



The global, regional, and national burden and its trends of inguinal, femoral, and abdominal hernia from 1990 to 2019: findings from the 2019 Global Burden of Disease Study – a cross-sectional study

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Background: Inguinal, femoral, and abdominal hernia repairs are the most common surgical procedure worldwide. However, studies on hernia disease burden are notably limited, in both developed and low-income and middle-income countries (LMICs). We investigated temporal trends in the incidence and prevalence of inguinal, femoral, and abdominal hernias at global, regional, and national levels in 204 countries and territories from 1990 to 2019 using data from the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 (GBD 2019).

Materials and Methods: Annual incident cases, prevalent cases, age-standardized incidence rates (ASIRs), and age-standardized prevalence rates (ASPRs) of inguinal, femoral, and abdominal hernias between 1990 and 2019 were extracted from the GBD 2019 study and stratified by sex, age, and location. Percentage changes in incident cases and prevalent cases, and the estimated annual percentage changes of ASIRs and ASPRs were calculated to quantify the trends in the incidence and prevalence of inguinal, femoral, and abdominal hernias. Data analysis for the present study was conducted from 15 June 2022 to 15 July 2022.

Results: Globally, there were 32.53 million [95% uncertainty interval (UI): 27.71–37.79] prevalent cases and 13.02 million (10.68–15.49) incident cases of inguinal, femoral, and abdominal hernias in 2019, which increased by 36.00% and 63.67%, respectively, compared with 1990. Eighty-six percent of the incident cases were males, the male-to-female ratio was 6 : 1, and most patients were aged 50–69 years. India (2.45 million), China (1.95 million), and Brazil (0.71 million) accounted for more than one-third (39%) of the incident cases worldwide. From 1990 to 2019, the ASIR and ASPR showed a decreasing trend worldwide, except in Central Sub-Saharan Africa, which had an increasing trend in ASIR and ASPR.

Conclusion: The global incident cases and prevalent cases of inguinal, femoral, and abdominal hernias increased substantially from 1990 to 2019, with a heavier burden observed in males, older adults, and in LMICs such as India and China. In addition, the ASIR and ASPR increased substantially in Central Sub-Saharan Africa. More efforts are warranted for hernia management to reduce the burden of inguinal, femoral, and abdominal hernias, such as by providing safe hernia surgical treatment for males, older adults, and LMICs.

Keywords: abdominal hernia, femoral hernia, global burden of disease, inguinal hernia, trend

Introduction

Inguinal, femoral, and abdominal hernia repairs are the most common surgical procedure performed worldwide, both in adults

and in children^[1–3]. Of these, cases of inguinal hernias constitute the vast majority^[2]. Male sex, increased age, smoking, and physical activity are risk factors thought to be associated with abdominal hernia^[1,4,5]. Surgical treatment is recommended for

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the majority of patients, and for patients with inguinal hernia, surgical repair has been shown to be highly cost-effective^[6–8]. Although numerous studies have investigated which method of hernia repair is most effective in developed countries^[9–11], studies on the hernia disease burden are notably quite limited, in both developed and low-income and middle-income countries (LMICs)^[12]. The paucity of data on the hernia disease burden worldwide and its temporal trends needs to be addressed.

The Global Burden of Diseases, Injuries, and Risk Factors Study 2019 (GBD 2019) assessed the burden of 369 diseases and injuries in 204 countries and territories worldwide^[13], thus providing an opportunity to evaluate the disease burden of inguinal, femoral, and abdominal hernias across sexes, age groups, socio-demographic index (SDI) levels, locations, and times in terms of incidence and prevalence. To our knowledge, a systematic analysis of the updated global disease burden and temporal trends of inguinal, femoral, and abdominal hernias based on the data from the GBD 2019 study has not yet been conducted. Therefore, we investigated the temporal trends in the incidence and prevalence of inguinal, femoral, and abdominal hernias at the global, regional, and national levels in 204 countries and territories from 1990 to 2019 by using estimates from the GBD 2019 study. This study aimed for a comprehensive analysis of the inguinal, femoral, and abdominal hernia disease burden from a global perspective, which may help to clarify the most up-to-date disease burden, allow for comparison of the trends in inguinal, femoral, and abdominal hernia burden across regions and nations, and inform targeted programs in hernia management, healthcare planning, and resource allocation.

Materials and methods

Data source

The GBD 2019 study estimated the incidence and prevalence of inguinal, femoral, and abdominal hernias for 23 age groups, both sexes, 204 countries and territories for every year from 1990 to 2019, and these were grouped into five SDI regions and 21 GBD regions^[13,14]. SDI is a composite indicator of a country's lag-distributed income per capita, average years of schooling, and total fertility rate in females under the age of 25 years^[14]. We extracted annual incident cases, prevalent cases, age-standardized incidence rates (ASIRs), and age-standardized prevalence rates (ASPRs) of inguinal, femoral, and abdominal hernias between 1990 and 2019 by sex, age, and location using the Global Health Data Exchange (GHDx) query tool (<http://ghdx.healthdata.org/gbd-results-tool>). In this study, we selected four age groups, including 0–14 years, 15–49 years, 50–69 years, and 70+ years. The University of Washington Institutional Review Board Committee approved the GBD 2019. Informed consent and institutional review board approval were waived because this study did not involve human subjects and was only a data analysis from the GBD 2019 study. This study has been reported in line with the STROCSS (Strengthening the Reporting of Cohort Studies in Surgery) criteria, Supplemental Digital Content 1, <http://links.lww.com/JS9/A117>^[15].

