths, and DALYs with projections to 2030

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Background: Hernias, particularly inguinal, femoral, and abdominal, present a global health challenge. While the global burden of disease (GBD) study offers insights, systematic analyses of hernias remain limited. This research utilizes the GBD dataset to explore hernia implications, combining current statistics with 2030 projections and frontier analysis.

Methods: We analyzed data from the 2019 GBD Study, focusing on hernia-related metrics: prevalence, incidence, deaths, and disability-adjusted life years (DALYs) across 204 countries and territories, grouped into 21 GBD regions by the socio-demographic index (SDI). Data analysis encompassed relative change calculations, as well as annual percentage change (APC) and average annual percentage change (AAPC), both of which are based on joinpoint regression analysis. The study additionally employed frontier analysis and utilized the Bayesian age-period-cohort model for predicting trends up to 2030. Analyses utilized R version 4.2.3.

Results: From 1990 to 2019, the global prevalence of hernia cases surged by 36%, reaching over 32.5 million, even as age-standardized rates declined. A similar pattern was seen in mortality and DALYs, with absolute figures rising but age-standardized rates decreasing. Gender data between 1990 and 2019 showed consistent male dominance in hernia prevalence, even as rates for both genders fell. Regionally, Andean Latin America had the highest prevalence, with Central Sub-Saharan Africa and South Asia noting significant increases and decreases, respectively. Frontier analyses across 204 countries and territories linked higher SDIs with reduced hernia prevalence. Yet, some high SDI countries, like Japan and Lithuania, deviated unexpectedly. Predictions up to 2030 anticipate increasing hernia prevalence, predominantly in males, while age-standardized death rates and age-standardized DALY rates are expected to decline.

Conclusions: Our analysis reveals a complex interplay between socio-demographic factors and hernia trends, emphasizing the need for targeted healthcare interventions. Despite advancements, vigilance and continuous research are essential for optimal hernia management globally.

Keywords: annual percentage change, average annual percentage change, frontier analysis, inguinal, femoral, and abdominal hernias, the bayesian age-period-cohort model, the global burden of disease study

Introduction

Hernias, specifically inguinal, femoral, and abdominal types, constitute a significant health concern worldwide[1,2]. These protrusions of an organ or tissue through the structure that normally contains them not only represent an anatomical dysfunction but can also pose dire clinical implications if not addressed timely[3,4]. As the global population grows and ages, understanding the comprehensive burden of these conditions becomes of paramount importance.

The global burden of disease (GBD) study offers an invaluable platform for assessing the health impacts of a plethora of diseases and injuries[5]. By extracting data from such a resource, researchers and policymakers can grasp the prevalence,

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incidence, mortality rates, and disability-adjusted life years (DALYs) of specific conditions, offering a panoramic view of their global, regional, and national implications[6–8]. Despite the known impacts of hernias on global health, systematic analyses of their comprehensive burden, especially leveraging GBD data, have been sporadic.

Moreover, the dynamic nature of disease patterns necessitates not just an understanding of the current scenario but also a forward-looking perspective. Projections, especially those extending a decade into the future, allow stakeholders to allocate resources, strategize healthcare priorities, and implement preventive measures with an informed foundation[9,10]. In the context of hernias, such projections could play a pivotal role in shaping surgical practices, public health campaigns, and patient education drives.

In addition, while mere statistical assessments provide a foundational understanding, it is the supplementary analyses, such as frontier analysis, that present a deeper dive into data intricacies, painting a more nuanced picture of disease implications[11]. Such analyses benchmark health performances against the best-performing counterparts, offering insights into potential areas of improvement and driving a more effective health response.

Considering these gaps and the immense value such a study can bring to the table, our research aims to systematically elucidate the global, regional, and national burdens of inguinal, femoral, and abdominal hernias. By harnessing the GBD dataset, this study presents a holistic view of the prevalence, incidence, mortality rates, and DALYs of these hernias. Additionally, we venture beyond the present-day data, offering projections up to 2030, complemented by frontier analysis, thereby presenting a comprehensive overview that is both current and future-oriented. Through this rigorous exploration, our work hopes to shed light on the magnitude and nuances of hernia implications worldwide, aspiring to inform healthcare decisions and contribute significantly to the existing body of knowledge.

HIGHLIGHTS

- The 2019 global burden of disease study sheds light on global hernia trends, with cases rising over three decades despite declining age-standardized rates.
- Frontier analyses highlight that higher socio-demographic indices generally correlate with reduced hernia prevalence, but high SDI nations, including Japan and Lithuania, presented unexpected deviations.
- Predictions until 2030 indicate an increase in hernia prevalence, particularly among males, with a simultaneous expected decrease in hernia-related death rates and disability-adjusted life years.

Methods

Research population and data compilation

Our study utilized data from the 2019 GBD Study, which employed DisMod-MR 2.1 to synthesize varied epidemiological data on non-fatal conditions, including inguinal, femoral, and abdominal hernia. This comprehensive model applies differential equations to enhance the accuracy of the derived insights.

We focused on four principal metrics: prevalence, incidence, mortality, and DALYs associated with hernias. The data, spanning from 1990 to 2019, was sourced from the Global Health Data Exchange (GHDx) and includes annual statistics across age, sex, and location. Our analysis covered 204 countries and territories, grouped into 21 GBD regions based on geographic proximity and further classified into five categories according to the socio-demographic index (SDI).

SDI

The SDI is a composite measure developed by GBD researchers to assess a region's socio-economic status. It integrates per capita income, educational attainment, and fertility rates into a single indicator that ranges from 0 to 1, reflecting the socio-economic health and progress of a region or country[5,12]. Higher SDI values correspond to better socio-economic conditions and health outcomes. The SDI categorizes regions into quintiles: low (0–0.454743), low-middle (0.454743–0.607679), middle (0.607679–0.689504), high-middle (0.689504–0.805129), and high (0.805129–1).

Data analysis

Our data analysis began with an exploration of the dataset's structure, calculating counts and rates for key measures such as prevalence, incidence, deaths, and DALYs of hernias on global, regional, and national levels. We then analyzed the metric variations from 1990 to 2019 across different regions. To determine relative changes, we used the formula:

Relative change (%) = [(Value in 2019 - Value in 1990) / Value in 1990] × 100%. This was applied to both case numbers and age-standardized rates (ASRs) per 100 000.

We employed a rigorous statistical approach to track hernia trends, using annual percentage change (APC) and average annual percentage change (AAPC)[13,14]. APC indicates year-to-year variations, while AAPC gives the average trend over specified periods.

Our analysis incorporated joinpoint regression analysis to identify significant changes in data trends over time, distinguishing real shifts in trends from random variability. We also examined the correlation between the SDI and hernia indicators using Pearson correlation, assessing the strength and direction of their linear relationship across various geographies.

Frontier analysis was applied to establish benchmarks for hernia burden, comparing countries and territories against the best-performing counterparts[11]. This method identifies leading countries and territories, setting standards and targets for others. We computed the 'effective difference' for each countries and territories, indicating the gap between the current and potential hernia burden, adjusted for SDI.

We utilized the Bayesian Age-Period-Cohort (BAPC) model to delineate and forecast hernia trends up to 2030[15,16]. This advanced model, incorporating past data and probability distributions, allowed us to estimate future hernia patterns with considerations for age, period, and cohort effects. The work has been reported in line with the strengthening the reporting of cohort, cross-sectional, and case–control studies in surgery (STROCSS) criteria[17]. Statistical analyses were executed using R version 4.2.3.

Results

Global trends

Between 1990 and 2019, global hernia prevalence saw a 36% absolute rise, with cases increasing from nearly 23.92 million to 32.53 million. Conversely, age-standardized prevalence rates decreased by 16.46%, from 488.3 to 407.9 cases per 100 000 individuals. Incidence rates escalated by 63.67% in absolute terms, though the age-standardized incidence rate remained stable at around 163 per 100000 cases. Mortality rose by 19.77%, yet the age-standardized mortality rate significantly decreased by 40.39%. Global DALYs—reflecting the burden of disease—increased by 9.25% in absolute numbers, while their ASRs fell by 31.12% (Tables 1–4).

An in-depth analysis using APC and AAPC revealed varied trends. Prevalence rates from 2005–2010 experienced the sharpest decline with an APC of – 1.50%. Incidence rates showed minor variations but an overall AAPC close to 0%, indicating stability. Death rates saw a marked decline during 1996–2004, with an APC of – 2.75%. DALY rates also dropped significantly between 1997 and 2001, with an APC of – 2.02% (Fig. 1).

Global trends by sex

A discernible decline in ASRs is observed over this three-decade period for both sex. While both males and females exhibited similar declining patterns, males consistently registered higher rates in all categories. On the other hand, when focusing on absolute numbers, a significant uptick is observed over time, especially noticeable in prevalence and incidence (Figs 2–3).

From 1990 to 2019, sex-specific analysis of hernia prevalence showed a marked decline in ASRs, with males and females experiencing the greatest reductions between 2005 and 2010 (APC: – 1.69%) and 1990–2000 (APC: – 0.93%), respectively. However, recent trends indicate a concerning reversal, with rising ASRs in both genders. Incidence rates also decreased, most notably for males between 2005 and 2009 (APC: – 0.77%) and for females during 2017–2019 (APC: – 1.91%). Across both prevalence and incidence, the data revealed that males had a higher ASR than females. Male prevalence declined faster (AAPC: – 0.69%) compared to females (– 0.44%). For incidence, male rates slightly decreased (AAPC: – 0.06%), while female rates increased (AAPC: 0.35%) (Fig. 4).

Across sexes, there were discernible trends in ASRs for deaths and DALYs. For deaths, males showed the most significant decrease between 1997 and 2005 (APC: – 2.94%), while females had a consistent decline with the sharpest fall between 1994 and 2001 (APC: – 2.63%), resulting in an overall AAPC of – 1.77%. DALY trends mirrored this positive trajectory, with both sexes experiencing substantial reductions; males between 1997 and 2000 and females from 1995 to 2002, each with an APC of – 2.07%. The overall downward trend in DALYs was captured by an AAPC of – 1.27%. (Fig. 5).

Global trends by age group

Prevalence rates escalate in older age groups, with a notable spike between 65 and 69 years, and males consistently outpacing females. Incidence rates similarly rise with age, peaking in the 65–69 years bracket, where males again register higher rates than females. Death rates surge most significantly for both sexes at 95 + years, with males showing a slightly elevated rate. As for DALYs, the trend mirrors age progression, reaching its zenith in the 95 + years group. Throughout these metrics, males consistently record higher rates than females across all age categories (Fig. 6).

Regional trends

From 1990 to 2019, there were significant variations in the prevalence of inguinal, femoral, and abdominal hernias across 21 regions. The highest ASR in 2019 was observed in Andean Latin America at 938.4 (95% CI: 801.5–1089.9) per 100000 cases, while high-income North America recorded the lowest at 175.6 (95% CI: 148.3–205.2) per 100000 cases. South Asia displayed a substantial decline in its ASR, marking a relative change of – 35.38% and an AAPC of –1.5% (95%CI: –1.57% to –1.44%). On the contrary, Central Sub-Saharan Africa showed an uptick in hernia cases, as evidenced by a 25.03% relative change in its ASR coupled with an AAPC of 0.77% (95% CI: 0.73%–0.81%). For incidences, Tropical Latin America reported the highest ASR in 2019 at 303.1 (95% CI: 248.1–364.8) per 100000 cases, while the North Africa and Middle East region indicated the lowest at 76.7 (95% CI: 62.8–91.3) per 100000 cases (Tables 1–2).

In terms of mortality, Central Europe underwent a significant reduction in ASR by 70.76% over the three decades, with an AAPC of –4.17% (95% CI: – 4.32% to – 4.02%). Conversely, Tropical Latin America saw a pronounced surge in numbers by 123.84%, even though its ASR decreased by – 14.81%. Regions like East Asia, Andean Latin America, and Central Asia experienced notable decreases in both numbers and ASRs. Furthermore, the impact of hernia-related DALYs showcased varied trends; for instance, Oceania exhibited the most substantial relative change in numbers at 103.63% but had a slight reduction in ASR by – 2.07% with an AAPC of –0.08% (95% CI: –0.14% to –0.01%). In stark contrast, Central Europe and Andean Latin America showed declining trends in their numbers by – 42.03% and – 34.74%, respectively, with AAPC values of –2.28% (95% CI: –2.48% to –2.07%) and –2.65% (95% CI: –2.86% to –2.45%) (Tables 3–4).

