Journal of Human Environment and Health Promotion
Print ISSN: 2476-5481 Online ISSN: 2476-549X

Global Burden, Trends, and Projections of Self-Harm and Interpersonal Violence: 1990–2040

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ARTICLE INFO

Article type:
Original article

Article history:
Received: 13 September 2025
Revised: 30 October 2025
Accepted: 15 November 2025
Available online: 26 November 2025

https://doi.org/10.61882/jhehp.714

Keywords:

Self-harm
Interpersonal violence
Projections
Spatial analysis
Joinpoint regression

ABSTRACT

Background: Self-harm and interpersonal violence contribute significantly to global mortality and disability. This study analyzes trends, projects future burdens, and identifies geographic patterns using the Global Burden of Disease (GBD) data.
Methods: We analyzed data from the Global Burden of Disease Study 2021 on age-standardized incidence rates (ASIR), disability-adjusted life year rates (ASDR), and mortality rates (ASMR) for self-harm and interpersonal violence across 204 countries. Temporal trends were assessed with Joinpoint regression. Projections for the year 2040 were generated using AutoRegressive Integrated Moving Average (ARIMA) and exponential smoothing models. Further, multilevel mixed-effects models examined the role of the Human Development Index (HDI), while spatial clustering was evaluated with Local Moran's I.
Results: Joinpoint regression analysis showed global declines in self-harm and interpersonal violence from 1990 to 2021, with average annual percent changes of -1.08% for ASIR, -1.53% for ASDR, and -1.35% for ASMR. Reductions were observed in Sub-Saharan Africa, South Asia, and Southeast Asia, while increases were observed in North Africa and the Middle East. Projections for 2040 indicate continued declines, although potential regional plateaus may emerge. Multilevel modeling showed no significant differences between developed and less developed regions.
Conclusion: Despite the observed global declines, disparities by region and gender necessitate the need for targeted interventions and improved mental health services to further reduce the burden by 2040.

1. Introduction

Self-harm and interpersonal violence are among the leading causes of death and disability worldwide (Daag Jacobsen et al., 2022). *Self-harm* refers to any deliberate self-inflicted injury, encompassing both non-suicidal self-injury and suicidal behaviors (including suicide attempts and suicide deaths) (Ougrin & Zundel, 2009; Rosenberg et al., 2006; Waters et al., 2005). *Interpersonal violence* is defined as intentional physical, sexual, or psychological harm caused by other individuals or groups. While both behaviors are clinically and psychologically significant, they differ in

How to cite: Masaebi, F., Farahmandkia, Z., Azizmohammad Looha, M., Asadimanesh, N., Mohebbi, H., & Mehrasbi, M. R. (2025). Global Burden, Trends, and Projections of Self-Harm and Interpersonal Violence: 1990–2040. *J Hum Environ Health Promot*, *12*(1), 36-46.

underlying motivations, outcomes, and required interventions. These behaviors are major contributors to the global burden of disease and have serious physical and mental health consequences (Waters et al., 2005). Despite significant advancements in mental health awareness, early intervention, and therapeutic strategies, self-harm and suicide continue to exert a substantial burden on individuals, families, and health systems worldwide. In 2013 alone, nearly 973 million people globally experienced injuries due to various causes, including violence, with approximately 4.8 million reported deaths, with suicide and homicide identified as leading causes. Among those injured, 5.8% (about 56.2 million individuals) required hospital admission, and 38.5% (about 21.7 million individuals) sustained bone fractures. Moreover, suicide accounts for approximately 817,000 deaths annually, representing about 2.2% of all deaths worldwide, underscoring the critical need for more targeted preventive efforts (Haagsma et al., 2016).