Data processing

The approach for estimating disease incidence and prevalence taken by the GBD 2019 was the same as for the GBD 2017,

HIGHLIGHTS

- Global cases of inguinal, femoral, and abdominal hernias increased from 1990 to 2019.
- Males, older adults, and low-income and middle-income countries, such as India and China, had heavy hernia burdens.
- The worldwide age-standardized incidence rate and age-standardized prevalence rate of hernias gradually decreased from 1990 to 2019.
- The age-standardized incidence rate and age-standardized prevalence rate increased substantially in Central Sub-Saharan Africa.

which has been described elsewhere^[16,17]. For inguinal, femoral, and abdominal hernias, the GBD maps all incidence and prevalence data using the International Statistical Classification of Diseases, Tenth Revision (ICD-10) (codes K40-K42.9, K44-K46.9) and International Classification of Diseases, Ninth Revision (ICD-9) (codes 550-551.1, 551.3-552.1, 552.3-553.1, 553.3-553.9)^[18], which include all primary and recurrent inguinal, femoral, umbilical, diaphragmatic, other abdominal, and unspecified abdominal hernias (Supplementary Table 1, Supplemental Digital Content 2, <http://links.lww.com/JS9/A118>). Ventral hernias (incisional, parastomal, other and unspecified ventral hernias) were not included. Data sources for GBD estimations of inguinal, femoral, and abdominal hernias were mainly collected from hospital inpatient discharge records, hospital information systems, health insurance and patient claims, and national patient registers and databases from different countries and territories^[19].

Statistical analysis

The disease burden for inguinal, femoral, and abdominal hernias were estimated using annual incident cases, prevalent cases, ASIRs, and ASPRs with 95% uncertainty intervals (UIs). We calculated the percentage changes in incident and prevalent cases, and the estimated annual percentage changes (EAPCs) of ASIRs and ASPRs to quantify the trends in the incidence and prevalence of inguinal, femoral, and abdominal hernias. The percentage changes in incident cases from 1990 to 2019 were calculated as [(incident cases in 2019 – incident cases in 1990)/incident cases in 1990] × 100%. The percentage changes in prevalent cases were calculated using the same method. The EAPC is a summary and widely used measure of the age-standardized rate (ASR) trend over a specified time interval^[20]. A regression line was fitted to the natural logarithm of the ASR, for instance, $y = \alpha + \beta x + \varepsilon$, where $y = \ln(\text{ASR})$ and $x = \text{calendar year}$. The EAPC (calculated as $100 \times [e^\beta - 1]$) and its 95% confidence interval (CI) were calculated to reflect the temporal trend in ASR^[20]. The ASR shows an upward trend when the EAPC and the lower boundary of its 95% CI are positive, and the ASR shows a downward trend when the EAPC and the upper boundary of its 95% CI are negative^[20]. Data analysis for the present study was conducted from 15 June 2022 to 15 July 2022. All analyses were performed using R version 4.0.0 (R Foundation).

Results

Global trends in incidence and prevalence

Globally, there were 32.53 million (95% UI: 27.71–37.79) inguinal, femoral, and abdominal hernia cases in 2019, which increased by 36.00% from 23.92 million (20.46–28.07) in 1990. In 2019, the incident cases worldwide were 13.02 million (10.68–15.49), which increased by 63.67% from 7.96 million (6.61–9.41) in 1990. From 1990 to 2019, the worldwide ASIR of inguinal, femoral, and abdominal hernias slightly decreased (EAPC: -0.08 , 95% CI: -0.12 to -0.04) from 163.03 to 162.96 per 100 000. The worldwide ASPR also decreased in the same period (EAPC: -0.81 , 95% CI: -0.88 to -0.74) from 488.33 to 407.93 per 100 000 (Table 1, Supplementary Table 2, <http://links.lww.com/JS9/A118>).

Global incidence and prevalence by sex and age

In 2019, 86% of the incident cases of inguinal, femoral, and abdominal hernias were males (11.24 million) and 14% were females (1.79 million), with a male-to-female ratio of 6 : 1; these incident cases were 62.63 and 70.51% higher than those in 1990, respectively. The ASIR decreased from 288.85 to 283.34 per 100 000 (EAPC: -0.18 , 95% CI: -0.22 to -0.13) among males but increased from 41.51 to 45.69 per 100 000 (EAPC: 0.52, 95% CI: 0.45–0.59) among females in the same period (Table 1).

In 2019, the prevalent cases were 25.50 million (21.75–29.63) among males and 7.03 million (5.89–8.26) among females. From 1990 to 2019, the prevalent cases increased by 35.35% in females and 36.17% in males, respectively. The ASPR decreased from 784.45 to 643.33 per 100 000 (EAPC: -0.90 , 95% CI: -0.97 to -0.82) among males and decreased from 204.54 to 179.34 per 100 000 (EAPC: -0.51 , 95% CI: -0.60 to -0.41) among females during the same period (Supplementary Table 2, [Supplementary Digital Content 2, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)).

From 1990 to 2019, the incident cases increased for all age groups in both sexes (Fig. 1). The incident cases in 2019 was highest among individuals aged 50–69 years (4.76 million), followed by individuals aged 15–49 years (4.72 million); these incident cases were 93.73 and 65.36% higher than those in 1990, respectively. In 2019, the number of incident cases among individuals aged 70 years or older was the lowest (1.33 million); however, this incidence was 131.37% higher than that in 1990 (Table 1).

The prevalent cases increased among individuals aged 15 years or older and were the highest among individuals aged 15–49 years (12.00 million) in 2019. The 70+ years age group had the lowest number of prevalent cases (3.27 million) in 2019; this prevalence was 80.21% higher than that in 1990, and this increase was the largest among all the age groups (Supplementary Table 2, [Supplementary Digital Content 2, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118), Supplementary Figure 1, [Supplementary Digital Content 2, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)).