National trends

From 1990 to 2019, the relative change in numbers of inguinal, femoral, and abdominal hernias saw marked variations across 204 countries and territories. In terms of prevalence, 191 countries experienced significant growth, with Qatar's spike at 608.78% being the most notable. Contrastingly, 13 countries, including Bulgaria at – 51.57% and Poland at – 44.3%, saw a decline. Regarding incidence, a majority, 196 out of 204, witnessed an increase, with Qatar's surge of 846.22% at the forefront. However, Bulgaria displayed the most substantial decline at – 48.91%. Mortality rates were diverse, with the United Arab Emirates recording the highest increase at 418.02%, while Mongolia showed the most significant decrease at – 86.98%. For DALYs, Qatar reported the steepest rise at 510.2%, whereas Albania marked the highest drop at – 70.16%. (Tables S1–S4, Supplemental Digital Content 1, http://links.lww.com/JS9/B752, Figures S1–S4, Supplemental Digital Content 2, http://links.lww.com/JS9/B753).

When considering ASRs, Bulgaria, Mongolia, and Poland consistently showcased significant declines across the different parameters. Specifically, Mongolia stood out with a decline of – 88.94% in mortality and – 73.98% in DALY. In contrast,

Table 1

Numbers and ASRs per 100 000 cases of prevalence of inguinal, femoral, and abdominal hernia in 1990 and 2019, along with the relative changes and AAPC in ASRs per 100 000 cases from 1990 to 2019, categorized by global, SID, and GBD regions.

Characteristic	Number in 1990 (95% CI)	Age-standardized rate in 1990 (95% CI)	Number in 2019 (95% CI)	Age-standardized rate in 2019 (95% CI)	Relative change of numbers from 1990 to 2019 (%)	Relative change of age-standardized rate from 1990 to 2019 (%)	AAPC (Age-standardized rate, 95% CI)	*P*
Global	23 919 446 (20 461 308–28 074 520)	488.3 (418.7–567)	32 529 665 (27 711 437–37 785 171)	407.9 (348.1–474.6)	36	– 16.46	– 0.62 (– 0.65 to – 0.58)	< 0.001
High SDI	3 142 227 (2 645 437–3 690 081)	358.1 (302.6–421.1)	3 600 960 (3 039 153–4 216 717)	293.4 (251.1–340.2)	14.6	– 18.05	– 0.68 (– 0.75 to – 0.6)	< 0.001
High-middle SDI	4 934 554 (4 172 571–5 809 357)	439.3 (370.7–515.2)	5 902 972 (4 950 502–6 926 816)	364.4 (308.4–426.5)	19.63	– 17.05	– 0.64 (– 0.65 to – 0.63)	< 0.001
Middle SDI	6 939 172 (5 834 019–8 244 172)	464.6 (399.1–542.3)	9 558 680 (8 153 280–11 198 443)	383.3 (329.7–445.1)	37.75	– 17.49	– 0.66 (– 0.7 to – 0.63)	< 0.001
Low-middle SDI	6 160 234 (5 253 685–7 205 553)	665.8 (574.6–768.3)	8 351 675 (7 081 571–9 818 130)	505.1 (431–590.5)	35.57	– 24.14	– 0.95 (– 0.99 to – 0.9)	< 0.001
Low SDI	2 728 420 (2 329 612–3 194 106)	672.8 (587.9–764.7)	5 091 908 (4 315 053–6 044 715)	578.7 (498–663.8)	86.62	– 13.99	– 0.52 (– 0.57 to – 0.47)	< 0.001
Andean Latin America	453 529 (398 095–518 618)	1185.1 (1049.4–1346.4)	583 152 (496 486–678 800)	938.4 (801.5–1089.9)	28.58	– 20.81	– 0.81 (– 0.84 to – 0.77)	< 0.001
Australasia	64 616 (53 412–76 318)	295 (244.6–348.3)	100 381 (82 967–118 445)	261.5 (218.4–306)	55.35	– 11.38	– 0.41 (– 0.44 to – 0.38)	< 0.001
Caribbean	280 181 (239 562–328 522)	831.7 (714.7–965)	419 263 (354 560–491 797)	874.5 (738.5–1028.1)	49.64	5.14	0.17 (0.16–0.18)	< 0.001
Central Asia	309 560 (260 994–364 273)	476.9 (408.3–555)	463 646 (385 216–551 502)	498.9 (417–591)	49.78	4.59	0.17 (0.07–0.26)	0.001
Central Europe	693 592 (606 294–788 301)	517.2 (451.8–588.7)	545 938 (467 726–625 784)	405.4 (352.5–461)	– 21.29	– 21.61	– 0.85 (– 1.15 to – 0.55)	< 0.001
Central Latin America	1 281 932 (1 093 957–1 494 828)	996 (867.2–1135.2)	1 889 111 (1 621 570–2 174 235)	765.1 (662.8–878.5)	47.36	– 23.18	– 0.9 (– 0.94 to – 0.86)	< 0.001
Central Sub-Saharan Africa	254 581 (205 356–308 167)	556.4 (474.6–640.9)	718 512 (583 986–872 810)	695.6 (581.6–817.2)	182.23	25.03	0.77 (0.73–0.81)	< 0.001
East Asia	3 142 155 (2 499 570–3 947 212)	283.4 (226.3–351.4)	3 873 669 (3 133 338–4 687 953)	251.4 (205.1–305)	23.28	– 11.31	– 0.42 (– 0.49 to – 0.35)	< 0.001
Eastern Europe	1 518 575 (1 256 878–1 826 714)	632 (521.6–763.4)	1 345 298 (1 102 505–1 634 799)	574.6 (471.4–703.9)	– 11.41	– 9.08	– 0.3 (– 0.37 to – 0.24)	< 0.001
Eastern Sub-Saharan Africa	595 777 (485 270–724 308)	407.3 (350.2–469.2)	1 313 507 (1 111 629–1 553 530)	448.9 (384.9–516.9)	120.47	10.21	0.33 (0.32–0.35)	< 0.001
High-income Asia Pacific	993 486 (824 428–1 189 803)	592.6 (489.9–711.8)	1 073 424 (897 793–1 273 465)	564.7 (475.9–664.3)	8.05	– 4.7	– 0.14 (– 0.22 to – 0.06)	< 0.001
High-income North America	704 290 (574 835–861 433)	226.2 (183.6–277.5)	813 579 (683 420–956 710)	175.6 (148.3–205.2)	15.52	– 22.4	– 0.88 (– 0.93 to – 0.83)	< 0.001
North Africa and Middle East	688 382 (551 451–855 343)	211.9 (174.3–253.5)	1 313 585 (1 083 333–1 576 363)	229 (188.8–273.3)	90.82	8.08	0.27 (0.25–0.29)	< 0.001
Oceania	14 374 (11 465–17 655)	269.7 (226.1–316.8)	36 251 (29 698–44 004)	314.9 (264.2–370.9)	152.19	16.77	0.54 (0.51–0.57)	< 0.001
South Asia	7 005 337 (5 972 845–8 259 742)	803.1 (692.9–931.9)	8 852 278 (7 385 004–10 642 285)	518.9 (437.6–619)	26.36	– 35.38	– 1.5 (– 1.57 to – 1.44)	< 0.001
Southeast Asia	1 769 281 (1 524 711–2 050 630)	491.5 (429.8–560)	2 590 594 (2 249 989–2 958 284)	387.1 (339.1–436.6)	46.42	– 21.25	– 0.86 (– 0.99 to – 0.74)	< 0.001
Southern Latin America	215 950 (183 752–249 716)	444.3 (377.1–512.9)	345 416 (289 543–403 214)	480.2 (405–559.3)	59.95	8.07	0.27 (0.22–0.32)	< 0.001
Southern Sub-Saharan Africa	392 542 (317 545–481 696)	784.5 (660.6–929.2)	532 448 (439 820–642 286)	694.2 (579.1–827.4)	35.64	– 11.5	– 0.42 (– 0.45 to – 0.39)	< 0.001
Tropical Latin America	920 589 (785 603–1 071 401)	765 (658.8–884.4)	1 592 874 (1 360 179–1 868 475)	664.3 (570.5–771.1)	73.03	– 13.17	– 0.48 (– 0.53 to – 0.42)	< 0.001
Western Europe	1 689 012 (1 425 184–1 984 763)	365.1 (309.6–428.1)	1 968 129 (1 636 608–2 333 383)	335.9 (283.6–396.4)	16.53	– 7.99	– 0.27 (– 0.33 to – 0.2)	< 0.001
Western Sub-Saharan Africa	931 705 (780 764–1 116 126)	581.4 (500.2–674.3)	2 158 609 (1 826 179–2 575 741)	602.2 (520.4–693.2)	131.68	3.58	0.12 (0.07–0.16)	< 0.001

Table 2

Numbers and ASRs per 100 000 cases of incidence of inguinal, femoral, and abdominal hernia in 1990 and 2019, along with the relative changes and AAPC in ASRs per 100 000 cases from 1990 to 2019, categorized by global, SID and GBD regions.