Despite growing global attention to self-harm and interpersonal violence, few studies have investigated their long-term trends, especially in relation to countries' geographical location and level of development. Existing research has largely focused on specific populations or regions, often overlooking the broader spatial patterns of disease burden and how these patterns may differ between more developed and less developed countries (Murray et al., 2003; Vos et al., 2020). For instance, one review summarized the prevalence of suicidal behavior, intentional self-harm, and non-suicidal self-injury exclusively (Vos et al., 2020), while another study assessed the burden of self-harm in 2019 but was limited to young Europeans (Castelpietra et al., 2022). Similarly, Mercy's article discussed the global impact, risk factors, and consequences of interpersonal violence in great depth, but it did not include a detailed quantitative analysis of long-term temporal trends or spatial patterns across countries with different levels of development (Mercy et al., 2017). A 2018 review also focused solely on the prevalence of interpersonal violence in Latin America (Gonzalez et al., 2020). The absence of comprehensive long-term trend analyses and spatial pattern assessments limits the ability of policymakers and public health practitioners to design targeted, evidence-based interventions that address the unique needs of different regions and populations. Understanding these patterns is essential for optimizing resource allocation and enhancing the effectiveness of prevention strategies across varying socioeconomic and geographic contexts. Among the existing body of literature, the study by Xiong et al. (2025) stands out for its comprehensive analysis of both temporal trends and spatial distribution of self-harm and interpersonal violence, utilizing GBD 2019 data to examine burden patterns from 1990 to 2019 across various demographic and regional contexts. Our study builds upon and extends this work by incorporating updated GBD 2021 data, introducing future projections through 2040, and comparing trends across countries with different levels of development.

Building upon previous research, this study provides an updated and comprehensive analysis of the global burden of self-harm and interpersonal violence by examining temporal and spatial trends from 1990 to 2021, and projecting their future incidence rates through 2040 across global super-regions. While earlier studies have primarily covered data only up to 2019 and lacked future projections, our research extends the timeline and offers a forward-looking perspective that is critical for proactive health planning. By comparing incidence trends across high-HDI (more developed) and low-HDI (less developed) regions, and identifying regional and country-level hotspots, this study aims to inform more equitable and effective public health responses. Furthermore, by linking projected increases in burden with the need for targeted interventions, it highlights the importance of allocating healthcare resources and designing culturally sensitive prevention strategies. By generating robust, data-driven insights, this study seeks to guide global health stakeholders in designing targeted interventions and ultimately contribute to enhanced mental health outcomes and reduced mortality related to self-harm and interpersonal violence.

2. Materials and Methods

2.1 Study Data and Setting

This study utilized secondary data from the Global Burden of Disease Study 2021 (GBD 2021), coordinated by the Institute for Health Metrics and Evaluation (IHME). The GBD database systematically compiles health data from over 204 countries and territories, drawing from sources such as vital registration systems, health surveys, hospital records, and peer-reviewed literature. Using advanced modeling techniques, the GBD generates standardized estimates of disease burden across time, geography, and demographics. This study focused on assessing the burden of self-harm and interpersonal violence, analyzing data from 1990 to 2021 across seven super-regions: Central Europe, Eastern Europe, and Central Asia (CEEECA); High-Income (HI) countries; Latin America and the Caribbean (LAC); North Africa and the Middle East (NAME); South Asia (SA); Southeast Asia, East Asia, and Oceania (SAEAO); and Sub-Saharan Africa (SSA). Data were accessed through the Global Health Data Exchange (GHDx) portal.

2.2 Variables

The primary outcomes were three key age-standardized measures: incidence rates (ASIR), disability-adjusted life year rates (ASDR), and mortality rates (ASMR) related to self-harm and interpersonal violence. The ASIR represents the annual rate of new cases per 100,000 individuals, adjusted for age distribution. The ASDR quantifies the combined burden of premature mortality and disability, also age-standardized. The ASMR captures the annual rate of deaths per 100,000 individuals, standardized by age. To investigate development-related disparities, countries were classified based on their HDI values. Following UNDP methodology, countries with an HDI $\geq$ 0.788 were classified as "more

developed," and those with an HDI < 0.788 as "less developed" (Bray et al., 2012). The average HDI over the study period (1990-2021) was used for classification rather than a single-year value to maintain consistency.