Regional trends in incidence and prevalence by SDI and GBD regions

In 2019, the middle SDI region had the highest incident cases (4.00 million) and prevalent cases (9.56 million) of inguinal, femoral, and abdominal hernias. The lowest number of incident cases was 1.44 million (1.20–1.71) in the low SDI region; this incidence was 108.95% higher than that in 1990. The high SDI

region had the lowest prevalent cases of 3.60 million (3.04–4.22). The highest ASIR was 183.67 per 100 000 (150.22–219.49) in the high-middle SDI region. The ASPR was highest in the low SDI region and lowest in the high SDI region (Table 1, [Supplementary Table 2, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)).

In 2019, the incident cases and prevalent cases were highest in South Asia (3.10 and 8.85 million, respectively), followed by East Asia (2.00 and 3.87 million, respectively) and Southeast Asia (1.06 and 2.59 million, respectively). Notably, South Asia, East Asia, and Southeast Asia accounted for approximately half of both the worldwide incident cases and prevalent cases (47% for both). The incident cases (213.04%) and prevalent cases (182.23%) increased the most in Central Sub-Saharan Africa. Across the 21 GBD regions, Central Sub-Saharan Africa had the highest increasing trend of ASIR (EAPC: 1.26, 95% CI: 1.23–1.30) and ASPR (EAPC: 0.71, 95% CI: 0.59–0.83) (Table 1, [Supplementary Table 2, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118); Fig. 2, [Supplementary Figure 2, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)).

National trends in incidence and prevalence

In 2019, India (2.45 million), China (1.95 million), and Brazil (0.71 million) accounted for more than one-third (39%) of the worldwide incident cases of inguinal, femoral, and abdominal hernias (Fig. 3B, [Supplementary Table 3, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)). Among these three countries, the ASIR decreased in India (EAPC = -1.39 , 95% CI: -1.55 to -1.23), increased in China (EAPC = 1.02, 95% CI: 0.96–1.08), and remained stable in Brazil (EAPC = 0.12, 95% CI: -0.13 to 0.37) from 1990 to 2019 (Fig. 4, [Supplementary Table 3, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)). Similarly, India (7.00 million), China (3.74 million), and Brazil (1.54 million) accounted for more than one-third (38%) of the worldwide prevalent cases in 2019. The ASPR exhibited a decreasing trend in these three countries. The ASPR decreased in India (EAPC = -2.11 , 95% CI: -2.27 to -1.95), China (EAPC = -0.52 , 95% CI: -0.57 to -0.48), and Brazil (EAPC = -0.48 , 95% CI: -0.60 to -0.36) from 1990 to 2019 ([Supplementary Table 4, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118), [Supplementary Figure 3B, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118), [Supplementary Figure 4, http://links.lww.com/JS9/A118](http://links.lww.com/JS9/A118)).

Discussion

To our knowledge, this is the most recent analysis assessing the global disease burden and temporal trends in the incidence and prevalence of inguinal, femoral, and abdominal hernias using data from the GBD 2019 study. It should be noted that inguinal hernia contributed the most incidence and prevalence in this study, given that inguinal hernias represent the vast majority of abdominal wall hernias^[2]. During the past 30 years, we found that the worldwide ASIR and ASPR of inguinal, femoral, and abdominal hernias showed a decreasing trend, whereas the absolute number of incident cases and prevalent cases of inguinal, femoral, abdominal hernias continue to increase, reaching 13.02 million new incident cases and a total of 32.53 million prevalent

Table 1**Incidence and ASIR per 100 000 individuals for inguinal, femoral, and abdominal hernia for 1990 and 2019.**