Characteristic	Number in 1990 (95% CI)	Age-standardized rate in 1990 (95% CI)	Number in 2019 (95% CI)	Age-standardized rate in 2019 (95% CI)	Relative change of numbers from 1990 to 2019 (%)	Relative change of age-standardized rate from 1990 to 2019 (%)	AAPC (Age-standardized Rate, 95% CI)	*P*
Global	7 955 575 (6 614 299–9 409 892)	163 (134.6–192.6)	13 020 725 (10 682 088–15 490 165)	163 (134.1–192.9)	63.67	– 0.04	0 (– 0.13 to 0.14)	0.977
High SDI	1 392 676 (1 133 442–1 650 067)	157.9 (128.6–187.3)	1 822 358 (1 457 593–2 172 805)	147.7 (121.8–174.5)	30.85	– 6.49	– 0.21 (– 0.27 to – 0.15)	< 0.001
High-middle SDI	1 986 702 (1 629 422–2 376 191)	176.8 (144.4–211.2)	3 006 397 (2 413 527–3 629 183)	183.7 (150.2–219.5)	51.33	3.89	0.14 (0.09–0.18)	< 0.001
Middle SDI	2 178 945 (1 822 444–2 577 017)	145.8 (120.6–172.1)	3 985 238 (3 255 768–4 738 506)	159.6 (131.6–188)	82.9	9.48	0.32 (0.23–0.4)	< 0.001
Low-middle SDI	1 704 877 (1 410 050–2 025 972)	181 (149.9–214.6)	2 761 206 (2 278 502–3 332 150)	167 (137.4–200.2)	61.96	– 7.72	– 0.27 (– 0.34 to – 0.19)	< 0.001
Low SDI	688 096 (574 311–811 241)	161.5 (135.1–188.5)	1 437 755 (1 197 110–1 710 868)	159 (132.3–187.3)	108.95	– 1.57	– 0.06 (– 0.09 to – 0.03)	< 0.001
Andean Latin America	96 148 (84 786–108 478)	252.8 (223.5–283.8)	180 437 (153 547–208 602)	289.8 (247.4–333.1)	87.67	14.6	0.46 (0.43–0.49)	< 0.001
Australasia	27 368 (22 485–32 298)	125.6 (103.1–147.5)	46 344 (38 252–54 952)	122.5 (101.6–144.7)	69.33	– 2.43	– 0.08 (– 0.09 to – 0.07)	< 0.001
Caribbean	76 339 (64 833–88 772)	226.9 (193.8–262.2)	127 187 (107 186–147 942)	265.4 (224.4–308.2)	66.61	16.97	0.54 (0.51–0.58)	< 0.001
Central Asia	88 992 (75 215–104 248)	134.5 (115.2–156.4)	151 180 (125 736–179 072)	160.9 (134.6–190.1)	69.88	19.6	0.62 (0.56–0.69)	< 0.001
Central Europe	254 331 (217 491–292 936)	190.2 (163.3–218.4)	241 151 (203 365–278 739)	184.6 (157.7–212.9)	– 5.18	– 2.94	– 0.08 (– 0.13 to – 0.04)	0.001
Central Latin America	422 740 (360 231–494 775)	325.3 (274.6–378.1)	724 490 (607 888–852 476)	293.5 (246.8–342.3)	71.38	– 9.79	– 0.35 (– 0.39 to – 0.31)	< 0.001
Central Sub-Saharan Africa	58 031 (47 494–70 061)	117.8 (101.1–135)	181 664 (147 366–218 099)	171.6 (143.2–201.9)	213.04	45.7	1.31 (1.23–1.38)	< 0.001
East Asia	1 047 642 (838 418–1 266 811)	95.4 (75.7–115.5)	1 994 954 (1 544 280–2 476 277)	124 (99.8–148.3)	90.42	30.02	0.9 (0.8–1)	< 0.001
Eastern Europe	663 359 (533 265–812 168)	277.1 (223.9–335)	681 018 (537 112–833 012)	291.7 (234.3–353.5)	2.66	5.27	0.19 (0.14–0.24)	< 0.001
Eastern Sub-Saharan Africa	142 542 (116 384–171 872)	92.7 (77.3–107.9)	372 703 (310 883–439 717)	125.9 (105.1–146.8)	161.47	35.76	1.06 (1.04–1.08)	< 0.001
High-income Asia Pacific	439 031 (349 623–528 748)	258.2 (210.1–307.7)	577 596 (454 326–704 255)	276 (226.9–323.9)	31.56	6.88	0.23 (0.2–0.27)	< 0.001
High-income North America	369 887 (289 443–448 830)	120.6 (94.8–146)	450 234 (358 359–545 737)	100.8 (82.6–119.7)	21.72	– 16.42	– 0.6 (– 0.66 to – 0.54)	< 0.001
North Africa and Middle East	188 015 (151 000–231 029)	56.2 (45.9–67.2)	439 992 (357 717–529 226)	76.7 (62.8–91.3)	134.02	36.44	1.08 (1.05–1.11)	< 0.001
Oceania	3496 (2839–4253)	64.9 (54.5–75.1)	9807 (8075–11 820)	83.5 (70.5–97.2)	180.54	28.68	0.87 (0.85–0.89)	< 0.001
South Asia	2 038 388 (1 654 311–2 439 958)	228.1 (185.9–273.6)	3 095 824 (2 484 942–3 804 158)	181.5 (146.2–220.9)	51.88	– 20.43	– 0.79 (– 0.88 to – 0.7)	< 0.001
Southeast Asia	538 745 (447 263–632 431)	149.3 (123.4–175.8)	1 063 925 (881 744–1 256 251)	157 (130.7–184.1)	97.48	5.17	0.14 (0–0.28)	0.053
Southern Latin America	58 894 (50 220–67 828)	121.6 (103.8–139.9)	116 045 (97 667–134 879)	162.3 (137.3–188.5)	97.04	33.51	1 (0.93–1.06)	< 0.001
Southern Sub-Saharan Africa	116 836 (95 078–142 314)	231.3 (191.2–276.8)	178 408 (146 141–216 078)	231.6 (190.3–279.3)	52.7	0.1	0 (– 0.04 to 0.03)	0.892
Tropical Latin America	357 729 (291 848–429 521)	294.1 (236.3–359.1)	725 963 (587 397–879 747)	303.1 (248.1–364.8)	102.94	3.09	0.11 (0.03–0.19)	0.009
Western Europe	693 248 (572 943–816 761)	150.9 (124.7–177.6)	958 832 (765 583–1 150 292)	166.4 (136.1–197)	38.31	10.28	0.39 (0.16–0.61)	0.001
Western Sub-Saharan Africa	273 812 (227 722–327 429)	163 (136.6–192)	702 970 (588 182–831 665)	189.4 (160–221.1)	156.73	16.21	0.51 (0.49–0.53)	< 0.001

Table 3

Numbers and ASRs per 100 000 cases of deaths of inguinal, femoral, and abdominal hernia in 1990 and 2019, along with the relative changes and AAPC in ASRs per 100 000 cases from 1990 to 2019, categorized by global, SID and GBD regions.

Characteristic	Number in 1990 (95% CI)	Age-standardized rate in 1990 (95% CI)	Number in 2019 (95% CI)	Age-standardized rate in 2019 (95% CI)	Relative change of numbers from 1990 to 2019 (%)	Relative change of age-standardized rate from 1990 to 2019 (%)	AAPC (Age-standardized rate, 95% CI)	*P*
Global	40 141 (32 804–45 418)	1.1 (0.9–1.2)	48 077 (41 654–54 021)	0.6 (0.5–0.7)	19.77	– 40.39	– 1.77 (– 1.85 to – 1.68)	< 0.001
High SDI	6725 (5639–7128)	0.7 (0.5–0.7)	7653 (6391–8854)	0.3 (0.3–0.4)	13.79	– 47.03	– 2.18 (– 2.33 to – 2.02)	< 0.001
High-middle SDI	7510 (6798–8286)	0.8 (0.7–0.9)	7674 (6786–9703)	0.4 (0.4–0.5)	2.18	– 51.15	– 2.43 (– 2.53 to – 2.32)	< 0.001
Middle SDI	9596 (7328–11 795)	1 (0.8–1.2)	12 698 (10 730–14 646)	0.6 (0.5–0.7)	32.32	– 37.7	– 1.62 (– 1.71 to – 1.54)	< 0.001
Low-middle SDI	10 023 (7577–11 935)	1.7 (1.2–2.2)	11 615 (9415–13 691)	1 (0.8–1.2)	15.87	– 41.93	– 1.78 (– 1.98 to – 1.58)	< 0.001
Low SDI	6255 (4167–7720)	2.4 (1.5–3.5)	8402 (6051–11 832)	1.7 (1.2–2.5)	34.32	– 28.02	– 1.11 (– 1.18 to – 1.04)	< 0.001
Andean Latin America	700 (414–1059)	1.9 (1.3–2.7)	393 (296–520)	0.7 (0.5–0.9)	– 43.78	– 63.52	– 3.45 (– 3.82 to – 3.08)	< 0.001
Australasia	114 (102–129)	0.5 (0.5–0.6)	237 (193–276)	0.4 (0.3–0.5)	107.25	– 20.26	– 0.75 (– 0.99 to – 0.5)	< 0.001
Caribbean	468 (266–722)	1.5 (1–2.1)	473 (328–638)	1 (0.7–1.3)	1.16	– 35.42	– 1.49 (– 1.71 to – 1.28)	< 0.001
Central Asia	375 (332–426)	0.7 (0.6–0.8)	251 (222–297)	0.4 (0.4–0.5)	– 33.23	– 40.9	– 1.81 (– 2.01 to – 1.6)	< 0.001
Central Europe	2034 (1541–2154)	1.6 (1.2–1.7)	1028 (870–1428)	0.5 (0.4–0.6)	– 49.48	– 70.76	– 4.17 (– 4.32 to – 4.02)	< 0.001
Central Latin America	1611 (1437–1817)	1.9 (1.6–2)	2783 (2349–3242)	1.2 (1–1.4)	72.79	– 34.83	– 1.43 (– 1.67 to – 1.2)	< 0.001
Central Sub-Saharan Africa	688 (306–1017)	2.2 (1.1–3.9)	902 (530–1665)	1.7 (1–3.1)	31	– 23.43	– 0.9 (– 0.97 to – 0.84)	< 0.001
East Asia	2987 (1520–4576)	0.4 (0.2–0.5)	1786 (1430–2264)	0.1 (0.1–0.1)	– 40.2	– 68.52	– 3.98 (– 4.11 to – 3.85)	< 0.001
Eastern Europe	1630 (1495–2030)	0.7 (0.6–0.8)	1650 (1424–2260)	0.5 (0.4–0.7)	1.22	– 27.7	– 1 (– 1.6 to – 0.4)	0.001
Eastern Sub-Saharan Africa	2093 (1027–2771)	2.2 (1.3–3.9)	2993 (1970–5623)	1.9 (1.2–3.8)	43	– 12.24	– 0.45 (– 0.52 to – 0.38)	< 0.001
High-income Asia Pacific	701 (568–754)	0.4 (0.3–0.5)	1078 (786–1376)	0.2 (0.1–0.2)	53.66	– 59.78	– 3.12 (– 3.26 to – 2.99)	< 0.001
High-income North America	1560 (1391–1654)	0.4 (0.4–0.5)	2419 (2058–2674)	0.4 (0.3–0.4)	55.06	– 15.89	– 0.59 (– 0.71 to – 0.47)	< 0.001
North Africa and Middle East	633 (311–1076)	0.3 (0.2–0.5)	853 (664–1210)	0.2 (0.2–0.4)	34.75	– 28.74	– 1.16 (– 1.38 to – 0.94)	< 0.001
Oceania	26 (14–40)	0.8 (0.5–1.3)	47 (29–78)	0.7 (0.4–1.1)	83.33	– 16.06	– 0.61 (– 0.77 to – 0.44)	< 0.001
South Asia	10 912 (7 338–12 923)	2.3 (1.5–3)	12 747 (9850–16 331)	1.1 (0.9–1.4)	16.81	– 52.37	– 2.49 (– 2.71 to – 2.26)	< 0.001
Southeast Asia	4971 (3207–6849)	1.9 (1.3–2.4)	6846 (5162–8109)	1.3 (1–1.6)	37.72	– 28.05	– 1.12 (– 1.19 to – 1.06)	< 0.001
Southern Latin America	392 (350–423)	0.9 (0.8–1)	557 (483–627)	0.7 (0.6–0.7)	42.23	– 27.62	– 1.13 (– 1.39 to – 0.87)	< 0.001
Southern Sub-Saharan Africa	266 (212–325)	0.9 (0.7–1.2)	503 (374–602)	1 (0.7–1.2)	89.05	3.31	0.14 (– 0.12 to 0.4)	0.286
Tropical Latin America	1144 (1023–1309)	1.3 (1.2–1.5)	2561 (2260–2833)	1.1 (1–1.2)	123.84	– 14.81	– 0.54 (– 0.76 to – 0.31)	< 0.001
Western Europe	5310 (4515–5636)	0.9 (0.8–1)	5244 (4434–6499)	0.5 (0.4–0.6)	– 1.24	– 49.81	– 2.35 (– 2.43 to – 2.26)	< 0.001
Western Sub-Saharan Africa	1525 (820–2280)	1.5 (0.9–2.5)	2727 (1869–4316)	1.4 (1–2.3)	78.78	– 6.53	– 0.23 (– 0.32 to – 0.13)	< 0.001

Table 4

Numbers and ASRs per 100 000 cases of DALYs of inguinal, femoral, and abdominal hernia in 1990 and 2019, along with the relative changes and AAPC in ASRs per 100 000 cases from 1990 to 2019, categorized by global, SID and GBD regions.