2.3 Statistical Analysis

2.3.1 Descriptive Statistics

Descriptive analyses were performed to summarize the trends in ASIR, ASDR, and ASMR from 1990 to 2021. Percent changes between 1990 and 2021 were calculated for each measure and stratified by sex and super-region. The percent change was computed using the formula: ((Value in 2021- Value in 1990) / Value in 1990) × 100. All analyses were also performed separately for males and females to assess sex-specific trends and patterns.

2.3.2 Joinpoint Regression Analysis

Temporal trends in ASIR, ASDR, and ASMR were assessed using Joinpoint regression models. This method identifies points in time where statistically significant changes in trend slopes occur by fitting segmented linear regressions. The Annual Percent Change (APC) for each segment and the Average Annual Percent Change (AAPC) over the entire period were estimated (Kim et al., 2004). The model structure was defined as:

$$y_i = \beta_0 + t_i + \gamma_1(t_i - \tau_1) + \ldots + \gamma_k(t_i - \tau_k) + \varepsilon_i$$

where y_i denotes the burden metric (ASIR, ASDR, ASMR) at time t_i, β and γ are regression coefficients, τ_k are the joinpoints, and ε_i is the error term. APC was calculated as:

$$APC = 100 \times [\exp(\beta_1) - 1].$$

Joinpoint regression was conducted using the Joinpoint Regression Program (version 5.2.0), with statistical significance set at $p < 0.05$ (National Cancer Institute, 2024).

2.3.3 Projection Analysis

Projections of the burden metrics for the period 2022-2040 were generated using time-series modeling based on historical GBD trends. A hybrid approach combining autoregressive integrated moving average (ARIMA) models and exponential smoothing (ETS) was applied to improve forecast robustness. Models were selected based on minimization of the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) (Hyndman et al., 2020). Forecasts were generated annually, and 95% uncertainty intervals were calculated. All projections assumed the continuation of historical patterns without major unforeseen disruptions (Hyndman & Koehler, 2006).

2.3.4 Longitudinal Multilevel Modeling

A multilevel mixed-effects regression model was used to examine differences in trends between more and less developed countries over time. Random intercepts were specified for country, region, and super-region levels to account for data clustering (Bray et al., 2012; Zhu et al., 2016). The outcome variables (ASIR, ASDR, ASMR) were modeled as functions of time, development status, and their interaction:

$$y_{ijkt} = \beta_0 + \beta_1 \text{Time}_t + \beta_2 \text{Development}_a + \beta_3 (\text{Time}_t \times \text{Development}_a) + u_x + v_a + w_n + \varepsilon_{ijkt}$$

where y_{ijkt} represents the burden metric for super-region i, region j, country k, and year t, and u, v, and w are random effects. Models were fitted using the lme4 package in R (version 4.2.1) with variance estimated via restricted maximum likelihood (REML) (Bates et al., 2015). Intraclass correlation coefficients (ICCs) were computed to quantify the proportion of variance explained at each hierarchical level, providing insights into the spatial clustering of self-harm and interpersonal violence burden (Theall et al., 2011).

2.3.5 Spatial Autocorrelation Analysis

Spatial clustering of the burden of self-harm and interpersonal violence was assessed using Local Moran's I statistic. A first-order Queen contiguity matrix was used to define country-level spatial relationships. Hotspots (high burden surrounded by high burden) and coldspots (low burden surrounded by low burden) were identified for ASIR, ASDR, and ASMR separately. Spatial analyses were performed using the spdep and sf packages in R. Statistical significance was determined using 999 Monte Carlo simulations, with *p-values* < 0.05 considered significant (Bivand et al., 2013; Brunsdon & Comber, 2018).