Characteristic	Incident cases, thousands			ASIR per 100 000		
	1990, <i>N</i> (95% UI)	2019, <i>N</i> (95% UI)	Percentage change (%)	1990, <i>N</i> (95% UI)	2019, <i>N</i> (95% UI)	EAPC, <i>N</i> (95% CI)
Global	7955.58 (6614.30–9409.89)	13020.72 (10682.09–15490.16)	63.67	163.03 (134.63–192.62)	162.96 (134.12–192.86)	−0.08 (−0.12 to −0.04)
Sex						
Female	1046.93 (866.87–1241.72)	1785.11 (1462.85–2132.45)	70.51	41.51 (34.23–49.10)	45.69 (37.67–54.48)	0.52 (0.45–0.59)
Male	6908.64 (5733.51–8168.87)	11235.61 (9221.15–13345.29)	62.63	288.85 (238.86–340.29)	283.34 (232.65–335.09)	−0.18 (−0.22 to −0.13)
Age group (year)						
0–14	2070.33 (1405.96–2761.08)	2212.61 (1503.72–2961.01)	6.87	—	—	—
15–49	2852.47 (2093.71–3745.34)	4716.73 (3432.42–6185.42)	65.36	—	—	—
50–69	2458.76 (1787.04–3385.97)	4763.26 (3410.86–6605.26)	93.73	—	—	—
70 + years	574.02 (405.85–752.61)	1328.13 (906.03–1784.87)	131.37	—	—	—
5 SDI Region						
Low SDI	688.10 (574.31–811.24)	1437.76 (1197.11–1710.87)	108.95	161.53 (135.09–188.55)	159.00 (132.28–187.31)	−0.25 (−0.31 to −0.19)
Low-middle SDI	1704.88 (1410.05–2025.97)	2761.21 (2278.50–3332.15)	61.96	180.97 (149.92–214.61)	167.01 (137.40–200.20)	−0.54 (−0.64 to −0.45)
Middle SDI	2178.95 (1822.44–2577.02)	3985.24 (3255.77–4738.51)	82.90	145.77 (120.57–172.14)	159.59 (131.60–188.04)	0.21 (0.16–0.25)
High-middle SDI	1986.70 (1629.42–2376.19)	3006.40 (2413.53–3629.18)	51.33	176.79 (144.44–211.19)	183.67 (150.22–219.49)	0.14 (0.09–0.20)
High SDI	1392.68 (1133.44–1650.07)	1822.36 (1457.59–2172.80)	30.85	157.90 (128.61–187.29)	147.66 (121.77–174.46)	−0.08 (−0.16 to 0.01)
21 GBD Region						
Andean Latin America	96.15 (84.79–108.48)	180.44 (153.55–208.60)	87.67	252.85 (223.50–283.81)	289.76 (247.36–333.10)	0.32 (0.22–0.41)
Australasia	27.37 (22.48–32.30)	46.34 (38.25–54.95)	69.33	125.56 (103.15–147.54)	122.51 (101.55–144.69)	−0.10 (−0.13 to −0.07)
Caribbean	76.34 (64.83–88.77)	127.19 (107.19–147.94)	66.61	226.92 (193.76–262.17)	265.44 (224.40–308.21)	0.56 (0.52–0.60)
Central Asia	88.99 (75.21–104.25)	151.18 (125.74–179.07)	69.88	134.50 (115.19–156.43)	160.86 (134.58–190.08)	0.91 (0.66–1.16)
Central Europe	254.33 (217.49–292.94)	241.15 (203.36–278.74)	−5.18	190.20 (163.30–218.36)	184.60 (157.70–212.85)	−0.13 (−0.23 to −0.02)
Central Latin America	422.74 (360.23–494.78)	724.49 (607.89–852.48)	71.38	325.30 (274.59–378.10)	293.46 (246.81–342.28)	−0.26 (−0.39 to −0.14)
Central Sub-Saharan Africa	58.03 (47.49–70.06)	181.66 (147.37–218.10)	213.04	117.77 (101.13–135.03)	171.59 (143.19–201.92)	1.26 (1.23–1.30)
East Asia	1047.64 (838.42–1266.81)	1994.95 (1544.28–2476.28)	90.42	95.37 (75.67–115.51)	124.00 (99.83–148.28)	1.00 (0.94–1.05)
Eastern Europe	663.36 (533.27–812.17)	681.02 (537.11–833.01)	2.66	277.08 (223.87–335.03)	291.69 (234.26–353.46)	0.27 (0.20–0.34)
Eastern Sub-Saharan Africa	142.54 (116.38–171.87)	372.70 (310.88–439.72)	161.47	92.72 (77.30–107.86)	125.88 (105.06–146.75)	1.08 (1.00–1.15)
High-income Asia Pacific	439.03 (349.62–528.75)	577.60 (454.33–704.26)	31.56	258.24 (210.12–307.73)	276.01 (226.91–323.91)	0.20 (0.16–0.24)
High-income North America	369.89 (289.44–448.83)	450.23 (358.36–545.74)	21.72	120.55 (94.77–146.04)	100.76 (82.56–119.66)	−0.73 (−0.93 to −0.53)
North Africa and Middle East	188.01 (151.00–231.03)	439.99 (357.72–529.23)	134.02	56.19 (45.92–67.17)	76.66 (62.83–91.26)	1.14 (1.11–1.17)
Oceania	3.50 (2.84–4.25)	9.81 (8.08–11.82)	180.54	64.88 (54.48–75.09)	83.49 (70.51–97.24)	0.74 (0.65–0.82)
South Asia	2038.39 (1654.31–2439.96)	3095.82 (2484.94–3804.16)	51.88	228.09 (185.89–273.58)	181.50 (146.25–220.94)	−1.19 (−1.34 to −1.04)
Southeast Asia	538.75 (447.26–632.43)	1063.92 (881.74–1256.25)	97.48	149.30 (123.37–175.76)	157.03 (130.70–184.06)	−0.11 (−0.23 to 0.01)
Southern Latin America	58.89 (50.22–67.83)	116.04 (97.67–134.88)	97.04	121.59 (103.76–139.93)	162.33 (137.28–188.53)	0.87 (0.74–1.00)
Southern Sub-Saharan Africa	116.84 (95.08–142.31)	178.41 (146.14–216.08)	52.70	231.33 (191.21–276.75)	231.56 (190.35–279.31)	−0.09 (−0.21 to 0.03)
Tropical Latin America	357.73 (291.85–429.52)	725.96 (587.40–879.75)	102.94	294.06 (236.32–359.11)	303.14 (248.14–364.78)	0.12 (−0.12 to 0.36)
Western Europe	693.25 (572.94–816.76)	958.83 (765.58–1150.29)	38.31	150.87 (124.72–177.62)	166.38 (136.12–196.99)	0.78 (0.46–1.10)
Western Sub-Saharan Africa	273.81 (227.72–327.43)	702.97 (588.18–831.67)	156.73	162.96 (136.58–192.00)	189.38 (159.99–221.15)	0.43 (0.41–0.46)

ASIR indicates age-standardized incidence rate; CI, confidence interval; EAPC, estimated annual percentage change; GBD, Global Burden of Disease; SDI, sociodemographic index; UI, uncertainty interval.