Characteristic	Number in 1990 (95% CI)	Age-standardized rate in 1990 (95% CI)	Number in 2019 (95% CI)	Age-standardized rate in 2019 (95% CI)	Relative change of numbers from 1990 to 2019 (%)	Relative change of age-standardized rate from 1990 to 2019 (%)	AAPC (Age-standardized rate, 95% CI)	*P*
Global	3 069 930 (2 355 864–3 897 903)	62.1 (48.5–77.5)	3 354 016 (2 610 569–4 247 142)	42.7 (33.4–54)	9.25	– 31.12	– 1.27 (– 1.33 to – 1.22)	< 0.001
High SDI	323 992 (252 196–409 587)	36 (27.6 46.1)	341 845 (261 098–432 826)	25.9 (19.3–33.6)	5.51	– 27.98	– 1.12 (– 1.2 to – 1.04)	< 0.001
High-middle SDI	540 943 (419 212–686 026)	50 (39.2–62.8)	533 108 (396 999–691 159)	32.6 (24.2–42.6)	– 1.45	– 34.78	– 1.45 (– 1.51 to – 1.38)	< 0.001
Middle SDI	888 722 (649 058–1 189 036)	59.2 (45.4–74.7)	945 356 (729 102–1 207 538)	39.2 (30.4–50.1)	6.37	– 33.76	– 1.42 (– 1.48 to – 1.37)	< 0.001
Low-middle SDI	833 624 (631 589–1 059 974)	88.5 (68.9–108.7)	875 136 (679 692–1 122 028)	55.6 (43.9–70.3)	4.98	– 37.17	– 1.58 (– 1.65 to – 1.51)	< 0.001
Low SDI	480 230 (334 892–615 767)	106.9 (81.5–130.4)	655 949 (499 451–832 433)	77.4 (59–99.7)	36.59	– 27.61	– 1.11 (– 1.15 to – 1.08)	< 0.001
Andean Latin America	79 977 (54 472–111 673)	182.2 (130.1–243.4)	52 197 (38 838–70 120)	84.5 (63.1–113.3)	– 34.74	– 53.6	– 2.65 (– 2.86 to – 2.45)	< 0.001
Australasia	6316 (4864–8097)	29.1 (22.4–37.1)	9583 (7277–12 328)	23.6 (17.6–30.7)	51.72	– 18.86	– 0.71 (– 0.77 to – 0.65)	< 0.001
Caribbean	45 153 (27 949–67 982)	124.8 (80.8–181.1)	44 267 (31 469–60 163)	94.9 (66.5–130.1)	– 1.96	– 23.97	– 0.95 (– 1.03 to – 0.87)	< 0.001
Central Asia	39 180 (31 405–48 460)	57.5 (46–71.8)	39 478 (28 590–53 646)	43.9 (32.2–59)	0.76	– 23.54	– 0.9 (– 0.98 to – 0.83)	< 0.001
Central Europe	90 762 (74 782–108 155)	70.6 (57.9–84.3)	52 616 (40 955–67 152)	36 (26.9–46.7)	– 42.03	– 49.03	– 2.28 (– 2.48 to – 2.07)	< 0.001
Central Latin America	145 520 (112 959–184 134)	111.9 (89.1–138.7)	185 912 (144 104–237 198)	76.7 (59.6–97.5)	27.76	– 31.48	– 1.3 (– 1.37 to – 1.24)	< 0.001
Central Sub-Saharan Africa	59 618 (34 174–87 662)	100.5 (65.3–131.5)	89 254 (62 543–132 401)	87.3 (62.8–127.1)	49.71	– 13.2	– 0.48 (– 0.54 to – 0.43)	< 0.001
East Asia	382 757 (248 176–547 112)	34.5 (22.9–48.4)	300 521 (207 472–407 260)	20.1 (14–28)	– 21.49	– 41.81	– 1.84 (– 1.98 to – 1.71)	< 0.001
Eastern Europe	140 391 (103 800–182 532)	59.5 (44.2–77.1)	121 328 (89 360–159 944)	49.3 (35.4–66.3)	– 13.58	– 17.14	– 0.63 (– 0.79 to – 0.47)	< 0.001
Eastern Sub-Saharan Africa	154 163 (85 907–212 558)	85.3 (56.6–111.3)	204 924 (150 651–290 015)	72 (52.2–111.6)	32.93	– 15.59	– 0.59 (– 0.65 to – 0.52)	< 0.001
High-income Asia Pacific	81 628 (57 839–111 537)	48.8 (34.7–67.5)	83 668 (58 698–112 642)	41.6 (28.4–58.4)	2.5	– 14.86	– 0.54 (– 0.61 to – 0.48)	< 0.001
High-income North America	76 260 (59 947–96 080)	24.4 (18.9–30.9)	92 204 (74 022–113 485)	19.5 (15.4–24.2)	20.91	– 20.17	– 0.78 (– 0.86 to – 0.71)	< 0.001
North Africa and Middle East	78 034 (49 888–113 022)	23.5 (16.1–32.1)	111 488 (80 063–150 494)	20.4 (14.9–27.1)	42.87	– 12.94	– 0.47 (– 0.54 to – 0.41)	< 0.001
Oceania	2217 (1503–3243)	40.2 (28–54.4)	4515 (3129–6640)	39.3 (28.6–53.2)	103.63	– 2.07	– 0.08 (– 0.14 to – 0.01)	0.017
South Asia	850 620 (660 191–1 052 866)	104.5 (81.9–127.5)	919 587 (700 868–1 191 111)	57.4 (44.4–73.3)	8.11	– 45.12	– 2.04 (– 2.21 to – 1.88)	< 0.001
Southeast Asia	345 232 (217 572–570 679)	87.3 (62.2–120.8)	348 090 (279 868–421 610)	56.1 (45.7–67.3)	0.83	– 35.74	– 1.53 (– 1.64 to – 1.42)	< 0.001
Southern Latin America	26 111 (21 065–32 429)	54.3 (43.8–67.2)	32 935 (25 229–42 278)	44.7 (33.9–58)	26.14	– 17.56	– 0.65 (– 0.82 to – 0.48)	< 0.001
Southern Sub-Saharan Africa	36 686 (26 562–49 306)	78.1 (58.6–101.6)	51 209 (37 842–68 707)	70.4 (52.8–93)	39.59	– 9.79	– 0.36 (– 0.43 to – 0.29)	< 0.001
Tropical Latin America	102 893 (79 705–129 993)	85.2 (67.3–106)	159 147 (123 400–203 160)	67.5 (52.7–85.8)	54.67	– 20.78	– 0.8 (– 0.94 to – 0.65)	< 0.001
Western Europe	193 431 (154 898–240 239)	39.6 (31.1–49.7)	193 550 (148 284–247 107)	29.3 (21.6–38.5)	0.06	– 26.13	– 1.03 (– 1.12 to – 0.94)	< 0.001
Western Sub-Saharan Africa	132 981 (86 983–172 353)	78.8 (56.8–103.4)	257 542 (190 011–332 759)	74.3 (55.7–97.6)	93.67	– 5.69	– 0.2 (– 0.23 to – 0.17)	< 0.001

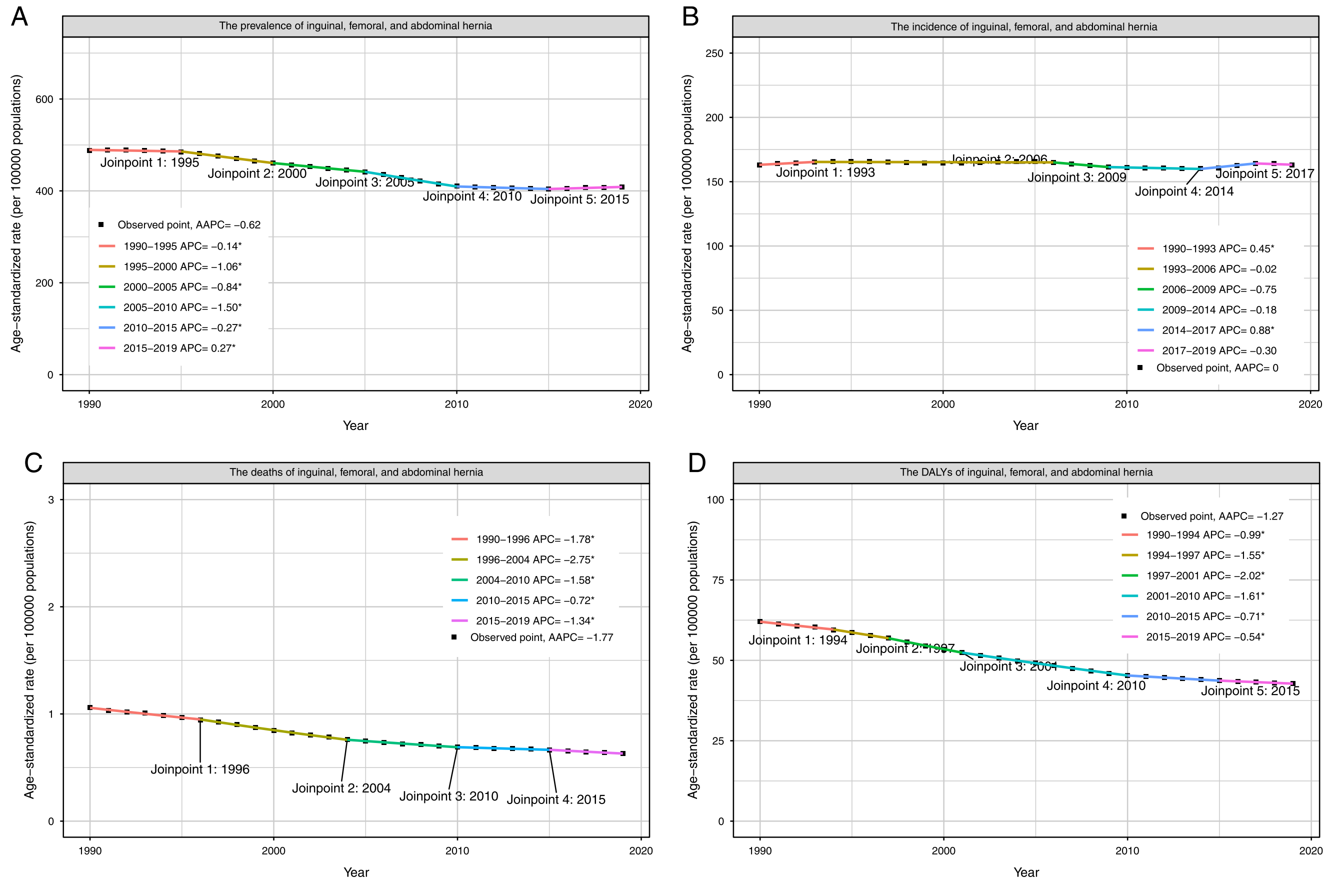

Figure 1. The APC and AAPC of ASR for prevalence (A), incidence (B), deaths (C) and DALYs (D) in inguinal, femoral, and abdominal hernias at the global level based on the joinpoint regression analysis model.

countries like Georgia, with a 57.43% rise in prevalence, and Burundi, with an 88.03% increase in incidence, led the upward trends. The AAPC provided deeper insights: Georgia and Burundi emerged with positive values, especially Georgia with an AAPC of 1.6% (95% CI: 1.5%–1.7%) for prevalence, and Burundi's 2.21% (95% CI: 2.13%–2.28%) for incidence. In contrast, Mongolia and Bulgaria displayed the most marked negative trends, particularly Mongolia's −7.32% (95% CI: −7.72% to −6.93%) in mortality rates. (Tables S1–S4, Supplemental Digital Content 1, http://links.lww.com/JS9/B752, Figures S5–S12, Supplemental Digital Content 2, http://links.lww.com/JS9/B753).

Correlations of ASR with SDI

Investigating hernia metrics across 21 regions, a nuanced correlation with the SDI emerged. Prevalence and incidence ASRs displayed negligible associations with SDI, being slightly negative ($R = -0.303$, $P = 0.182$) and marginally positive ($R = 0.122$, $P = 0.599$), respectively, neither reaching statistical significance. Conversely, a strong negative correlation was observed between mortality ASR and SDI ($R = -0.763$, $P < 0.001$). This trend continued with DALYs ASR, which also negatively correlated with SDI ($R = -0.599$, $P = 0.004$). Similarly, a broader analysis across 204 countries and territories confirmed these patterns: prevalence ASR negatively correlated with SDI ($R = -0.341$, $P < 0.001$), and while incidence ASR's positive correlation was not statistically significant ($R = 0.063$, $P = 0.12$), mortality and DALYs ASRs strongly negatively correlated ($R = -0.664$ and $R = -0.6$, respectively, $P < 0.001$) (Figs 7–8).

Frontier analysis

In the comprehensive frontier analysis based on SDI and ASRs of inguinal, femoral, and abdominal hernias spanning from 1990 to 2019 across 204 countries and territories, distinct trends emerged. For prevalence, as the SDI value ascended from 0.0 to 1.0, there was an overall decline in ASR for hernias, characterized by a progressive density shift from lighter to darker shades over the years, indicative of a general reduction in prevalence. Similarly, the death rate due to hernias presented a downward trend with increasing SDI, while the DALYs followed a similar pattern, revealing that as developmental progress occurs, the burden of hernias tends to diminish (Fig. 9).