3. Results and Discussion

Between 1990 and 2021, global ASIR of self-harm and interpersonal violence declined by 30.7% overall, with reductions observed in both males (-29.86%) and females (-33.33%). The largest decreases occurred in SSA (-59.10%) and SA (-44.36%), while the most significant regional increase was noted in the NAME region, where ASIR rose by 78.25%. Similarly, ASDR declined globally by 33.15%, with greater reductions among females (-43.53%) compared to males (-28.51%). Sizable decreases were recorded in SAEAO (-60.11%) and SSA (-47.13%), whereas ASDR increased in NAME (+34.29%). In terms of ASMR, a global reduction of 35.45% was observed, including a 47.19% drop among females and 30.52% among males. The steepest declines occurred in SAEAO (-60.92%) and SSA (-43.71%), while NAME again showed an opposing trend, with a 34.3% increase in ASMR. Further details are presented in Table 1.

Joinpoint regression analysis (Tables S1-S3) showed overall declining trends in ASIR, ASDR, and ASMR of self-harm and interpersonal violence from 1990 to 2021, with significant reductions observed in most regions, especially in SA, SAEAO, and SSA. In contrast, NAME and LAC exhibited periods of increase before recent declines. The sharpest reductions were observed among females in SAEAO. Full trend details are provided in Tables S1-S3.

Table 1. Trends in the Burden of Self-Harm and Interpersonal Violence by Region, Sex, and Measure, 1990–2021