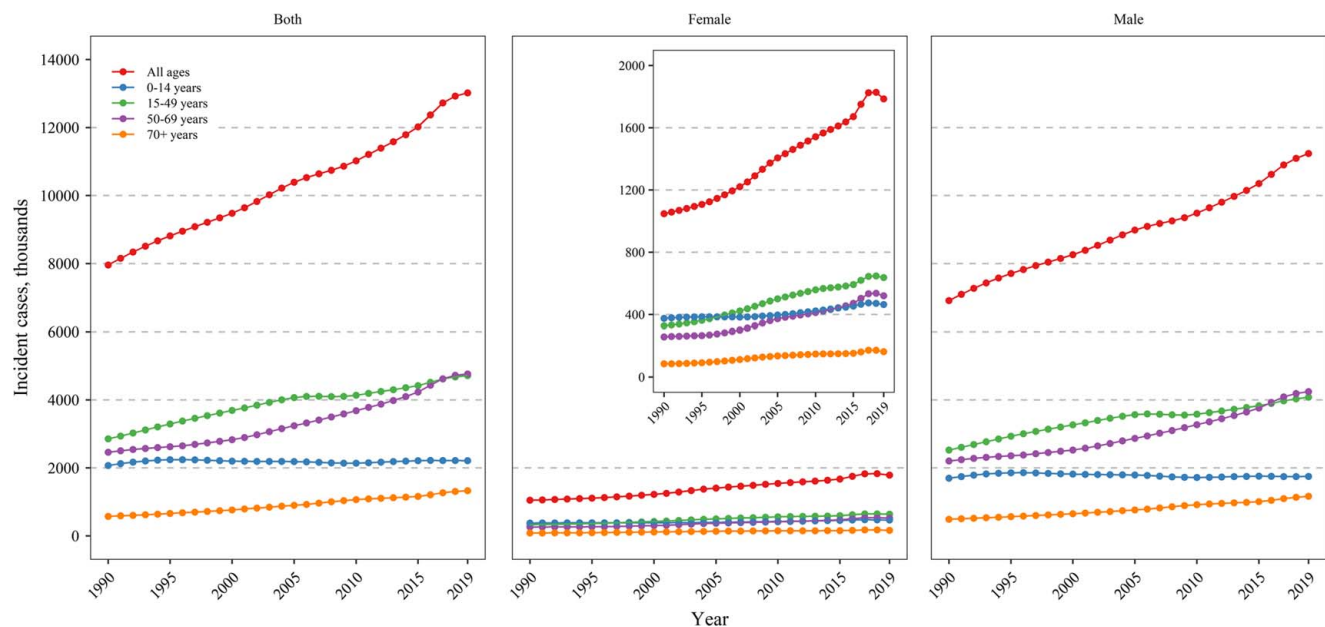


Figure 1. Trends of incident cases for inguinal, femoral, and abdominal hernia from 1990 to 2019 by age groups in both sexes, female and male.

cases in 2019. In 2019, 86% of the incident cases were males, and the male-to-female ratio was 6 : 1. This finding is consistent with the literature, which indicates that the male sex is a major risk factor for inguinal hernia^[2,4,21]. During the study period, the ASIR exhibited an increasing trend among females but decreased among males. This indicates that the management of hernias among females should not be neglected, especially when femoral hernias are more common among females than males^[1]. Femoral hernias account for only 3–5% of groin hernias; however, they are associated with a much higher risk of strangulation and mortality^[3,4]. In this study, the incidence and prevalence of femoral hernia alone were not available, which we hope could be identified in the future GBD study, to estimate the disease burden of femoral hernia.

In this study, the burden of inguinal, femoral, and abdominal hernias was highest among individuals who were middle-aged and older, consistent with previous studies that have reported that the risk of inguinal hernia increases with age^[1,4,21]. We found that the incident cases were highest among individuals aged 50–69 years. An imbalance between intra-abdominal pressure and the strength of the abdominal wall is considered a potential mechanism in the pathogenesis of inguinal hernia^[5,21]. Aging predisposes individuals to increased weakness in connective tissues and muscles, which decreases abdominal wall strength and thereby increases the risk of inguinal hernia^[21]. Furthermore, obstipation and prostatism, which are common problems in older men, increase intra-abdominal pressure^[21]. Over the past century, improvements in mesh technology and

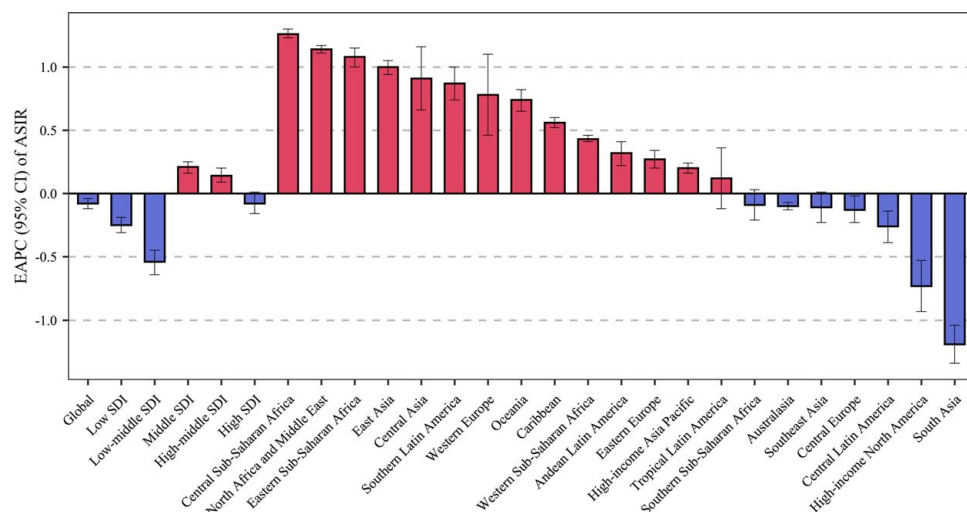


Figure 2. EAPCs of ASIRs of inguinal, femoral, and abdominal hernia from 1990 to 2019 at the regional level. ASIRs, age-standardized incidence rates; EAPCs, estimated annual percentage changes; SDI, sociodemographic index.