Turning our attention to the frontier analysis results from 2019, the visual representations delineated clear distinctions among countries and territories. For prevalence, 15 countries such as Haiti, Zimbabwe, and Guatemala, among others, were observed to have significantly higher rates, placing them distant from the frontier. In contrast, countries like Somalia, Yemen, Popua New Guinea, and the Solomon Islands were closer to the frontier, suggesting optimal outcomes given their SDI. When assessing the death rates, nations like the Central African Republic, Burkina Faso, and Burundi

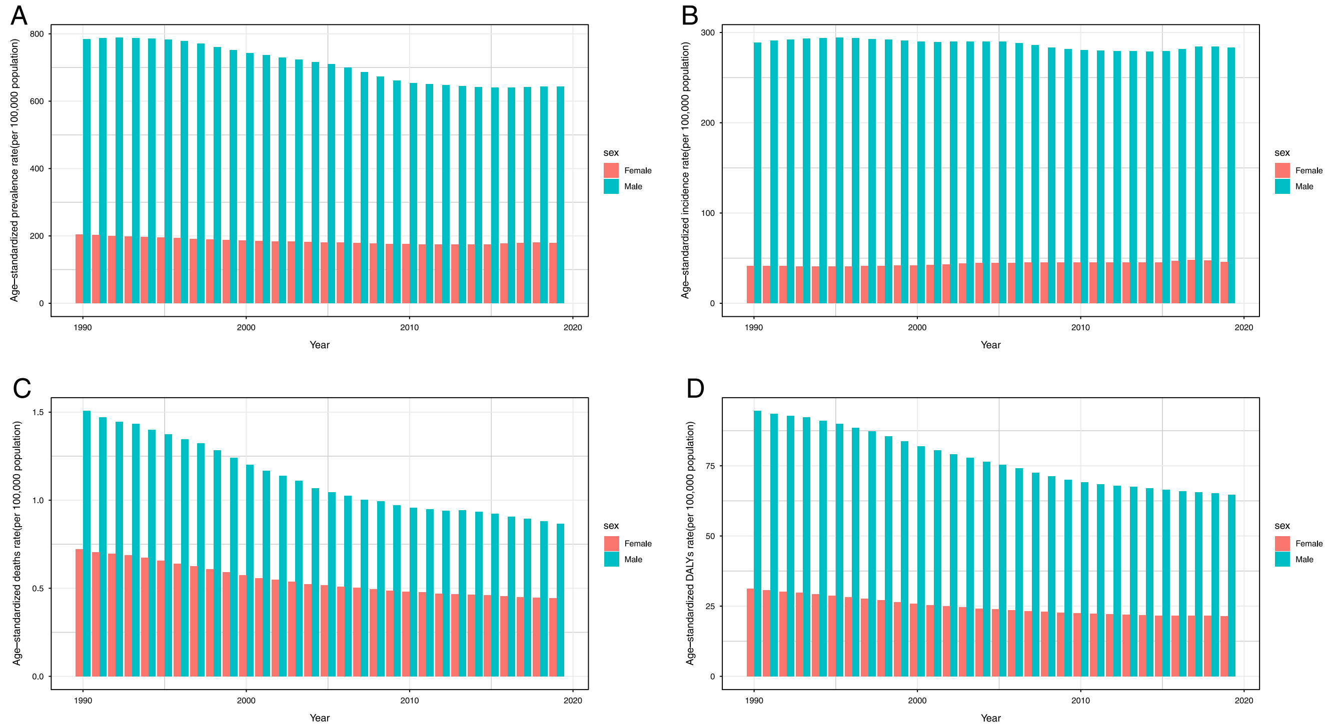

Figure 2. The trends in ASR of prevalence (A), incidence (B), deaths (C), and DALYs (D) for inguinal, femoral, and abdominal hernias among different sexes, female and male, from 1990 to 2019.

exhibited larger gaps from the frontier. Interestingly, high SDI countries such as Qatar, the United Kingdom, and Slovakia showed relatively high effective differences for their developmental stage. Lastly, in the DALYs analysis, countries like Somalia, Yemen, and the Solomon Islands depicted rates closer to the aspirational benchmark set by the frontier (Fig. 9).

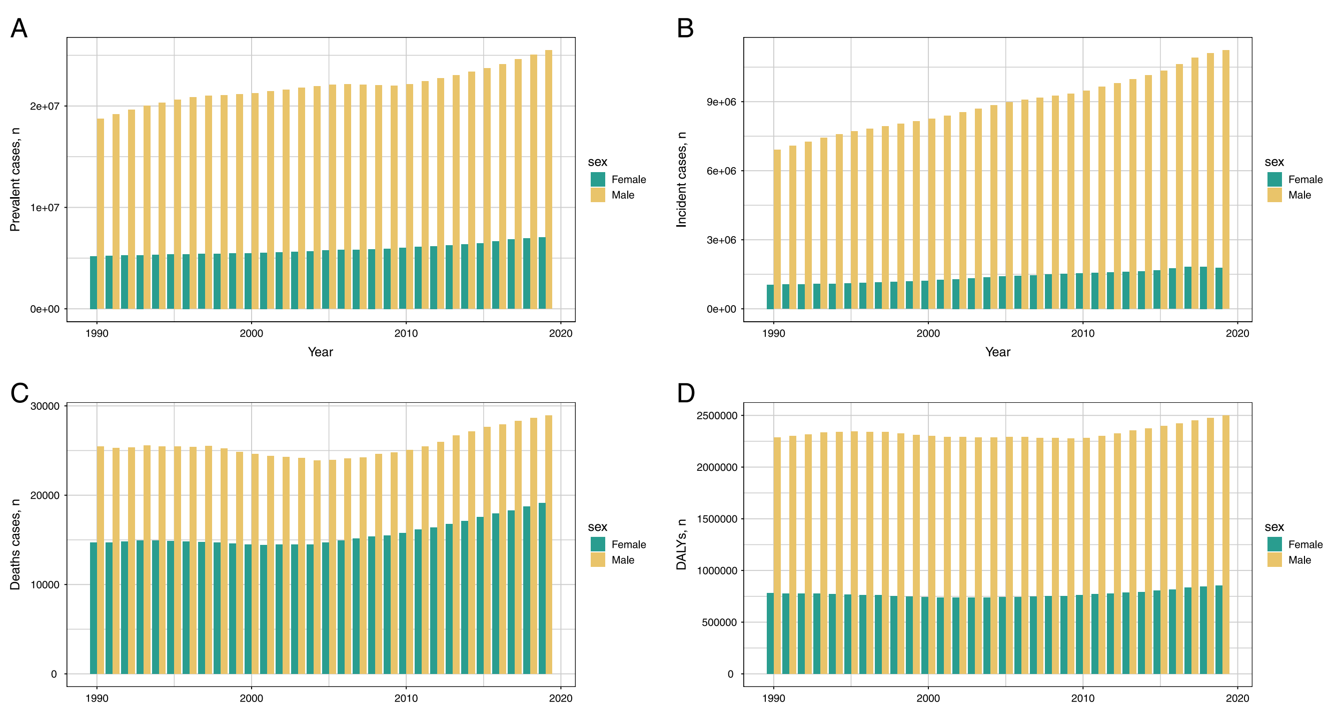

Figure 3. The trends in numbers of prevalence (A), incidence (B), deaths (C), and DALYs (D) for inguinal, femoral, and abdominal hernias among different sexes, female and male, from 1990 to 2019.

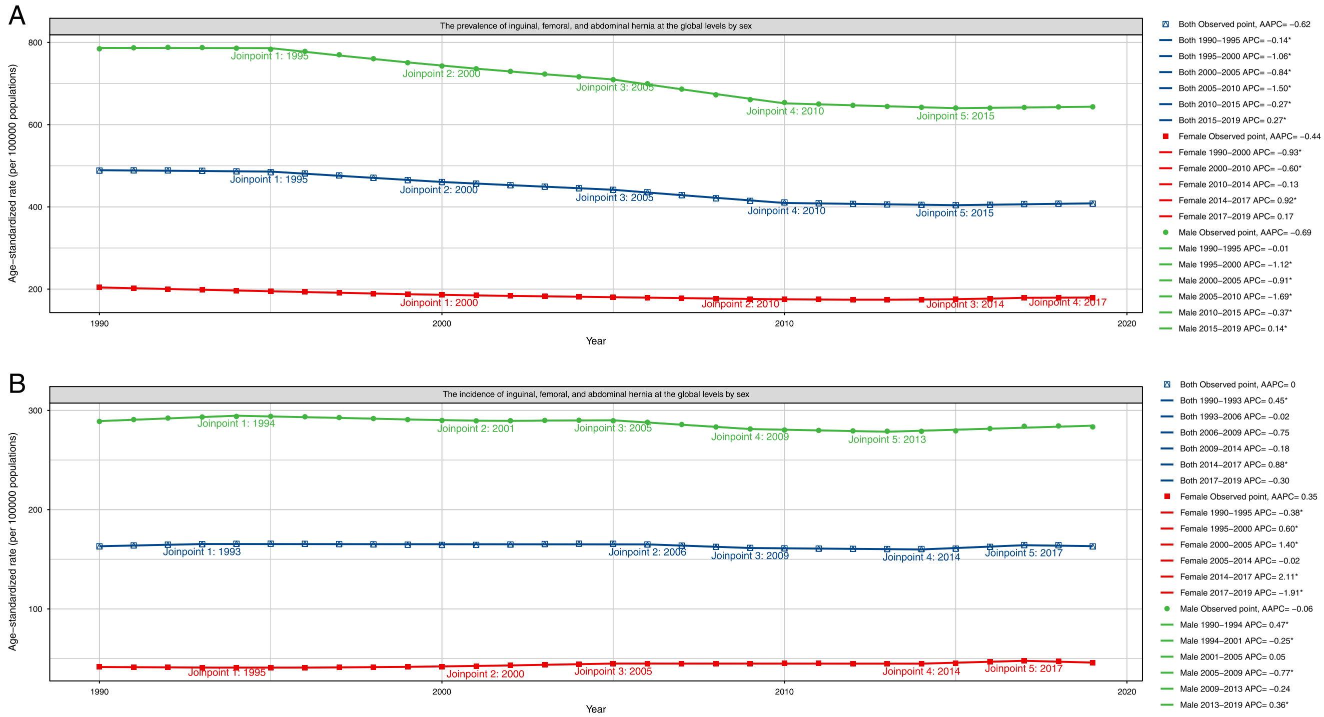

Figure 4. The APC and AAPC of ASR for prevalence (A) and incidence (B) by gender (both, female and male) in inguinal, femoral, and abdominal hernias at the global level based on the joinpoint regression analysis model.

Trends of inguinal, femoral, and abdominal hernias from 1990 to 2030

From 1990 to 2030, data on inguinal, femoral, and abdominal hernias reveals discernible trends in both prevalence and incidence. The combined prevalence in numbers for both sexes is characterized by a steady rise, with males showing a consistent increase and females a more subtle uptick. The ASR of prevalence for both sexes initially declines, stabilizes, and then modestly

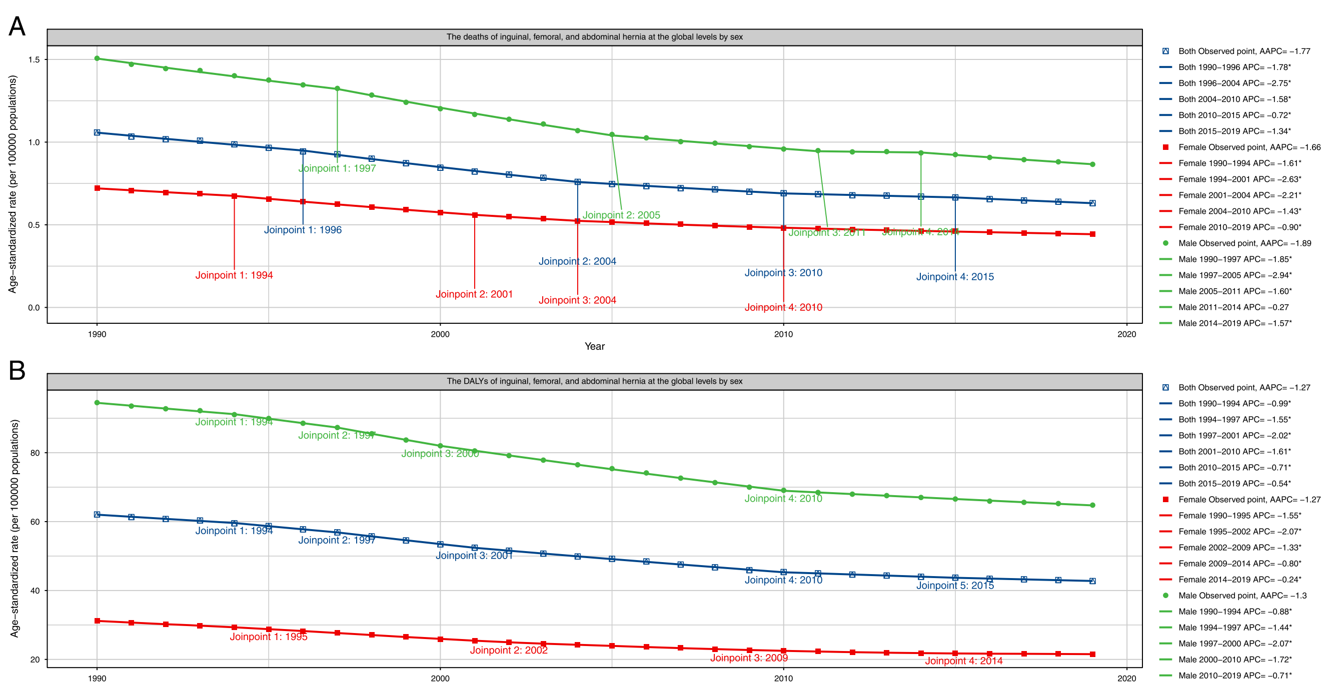

Figure 5. The APC and AAPC of ASR for deaths (A) and DALYs (B) by gender (both, female and male) in inguinal, femoral, and abdominal hernias at the global level based on the joinpoint regression analysis model.