Measure	Region	Sex	1990 (95% UI)	2021 (95% UI)	Percent change
DALY	Global	Male	1783.96 (1678.24, 1877.60)	1275.35 (1202.13, 1356.94)	**-28.51**
		Female	823.85 (683.66, 894.16)	465.20 (422.96, 512.20)	**-43.53**
		Both	1305.16 (1203.18, 1370.69)	872.44 (821.88, 928.14)	**-33.15**
	CEEECA	Male	2593.72 (2536.65, 2657.81)	1694.72 (1585.61, 1799.49)	**-34.66**
		Female	684.67 (659.11, 711.22)	411.78 (379.87, 444.32)	**-39.86**
		Both	1609.36 (1570.67, 1651.91)	1039.05 (973.34, 1096.78)	**-35.44**
	HI	Male	1304.79 (1284.31, 1358.79)	1060.94 (1031.57, 1084.80)	**-18.69**
		Female	455.31 (442.32, 481.60)	346.56 (332.79, 360.06)	**-23.88**
		Both	876.28 (860.31, 913.41)	704.89 (683.68, 722.79)	**-19.56**
	LAC	Male	3517.79 (3449.77, 3596.45)	3107.82 (2933.48, 3302.55)	**-11.65**
		Female	562.39 (539.41, 586.65)	482.13 (441.32, 523.47)	**-14.27**
		Both	2005.36 (1960.97, 2054.32)	1772.28 (1673.26, 1885.46)	**-11.62**
	NAME	Male	1348.13 (1193.42, 1565.30)	1848.97 (1705.90, 2036.77)	**37.15**
		Female	450.06 (366.65, 578.32)	547.38 (493.99, 620.17)	**21.62**
		Both	909.62 (799.29, 1078.11)	1221.50 (1123.36, 1350.61)	**34.29**
	SA	Male	1444.70 (1241.02, 1596.57)	986.06 (878.40, 1100.83)	**-31.75**
		Female	1053.99 (784.13, 1206.70)	607.23 (508.65, 687.38)	**-42.39**
		Both	1258.36 (1051.32, 1378.87)	797.68 (712.81, 869.21)	**-36.61**
	SAEAO	Male	1264.42 (1035.05, 1411.52)	587.00 (524.56, 662.42)	**-53.58**
		Female	980.12 (716.62, 1141.27)	304.53 (261.10, 368.24)	**-68.93**
		Both	1122.75 (909.69, 1238.86)	447.85 (403.25, 502.50)	**-60.11**
	SSA	Male	3696.39 (3443.38, 3955.77)	1962.18 (1725.16, 2264.24)	**-46.92**
		Female	1036.48 (946.93, 1130.45)	560.77 (473.11, 659.00)	**-45.90**
		Both	2335.25 (2194.53, 2494.64)	1234.71 (1091.50, 1433.34)	**-47.13**
Death	Global	Male	33.26 (31.00, 34.76)	23.11 (21.93, 24.40)	**-30.52**
		Female	14.58 (11.66, 15.94)	7.70 (6.90, 8.50)	**-47.19**
		Both	23.75 (21.71, 24.76)	15.33 (14.46, 16.24)	**-35.45**
	CEEECA	Male	51.27 (50.80, 51.71)	34.10 (31.78, 36.30)	**-33.50**
		Female	13.18 (12.96, 13.37)	7.50 (6.93, 8.15)	**-43.07**
		Both	31.01 (30.71, 31.26)	20.13 (18.95, 21.26)	**-35.07**
	HI	Male	26.22 (25.87, 27.31)	20.90 (20.22, 21.32)	**-20.28**
		Female	8.78 (8.55, 9.26)	6.29 (6.02, 6.45)	**-28.36**
		Both	17.13 (16.87, 17.90)	13.50 (13.04, 13.76)	**-21.22**
	LAC	Male	61.46 (60.74, 62.22)	54.00 (50.84, 57.53)	**-12.14**
		Female	9.14 (8.90, 9.39)	7.90 (7.24, 8.57)	**-13.56**
		Both	34.62 (34.22, 35.10)	30.40 (28.63, 32.39)	**-12.20**
	NAME	Male	18.32 (16.92, 20.23)	25.29 (23.66, 27.20)	**38.04**
		Female	5.75 (4.56, 6.37)	6.76 (6.12, 7.37)	**17.50**
		Both	12.18 (11.16, 13.36)	16.36 (15.28, 17.56)	**34.29**
	SA	Male	26.25 (22.14, 29.19)	18.49 (16.27, 20.79)	**-29.54**
		Female	16.76 (11.98, 19.31)	10.02 (7.97, 11.55)	**-40.24**
		Both	21.72 (17.71, 23.85)	14.24 (12.35, 15.65)	**-34.47**
	SAEAO	Male	25.61 (19.90, 29.08)	11.99 (10.42, 14.05)	**-53.18**
		Female	19.24 (12.59, 22.93)	5.59 (4.62, 7.10)	**-70.97**
		Both	22.32 (17.12, 24.77)	8.72 (7.69, 9.98)	**-60.92**
	SSA	Male	67.06 (61.89, 71.78)	38.66 (34.19, 43.49)	**-42.35**
		Female	18.17 (16.49, 19.69)	10.12 (8.23, 11.71)	**-44.30**
		Both	42.01 (39.27, 44.47)	23.65 (20.90, 26.79)	**-43.71**
Incidence	Global	Male	1317.43 (1175.85, 1462.65)	924.04 (834.74, 1032.88)	**-29.86**
		Female	558.28 (506.61, 617.51)	372.23 (334.32, 413.38)	**-33.33**
		Both	940.49 (849.41, 1040.77)	651.51 (587.04, 728.47)	**-30.73**
	CEEECA	Male	1895.58 (1667.99, 2122.70)	1222.17 (1097.33, 1353.07)	**-35.53**
		Female	724.96 (648.23, 792.57)	469.27 (425.57, 511.66)	**-35.27**
		Both	1295.36 (1146.84, 1439.47)	837.47 (754.47, 916.46)	**-35.35**
	HI	Male	714.91 (644.54, 782.27)	600.57 (547.39, 653.26)	**-15.99**
		Female	403.07 (365.68, 442.21)	351.89 (316.43, 383.69)	**-12.70**
		Both	559.45 (507.29, 611.05)	477.65 (437.95, 516.76)	**-14.62**
	LAC	Male	1717.66 (1512.07, 1936.27)	1262.62 (1129.47, 1412.01)	**-26.49**
		Female	285.54 (256.19, 320.79)	175.25 (159.78, 190.95)	**-38.62**
		Both	985.77 (874.80, 1107.25)	711.36 (641.79, 792.79)	**-27.84**
	NAME	Male	1342.41 (1162.35, 1580.97)	2338.39 (2007.58, 2710.25)	**74.19**
		Female	476.39 (424.14, 542.89)	891.09 (749.36, 1049.83)	**87.05**
		Both	919.38 (808.49, 1059.95)	1638.79 (1402.87, 1902.15)	**78.25**
	SA	Male	1155.68 (996.51, 1333.35)	631.64 (561.86, 703.53)	**-45.34**
		Female	519.94 (460.78, 581.45)	310.75 (273.70, 347.01)	**-40.23**
		Both	849.90 (751.43, 968.03)	472.87 (424.59, 521.72)	**-44.36**
	SAEAO	Male	1012.04 (895.59, 1126.30)	558.88 (499.20, 626.08)	**-44.78**
		Female	531.94 (478.26, 588.72)	299.80 (264.75, 338.86)	**-43.64**
		Both	775.45 (693.97, 855.53)	433.71 (388.54, 485.78)	**-44.07**
	SSA	Male	3094.29 (2750.85, 3445.72)	1317.58 (1145.41, 1545.74)	**-57.42**
		Female	1135.42 (991.30, 1306.22)	420.45 (369.04, 488.52)	**-62.97**
		Both	2090.99 (1850.77, 2344.01)	855.22 (744.89, 998.21)	**-59.10**