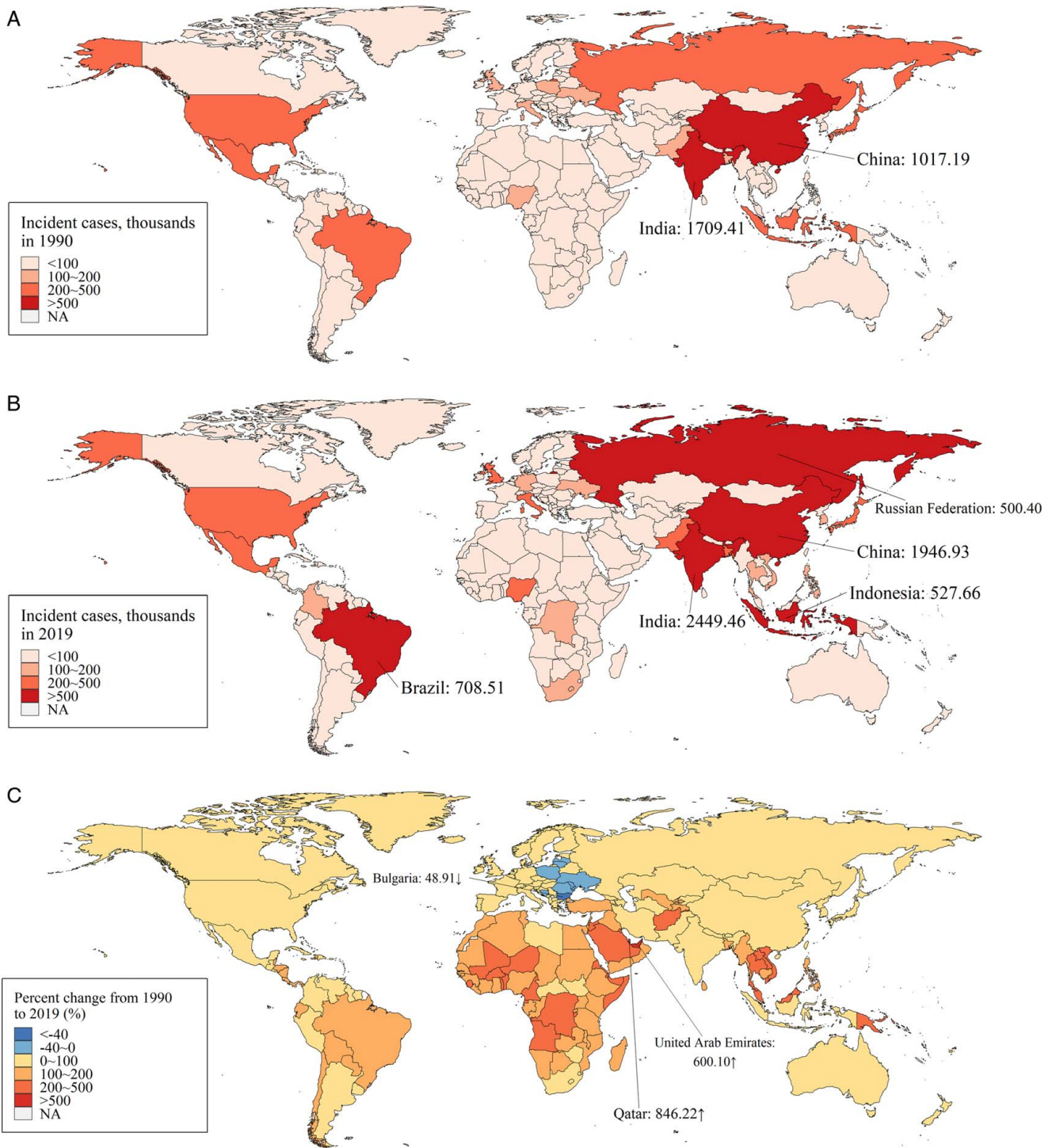


Figure 3. Global trends in the incident cases of inguinal, femoral, and abdominal hernia in 204 countries and territories.

tension-free repairs have reduced recurrence rates significantly^[22]. A shift from suture repairs to open and laparoscopic mesh repair has occurred, and in countries with highly developed healthcare systems, robotic surgical techniques have more recently emerged^[12]. Of these surgical treatments, open inguinal repair continues to provide durability, low risk, relatively low cost, ease of mastery, and excellent outcomes and remains a fundamental foundation for hernia surgery^[23,24].

Notably, open repair is safer for older patients with cardiopulmonary insufficiency because it can be performed under local anesthesia^[24,25]. However, we observed a large increase in the prevalent cases among individuals aged 70 years or older from 1990 to 2019, which would seem to suggest a vast unmet need for surgical treatment among older adults^[26]. Given that older age is a risk factor for obstruction or incarceration of inguinal hernias^[27], this unmet need for surgical treatment should be