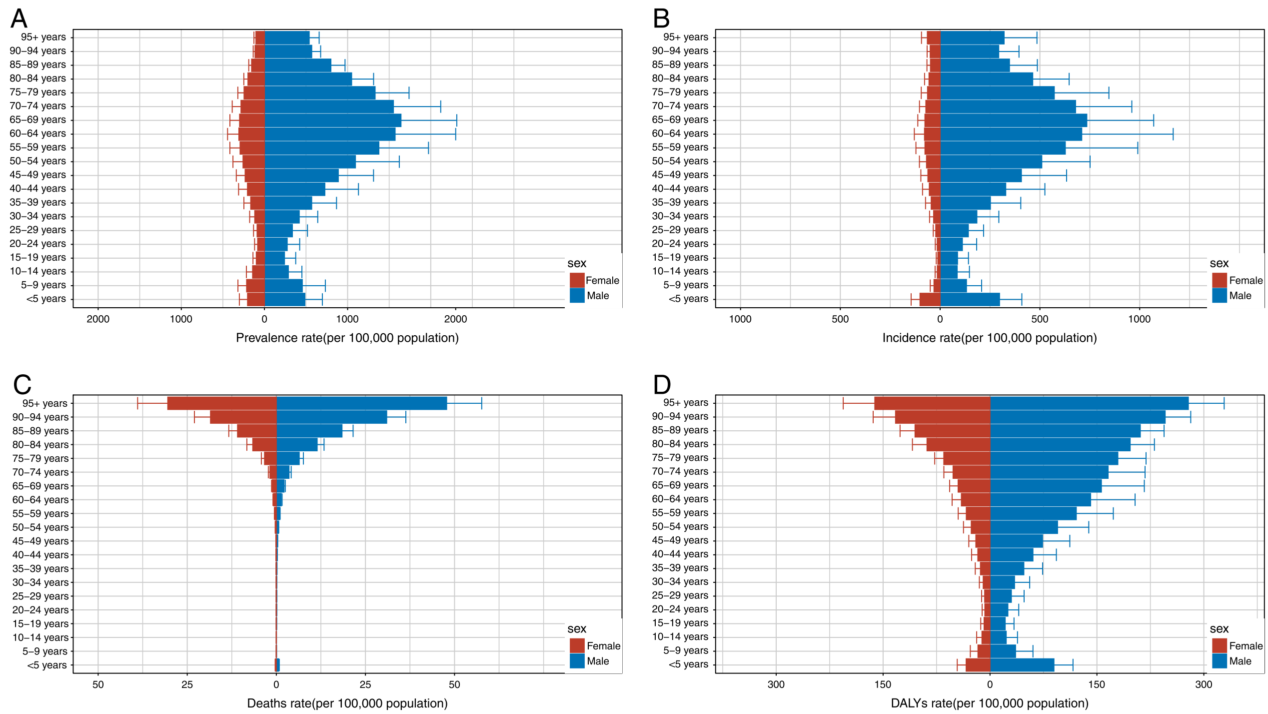

Figure 6. The trends in prevalence (A), incidence (B), deaths (C), and DALYs (D) for inguinal, femoral, and abdominal hernias across different genders, female and male, by age groups ranging from under 5 years to 95+ years.

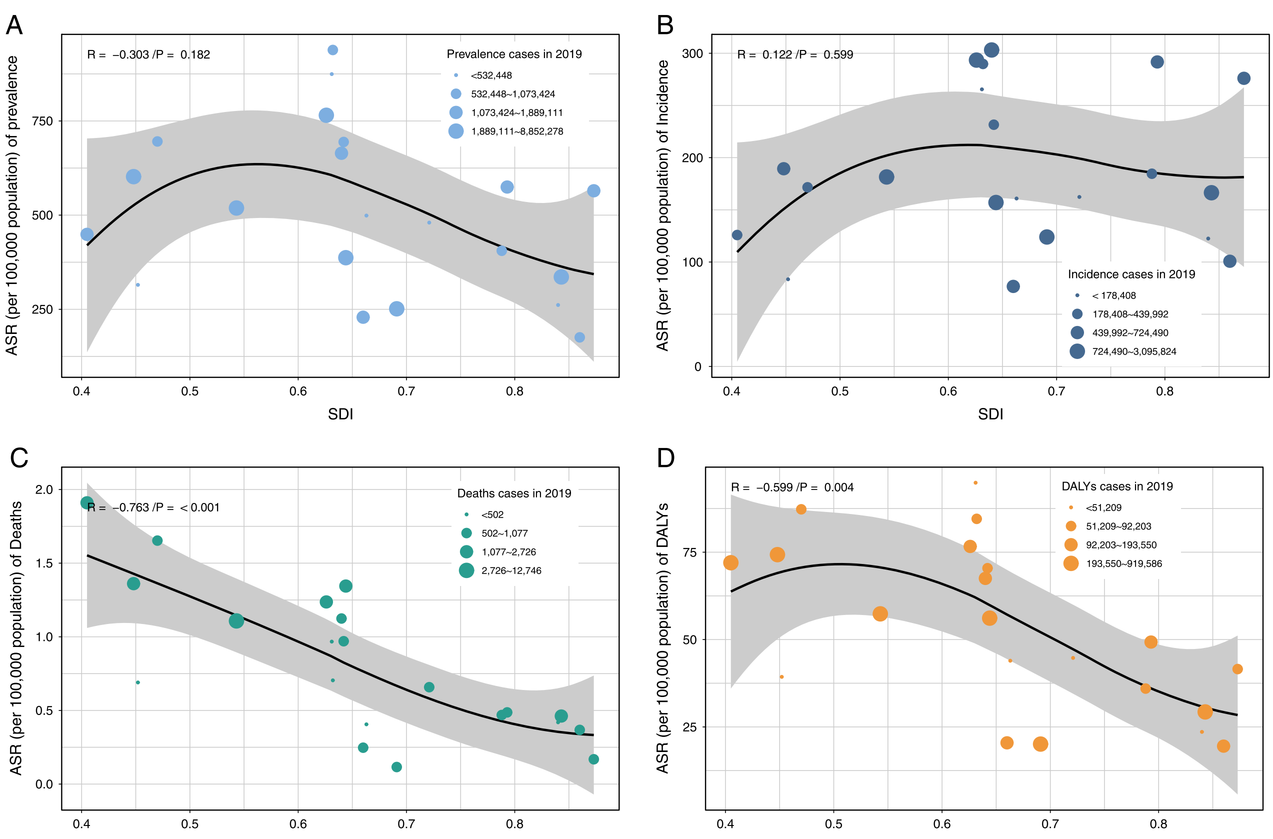

Figure 7. Pearson correlation analysis between the SDI and ASR of prevalence (A), incidence (B), deaths (C), and DALYs (D) for inguinal, femoral, and abdominal hernias across 21 regional levels in 2019 (The cases of prevalence, incidence, deaths, and DALYs from 21 regions in 2019 are represented by circles. The size of the circles increased with the cases of prevalence, incidence, deaths, and DALYs.).

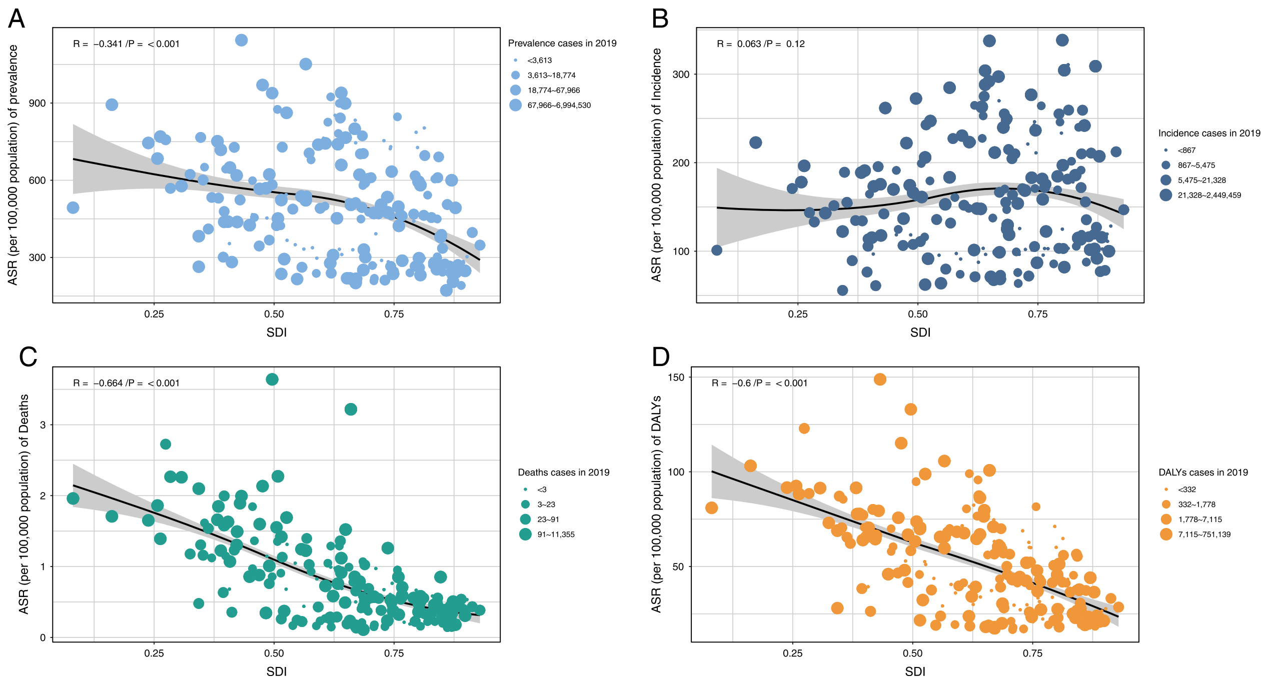

Figure 8. Pearson correlation analysis between the SDI and ASR of prevalence (A), incidence (B), deaths (C), and DALYs (D) for inguinal, femoral, and abdominal hernias at the country and territorial levels in 2019 (The cases of prevalence, incidence, deaths, and DALYs from 204 countries and territories in 2019 are represented by circles. The size of the circles increased with the cases of prevalence, incidence, deaths, and DALYs.).