Note: Disability-Adjusted Life Years (DALYs), deaths, and incidence rates per 100,000 population for self-harm and interpersonal violence from 1990 to 2021 are presented, stratified by sex and Global Burden of Disease (GBD) regions. Percent change indicates the relative difference between 1990 and 2021 values. Values in parentheses denote the 95% uncertainty intervals (UIs). Region abbreviations are as follows: CEEECA - Central Europe, Eastern Europe, and Central Asia; HI - High-income countries; LAC - Latin America and the Caribbean; NAME - North Africa and the Middle East; SA - South Asia; SAEA0 - Southeast Asia, East Asia, and Oceania; SSA - Sub-Saharan Africa.

Between 1990 and 2021, the global burden of self-harm and interpersonal violence declined significantly across all three key indicators-ASIR, ASDR, and ASMR-with respective AAPCs of -1.08, -1.53, and -1.35. These reductions were more pronounced among females across all measures. At the regional level, the most substantial and consistent declines were observed in SSA (ASIR: -2.91; ASDR: -2.44; ASMR: -2.23), SA (ASIR: -2.08; ASDR: -1.43; ASMR: -1.32), and SAEAO (ASIR: -2.26; ASDR: -3.02; ASMR: -3.11), highlighting considerable progress in these regions. In contrast, NAME was the only region to experience a statistically significant increase in both ASIR (+1.79) and ASDR (+0.68), along with a borderline rise in ASMR (+0.64, $p = 0.054$). These trends are visualized in Figure 1, with comprehensive numerical results presented in Table 2.