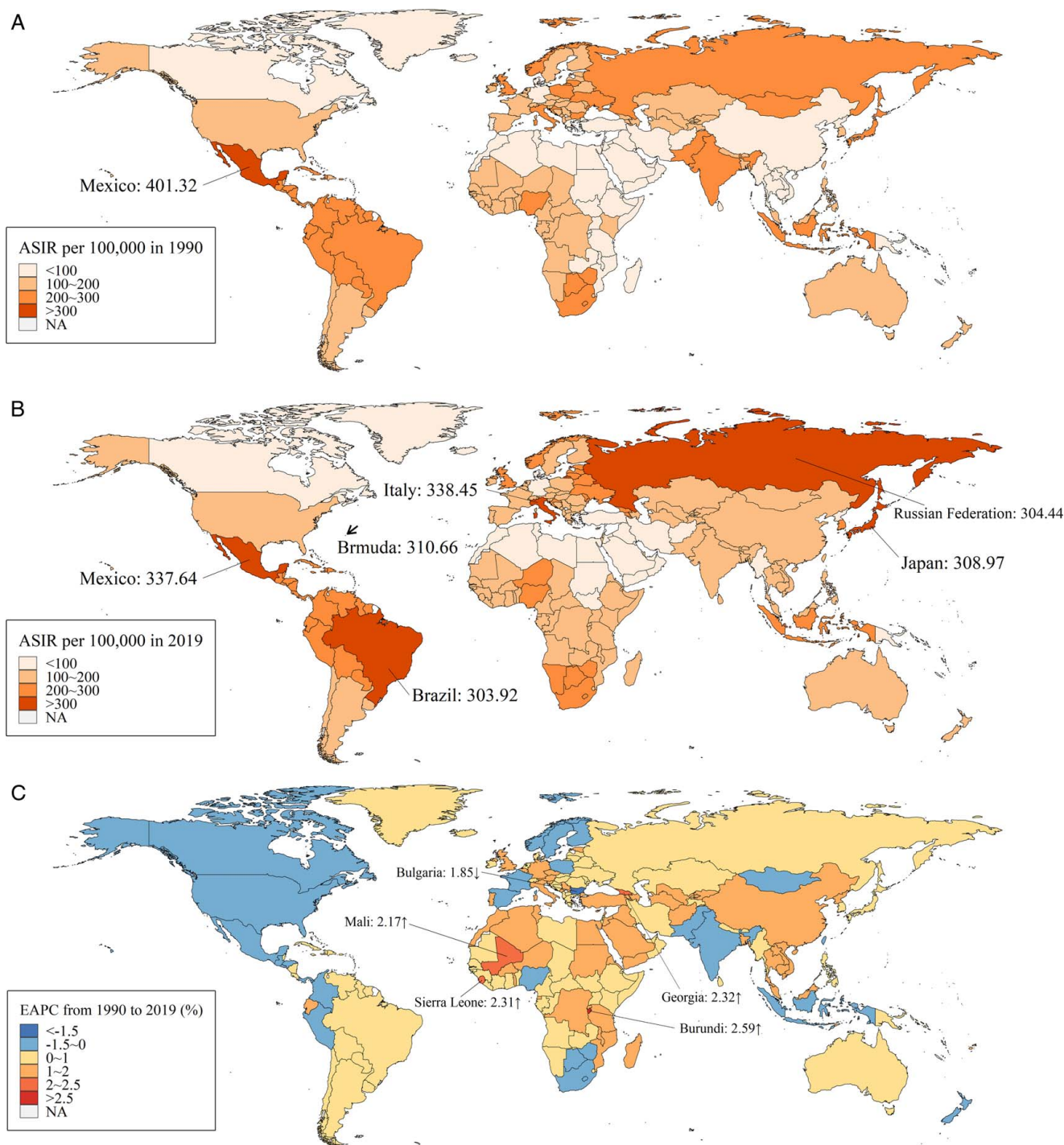


Figure 4. Global trends in the ASIRs of inguinal, femoral, and abdominal hernia in 204 countries and territories. ASIRs, age-standardized incidence rates; EAPC, estimated annual percentage change.

addressed to increase the rate of elective repair and reduce emergency repair-associated morbidity and mortality among older patients^[28]. With an aging population, inguinal hernias are postulated to increase over the coming years and continue to be a global public health challenge^[29].

The decreasing trend of the ASIR and ASPR of inguinal, femoral, and abdominal hernias observed in this study is multifactorial. Previous studies have reported a similar decreasing

trend in inguinal hernia repair rates in developed countries such as the United States^[2], Australia^[29], and England^[30]. One explanation for the dramatically decreased incidence of recurrent inguinal hernia is the widespread adoption of prosthetic mesh repairs^[4,31,32]. Another explanation is that overweight and obesity are associated with a lower risk of inguinal hernia, and an increase in the proportion of obese and overweight individuals in the population has been observed^[21,33,34]. Obesity, through its

association with increased intra-abdominal pressure, may intuitively be considered a risk factor for inguinal hernia^[35]; however, several studies have suggested the opposite^[21,35,36]. A prospective cohort study conducted in a large community-based sample of middle-aged Swedish men found that being overweight and obese was associated with a lower risk for inguinal hernia^[21]. A population-based incidence study in the United States and a prospective cohort study in the Netherlands also confirmed that overweight or obesity was associated with a decreased incidence of inguinal hernia^[35,36]. Globally, the prevalence of obesity has increased substantially over the past 40 years^[37].

This study found that the burden of inguinal, femoral, and abdominal hernias was greatest in Asia. Notably, South Asia, East Asia, and Southeast Asia accounted for approximately half of the worldwide incident cases. The ASIR exhibited a decreasing trend in South Asia, consistent with the trend worldwide. This is most likely attributable to the decreasing trend of ASIR in India, where the incident cases and prevalent cases of inguinal, femoral, and abdominal hernias were the highest. China, one of the countries in East Asia, had the second highest incident cases and prevalent cases worldwide, with an increasing trend of ASIR. This raises concerns that China might surpass India in the future to become the country for which the burden of inguinal, femoral, and abdominal hernias is the greatest among all the countries in the world. Inguinal hernia repair represents a substantial burden to the local healthcare systems of countries with large populations^[2]. Due to aging populations, it is expected that the incidence of inguinal hernias will increase over the coming years^[29]. Thus, the need for hernia management has become an important socioeconomic problem and may affect healthcare systems worldwide, especially in China and India^[7].