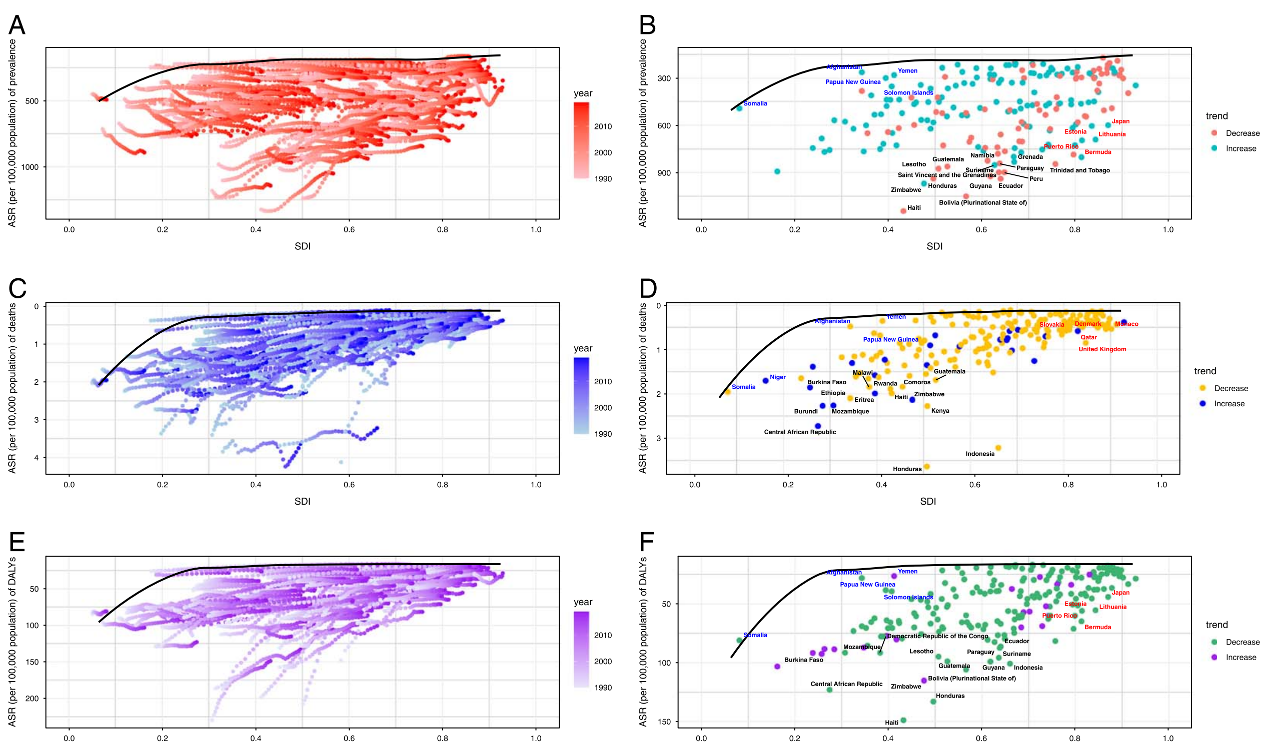

Figure 9. Frontier analysis, represented by the solid black lines, explores the relationship between Socio-Demographic Index (SDI) and Age-Standardized Rate (ASR) for prevalence (A, B), deaths (C, D), and DALYs (E, F) in the context of inguinal, femoral, and abdominal hernias. The color gradient in graphs A, C, and E illustrates the progression of years, ranging from light shades representing 1990 to the darkest shades denoting 2019. In graphs B, D, and F, each dot signifies a specific country or territory for the year 2019, with the top 15 countries displaying the most significant deviation from the frontier labeled in black. Countries with low SDI (> 0.455) and minimal deviation from the frontier are highlighted in blue, while those with high SDI (> 0.805) and notable deviation for their developmental level are emphasized in red. The direction of change from 1990 to 2019 in ASR is indicated by the color of the dots: decrease dots represents a decrease, while increase dots signifies an increase.

climbs in later years. Specifically, the male ASR aligns with this pattern, while the female ASR undergoes a decline until 2015, rebounding gradually thereafter. In terms of the numbers of incidence, there is a marked upswing for both genders combined, more pronounced in males, spanning from 1990 to 2030. In contrast, female incidence began to diminish in 2018 and is projected to maintain this downward trajectory. The ASR of incidence for both sexes remains fairly constant, with males reflecting this stability and females expected to experience a slight dip in the coming years (Figs 10–11).

Regarding death and DALY trends associated with these hernias from 1990 to 2030, both sexes combined consistently display a decline in the ASR of deaths, projected to continue till 2030. Males mirror this decline, while females consistently record a marginally lower ASR. Even with declining rates, the absolute death count has exhibited fluctuations, particularly a sharp increase since 2010. By 2030, the death count for both sexes is projected to rise, with males predominantly leading. Simultaneously, the ASR of DALYs has continuously decreased across the general population, with this downward trend also being consistent in both males and females. Despite the male populace often having a higher rate, the total DALYs count for both sexes is increasing, with projections indicating a continuation of this trend in the ensuing decade (Figs 12–13).

Discussion

From 1990 to 2019, the global prevalence of hernia cases rose by 36% to 32.5 million, while ASRs dropped 16.46%. Absolute incidence spiked 63.67%, but its age-standardized measure was stable. Mortality rose 19.77%, but age-standardized mortality dropped 40.39%. Males had higher rates, but both sexes saw reduced ASRs. Elderly individuals, especially ages 65–69, showed a higher prevalence. Andean Latin America had 2019's highest prevalence, with notable regional variations. High-SDIs linked to better hernia outcomes. Frontier analysis from 1990 to 2019 across 204 countries showed decreasing hernia rates with rising SDIs. Countries like Haiti and Guatemala had high prevalence, while Somalia and Yemen fared better relative to their SDIs. Surprisingly, high-SDI countries like Qatar and the UK had elevated rates. Data from 1990 to 2030 showed rising male hernia prevalence and fluctuating ASRs. The numbers of incidence increased for both sexes, with a forecasted female decline post-2019. Hernia-related deaths and DALYs between 1990 and 2030 indicate falling ASRs but rising absolute counts by 2030, mainly in males. The age-standardized DALY rate's decline slowed significantly post-2015, but total DALYs are expected to rise.

The 36% rise in global hernia cases from 1990 to 2019, juxtaposed with a 16.46% decrease in ASRs, paints a complex picture of hernia epidemiology. This contrast suggests that while the total number of hernia cases has increased, likely due to factors such as lifestyle changes, dietary shifts, and enhanced diagnostic capabilities, the age-specific incidence is declining, possibly reflecting the impact of improved public health measures and healthcare advancements[18,19]. These insights reveal a nuanced narrative of hernia management: despite the overall rise in cases, there are encouraging signs of progress and opportunities for targeted healthcare strategies and research.

From 1990 to 2019, both males and females experienced a decline in ASRs for hernias, though males consistently exhibited higher rates, likely due to anatomical differences[20,21]. Females saw a pronounced decrease, particularly between 2017 and 2019, where the APC in hernia incidence was – 1.91%, suggesting more

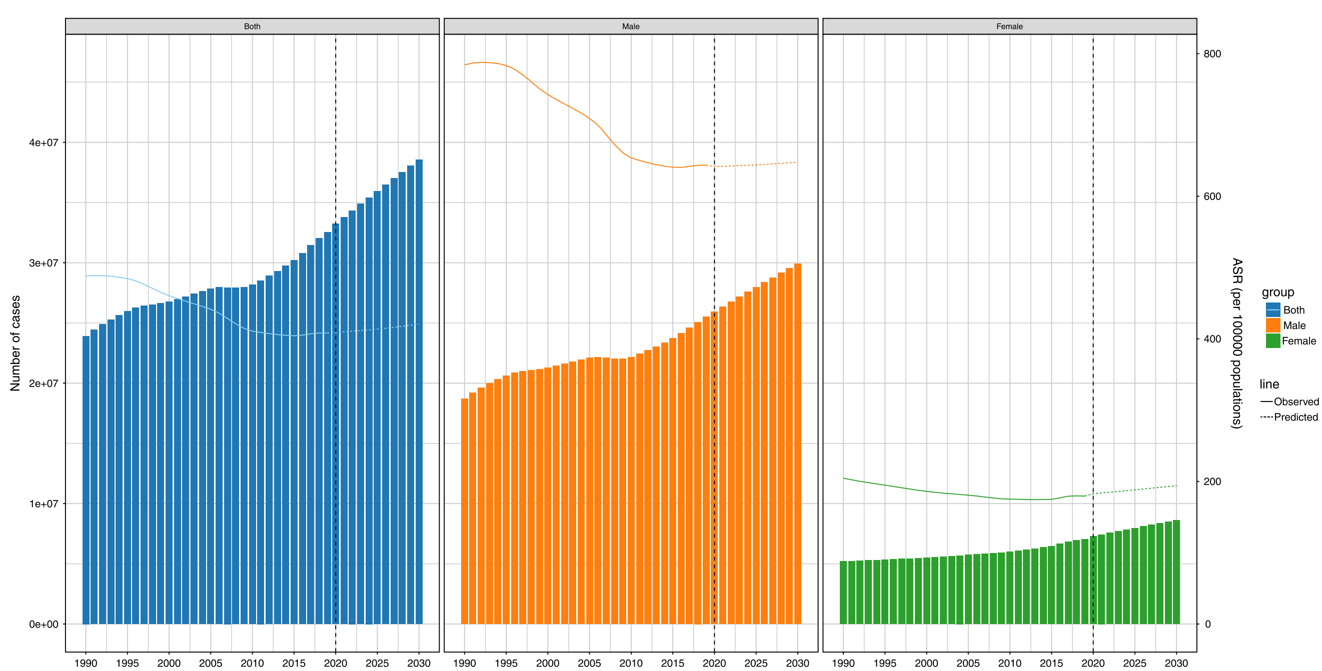

Figure 10. Projected numbers and ASR of prevalence for inguinal, femoral, and abdominal hernias by gender (both, male, and female) from 1990 to 2030 based on the BAPC model.

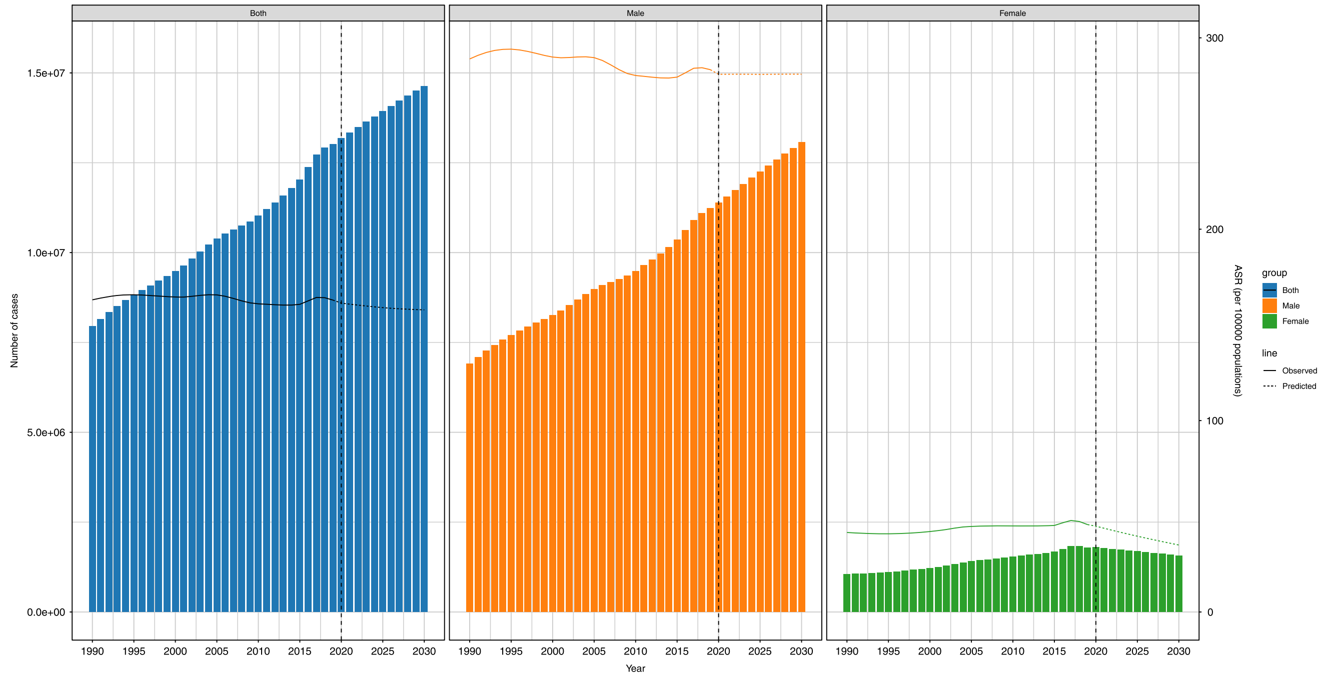

Figure 11. Projected numbers and ASR of incidence for inguinal, femoral, and abdominal hernias by gender (both, male, and female) from 1990 to 2030 based on the BAPC model.

effective healthcare interventions and possibly societal shifts toward less physically demanding roles for women, alongside improved health awareness. While global health strategies seem to have successfully reduced DALYs for both sexes, the greater declines in male mortality and DALYs imply that men might be reaping more benefits from these healthcare advancements. Despite these advances, the increase in absolute hernia cases highlights the impact of population growth and better reporting