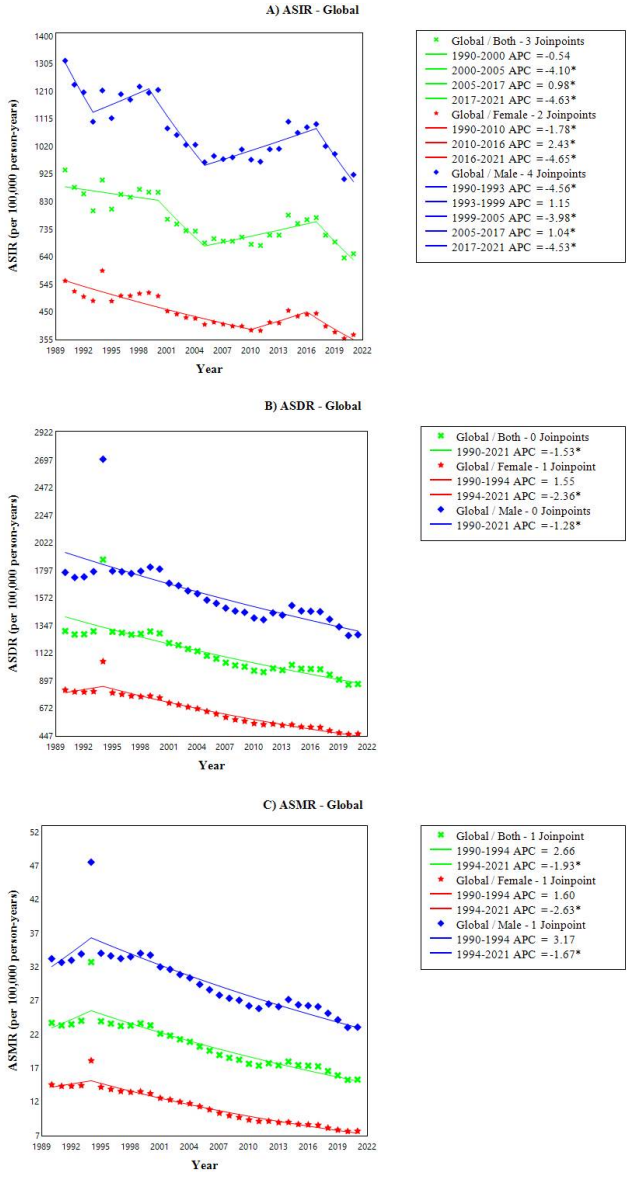

Figure 1. Joinpoint Regression Analysis of Global Trends in Age-Standardized Incidence, DALY, and Mortality Rates for Self-Harm and Interpersonal Violence by Sex, 1990-2021

Based on projections for 2022 and 2040, the global burden of self-harm and interpersonal violence is expected to decline in most regions across all three measures-ASIR, ASDR, and ASMR. Notably, at the global level, ASIR (837.47), ASDR (1039.05), and ASMR (22.43) are projected to remain constant over time. Regionally, ASIR is expected to decrease most notably in CEEECA (from 632.92 to 472.55), followed by HI (469.26 to 417.51). The most marked reductions in ASDR are projected in SAEAO (from 402.28 to 12.16), followed by SA (782.82 to 515.32) and HI (708.42 to 611.80). For ASMR, the steepest declines are forecasted in SAEAO (15.66 to 13.08), SSA (34.84 to 30.20), and HI (16.08 to 15.46). These global and regional projections are visualized in Figure 2, with detailed yearly estimates from 2022 to 2040 presented in Tables 3, S4-S6 and Figures S1-S3.