Across the five SDI regions, the high SDI region had the lowest ASIR, ASPR, and prevalent cases. In addition, the number of incident cases and ASIR showed a decreasing trend in high SDI regions, such as Central Europe and high-income North America. These regions probably benefit from the widespread adoption of mesh repair and improvements in surgical techniques^[7,12]. It was reported that mesh repairs accounted for 97.6% in the United Kingdom, but only up to 50% of inguinal hernia repairs in LMICs, with the lowest usage in Africa^[12]. In this study, the incident cases increased the most in the low SDI region, with the largest absolute increase occurring in Central Sub-Saharan Africa. Furthermore, Central Sub-Saharan Africa had the highest increase in ASIR and ASPR compared to the global decreasing trend of ASIR and ASPR from 1990 to 2019. In limited-resource countries, the morbidity and mortality related to inguinal hernias are unacceptably high, and the need for surgical care is immense^[38,39]. Resource constraints restrict the capacity to provide a sufficient volume of surgical treatment^[8]. A substantial number of patients go untreated due to a lack of access to surgical care; this has resulted in a large inguinal hernia burden in low SDI regions, especially in Sub-Saharan Africa^[12,40,41]. Limited resources also influence the choice of the surgical technique^[8]. Although mesh repair has become the preferred technique in high-resource countries, it is still not commonly used in LMICs^[12]. Even worse, inguinal hernias have a major effect on already fragile economies^[42]. Inguinal hernia patients in Ghana^[42], Zambia^[43], Cameroon^[40], Sierra Leone^[44], and Tanzania^[41] were often affected by both the payments for surgical treatment and the income loss due to an inability to work.

Hernia repair is one of the most cost-effective of all operations; it can return individuals to a state of health quickly and lasts a lifetime, and should be available to everyone worldwide^[45,46]. LMICs bear the majority of the burden of inguinal hernias, where access to surgical care and surgical outcomes are likely to be the poorest^[47,48]. Thus, more efforts are needed to increase access to safe hernia repair and to reduce the burden of inguinal, femoral, and abdominal hernias in limited-resource settings, such as by using low-cost mesh, conducting systematic training and improving surgical expertise, and implementing a reliable local production system for surgical devices or implants, as well as a healthcare system to deliver high-quality surgery at an affordable cost for all^[8,31,38,46].

This study is the first to use data from the GBD 2019 study to evaluate the most up-to-date worldwide disease burden and temporal trends in the incidence and prevalence of inguinal, femoral, and abdominal hernias. These results provide comprehensive and comparable estimates that can potentially inform targeted hernia management programs. We found that males, older adults, and LMICs had large burdens of inguinal, femoral, and abdominal wall hernias. These findings can be used by policymakers and healthcare providers to inform efforts for the management of inguinal hernia and reduce the disease burden worldwide. However, this study has several limitations. The major limitation of the GBD analysis is the availability of primary data^[13]. For inguinal, femoral, and abdominal hernias, the primary data for the GBD 2019 study were mainly sourced from hospital inpatient discharge records, hospital information systems, health insurance and patient claims, and national patient registers and databases. Population-based epidemiological studies are not present in the primary data, and the estimates of incidence and prevalence might be affected by bias. The incidence might be underestimated because people with asymptomatic hernias or those who refuse to seek medical treatment cannot be identified by using patient databases or claims data sets^[49]. Thus, the actual burden of inguinal, femoral, and abdominal hernias should be determined using nationwide population-based surveys in the future if conditions permit. Second, primary data access and quality are heterogeneous among different countries and territories. Data from countries with relatively robust registration systems are more reliable, while data from countries with inadequate registration systems and patient databases are relatively sparse. The estimates of incidence and prevalence from GBD studies in countries with insufficient data might be more biased. Third, the GBD 2019 study grouped inguinal, femoral, umbilical, diaphragmatic, other abdominal, and unspecified abdominal hernias into a single digestive disease category, which made it impossible to evaluate the incidence and prevalence for each type of hernia. We hope that the disease burden of each type of hernia can be identified in the future GBD study. Despite these limitations, the GBD 2019 study is a valuable resource for identifying the most up-to-date disease burden and for comparing the trends in the inguinal, femoral, and abdominal hernia burden worldwide.

Conclusion

In summary, the worldwide incident cases and prevalence cases of inguinal, femoral, and abdominal hernias increased substantially from 1990 to 2019. A heavier burden was observed in males,

older adults, and in LMICs such as India and China. In addition, the worldwide ASIR and ASPR of inguinal, femoral, and abdominal hernias gradually decreased, although the ASIR and ASPR increased substantially in Central Sub-Saharan Africa. More efforts are warranted for hernia management to reduce the burden of inguinal, femoral, and abdominal hernias, such as by providing safe hernia surgical treatment for males, older adults, and LMICs.

Ethical approval

The University of Washington Institutional Review Board Committee approved GBD 2019.

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Author contribution

Q.M. and M.L.: designed the study, analyzed the data, interpreted the results, and drafted the manuscript; Q.M., W.J., X.L., J.L., and J.C.: searched the literature, collected the data, and revised the manuscript; M.L.: conceived the study, designed the study, supervised the study, interpreted the results, and revised the manuscript. All authors contributed to the writing of the manuscript.

Conflicts of interest disclosure

There are no conflicts of interest.

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Guarantor

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Data availability statement

The datasets generated during and/or analyzed during the current study are available in the GBD repository, <http://ghdx.healthdata.org/gbd-results-tool>.

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