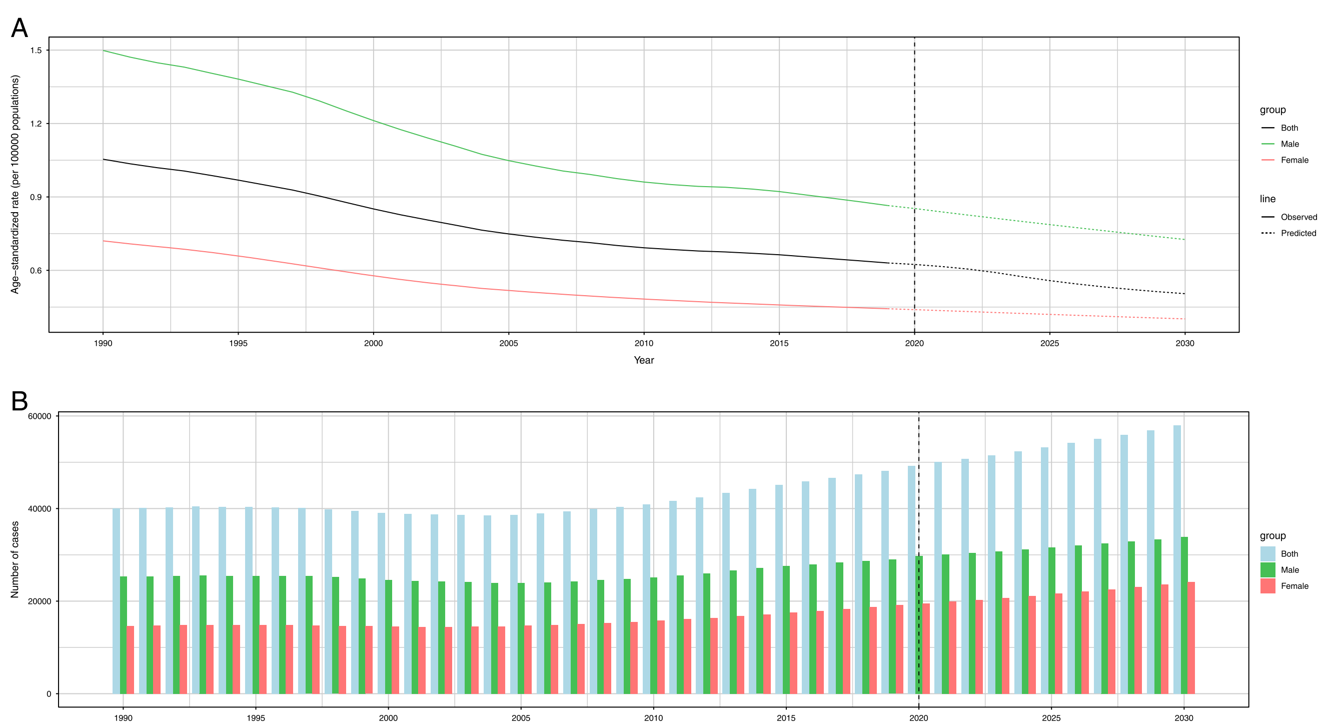

Figure 12. Projected ASR (A) and numbers (B) of deaths for inguinal, femoral, and abdominal hernias by gender (both, male, and female) from 1990 to 2030 based on the BAPC model.

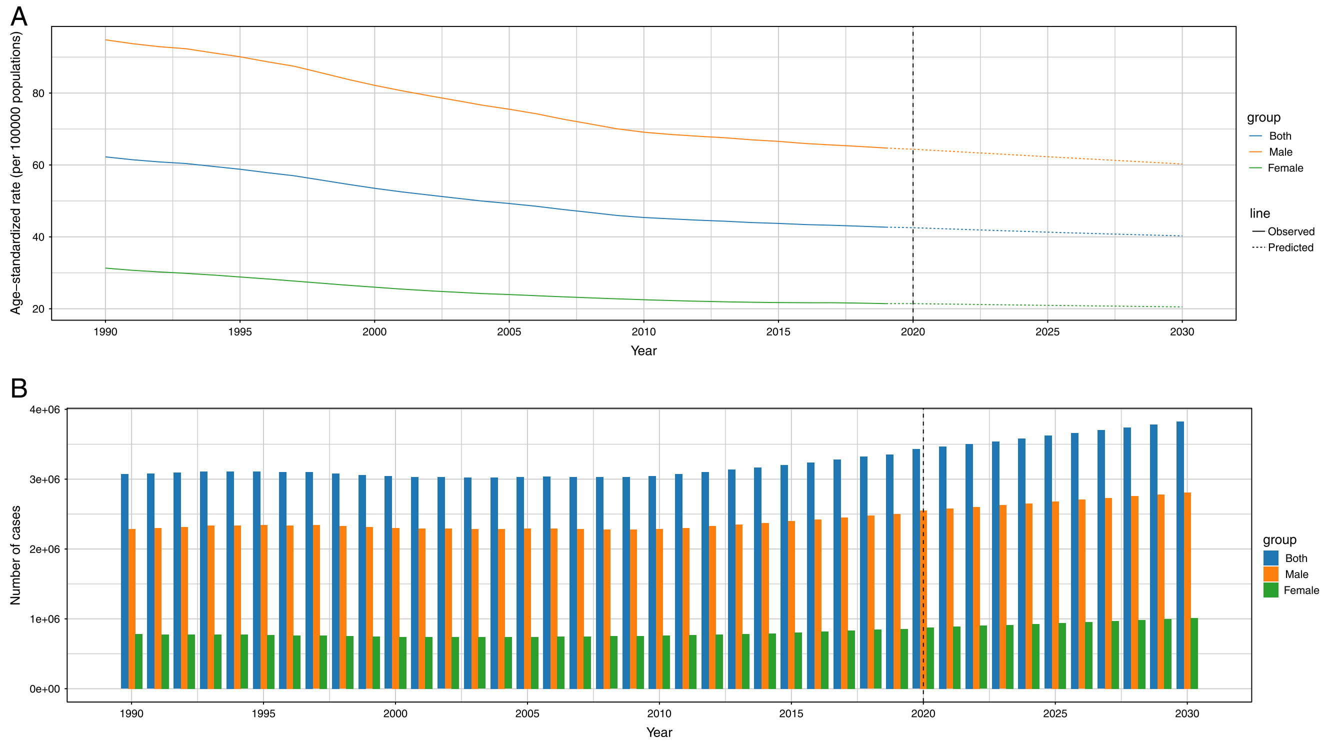

Figure 13. Projected ASR (A) and numbers (B) of DALYs for inguinal, femoral, and abdominal hernias by gender (both, male, and female) from 1990 to 2030 based on the BAPC model.

practices, indicating the need for ongoing sex-specific research to further refine prevention and treatment strategies.

The hernia trends across various regions and nations over the past three decades underscore a complex interplay of socio-demographic, economic, and healthcare determinants[22,23]. Andean Latin America's high prevalence ASR contrasts starkly with high-income North America, suggesting that regional differences in factors like genetic predisposition, healthcare accessibility, and environmental factors might be at play[24–26]. South Asia's substantial decline, potentially linked to improving healthcare systems and advancements in hernia management strategies, contrasts Central Sub-Saharan Africa's uptick, perhaps attributable to increasing population ages or a lag in medical advancements[27,28]. The dramatic reduction in mortality ASR observed in Central Europe may point toward the efficacy of their healthcare protocols and accessibility to timely treatment. Conversely, the surge in mortality in regions like Tropical Latin America warrants an in-depth investigation into potential gaps in healthcare delivery or emerging risk factors.

At a national level, the striking growth in hernia-related metrics for Qatar raises questions about changing lifestyle factors, potentially accelerated urbanization, or perhaps increased diagnostic capabilities[18]. Mongolia's notable reduction in mortality and DALYs signifies effective health interventions and possible shifts in public health priorities. However, the upward trajectories observed in countries like Georgia and Burundi call for an urgent need to address potential epidemiological changes, health system constraints, or socio-economic factors that may be influencing these trends. The diverse patterns observed across regions and countries emphasize the importance of tailor-made health strategies, accounting for each area's unique challenges and strengths.

The relationship between the SDI and hernia health outcomes is strikingly negative, particularly for hernia-related deaths and DALYs, underscoring the beneficial impact of higher SDIs on reducing mortality and morbidity from hernias. This correlation is likely attributable to the superior healthcare systems, increased access to medical care, and higher health literacy typically found in regions with higher SDIs[22,29]. The connection between SDI and hernia prevalence or incidence, however, is less pronounced at the regional levels, indicating that additional factors such as genetics, environment, or occupation may also play significant roles. Nevertheless, the data affirms that socio-demographic progress is crucial for enhancing hernia health outcomes, highlighting the importance of improving SDI as a central goal in health policies[30].

The frontier analysis, anchored on the SDI and ASRs of hernias, offers pivotal insights into the trajectory of hernia trends from 1990 to 2019 across the globe. The overarching narrative paints a clear picture: as socio-demographic indices climb, the weight of hernias—whether gauged through prevalence, death rates, or DALYs—lightens. Yet, a deeper dive into the 2019 data unveils nuanced disparities among nations. It is striking that countries like Haiti, Zimbabwe, and Guatemala, despite their varied socio-demographic backdrops, all grapple with inflated prevalence rates, distancing them from the optimal frontier. Conversely, nations like Somalia and Yemen, often mired in socio-political challenges, appear to fare better in hernia outcomes vis-à-vis their SDI, inching closer to the frontier's aspirational benchmark. This disparity underscores the multifaceted nature of healthcare outcomes, suggesting that while SDI is a significant influencer, other latent factors—be they environmental, genetic, or healthcare system intricacies—also play pivotal roles in shaping hernia trends.

Over the 30 years, the rising incidence numbers of hernias has highlighted a critical public health issue, with a more significant impact on males yet displaying a recent decline in females post-2018, pointing to the need for further research into the reasons behind these sex differences. While age-standardized prevalence rates have fluctuated, indicating decreases and stabilization, an expected upward trend raises concerns about the effects of an aging population on disease incidence. Although the increase in raw mortality figures since 2010 is alarming, the downward trend in age-standardized death rates reflects improvements in hernia management and medical treatments. Nevertheless, the steady rate of DALYs since 2015, alongside rising total DALY figures, underscores a persistent morbidity, stressing the importance of enhancing life quality after treatment. These trends underscore the urgency for nuanced health policies that focus on reducing the incidence and improving long-term outcomes for hernia patients.

Our study undoubtedly has inherent limitations. While we have endeavored to provide a comprehensive analysis, the accuracy and consistency of data across diverse regions can vary, potentially introducing biases or inaccuracies. Furthermore, our projections up to 2030, though based on rigorous statistical models, rest on certain assumptions, which external factors could influence. Additionally, the historical span of our research, encompassing data from 1990 onwards, might be affected by evolving diagnostic criteria and medical technologies over the years. Hence, while our findings shed valuable light on global hernia trends, they should be interpreted with caution, acknowledging the nuanced intricacies and potential deviations embedded within the broader landscape of our research.

Conclusions

Our research highlights key patterns linking hernia trends with socio-demographic factors, offering critical insights for health policy and practice. Findings indicate that regions with higher socio-demographic indices report fewer hernia-related deaths and better outcomes, though disparities persist. Given the ongoing global burden of hernias, the need for continuous monitoring and adaptive health strategies is evident. Effective reduction in hernia impact will require persistent research and proactive healthcare approaches.

Ethical approval

Our research involved a secondary evaluation of the publicly accessible GBD Study dataset, without primary data collection. Hence, no ethical approval was necessary.

Consent

No informed consent was required since our research is a secondary analysis of public data.

Sources of funding

No funding supported.

Author contribution

In this research effort, W.F. and L.X.L. provided critical data curation and analysis, validating the findings, and drafting the initial manuscript; M.B.Z. was instrumental in conceptualizing the study framework, honing the methodology, and supervising the project, in addition to refining the manuscript through substantive review and editing; M.Q.Y. supported the research with essential data curation, software handling, and contributed to the visualization of results, also participating in the manuscript's refinement. As the corresponding author, L.X.L. orchestrated the study's design and coordination, managed project administration, and led the methodology development and validation processes. Her role was pivotal in the manuscript's final review, ensuring the integrity and accuracy of the work presented.

Conflicts of interest disclosure

All the authors have no conflicts of interest.

Research registration unique identifying number (UIN)

1. Name of the registry: not applicable.
2. Unique identifying number or registration ID: not applicable.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): not applicable.

Guarantor

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Data availability statement

The data comes from a public database, can through this link: https://vizhub.healthdata.org/gbd-results/ for the relevant data.

Provenance and peer review

Our paper was not invited. Not commissioned, externally peer reviewed.

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