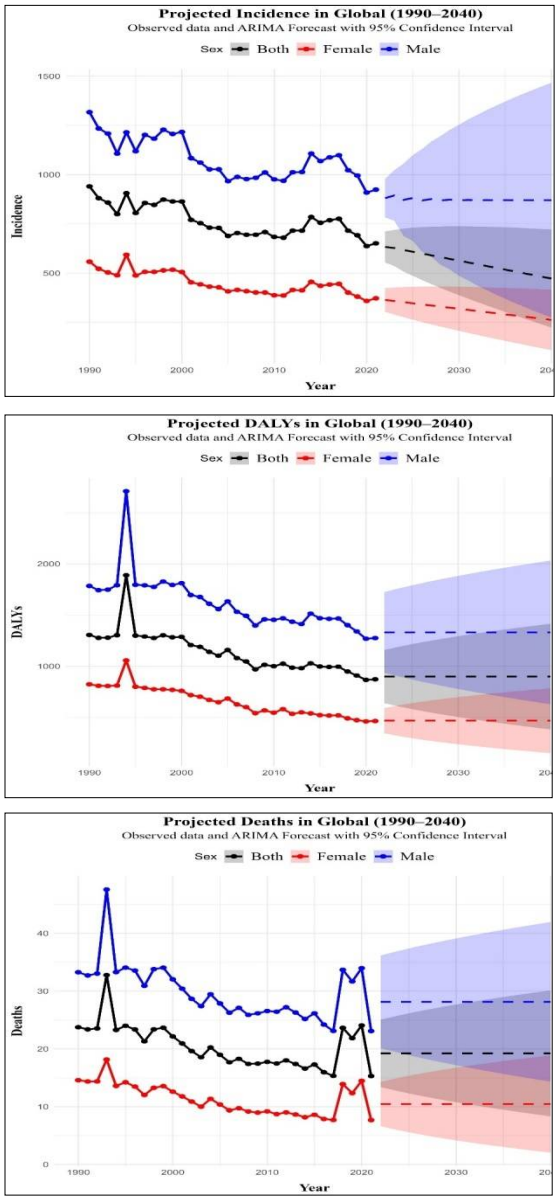

Figure 2. Global Trends and Projections of Age-Standardized Incidence, DALYs, and Death Rates for Self-Harm and Interpersonal Violence by Sex, 1990–2040

Table 2. Average Annual Percent Change (AAPC) in Age-Standardized Incidence, DALY, and Mortality Rates for Self-Harm and Interpersonal Violence by Region and Sex, 1990–2021

Region	Sex	ASIR		ASDR		ASMR	
		AAPC (95% CI)	*P-value*	AAPC (95% CI)	*P-value*	AAPC (95% CI)	*P-value*
Global	Both	-1.08* (-1.38, -0.81)	< 0.001	-1.53* (-1.85, -1.20)	< 0.001	-1.35* (-1.90, -0.95)	< 0.001
	Female	-1.45* (-1.76, -1.18)	< 0.001	-1.87* (-2.36, -1.50)	< 0.001	-2.09* (-2.48, -1.81)	< 0.001
	Male	-1.21* (-1.44, -0.98)	< 0.001	-1.28* (-1.63, -0.92)	< 0.001	-1.06* (-1.66, -0.63)	< 0.001
CEEECA	Both	-1.43* (-2.18, -0.99)	< 0.001	-1.38* (-1.68, -1.05)	< 0.001	-1.36* (-1.65, -1.03)	< 0.001
	Female	-1.38* (-2.07, -0.96)	< 0.001	-1.60* (-1.88, -1.32)	< 0.001	-1.79* (-2.11, -1.42)	< 0.001
	Male	-1.45* (-2.21, -0.95)	< 0.001	-1.34* (-1.64, -1.01)	< 0.001	-1.28* (-1.55, -0.95)	< 0.001
HI	Both	-0.59* (-0.67, -0.52)	< 0.001	-0.72* (-0.79, -0.65)	< 0.001	-0.81* (-0.90, -0.74)	< 0.001
	Female	-0.43* (-0.52, -0.36)	< 0.001	-0.89* (-0.94, -0.86)	< 0.001	-1.09* (-1.13, -1.06)	< 0.001
	Male	-0.65* (-0.74, -0.56)	< 0.001	-0.68* (-0.77, -0.59)	< 0.001	-0.79* (-0.89, -0.70)	< 0.001
LAC	Both	-1.22* (-1.53, -0.90)	< 0.001	-0.47* (-0.61, -0.37)	< 0.001	-0.50* (-0.63, -0.40)	< 0.001
	Female	-1.00* (-1.33, -0.66)	< 0.001	-0.36* (-0.44, -0.25)	< 0.001	-0.35* (-0.45, -0.24)	< 0.001
	Male	-1.19* (-1.50, -0.87)	< 0.001	-0.49* (-0.63, -0.39)	< 0.001	-0.52* (-0.68, -0.40)	< 0.001
NAME	Both	1.79* (0.74, 2.55)	0.006	0.68* (0.10, 1.14)	0.021	0.64 (-0.01, 1.17)	0.054
	Female	1.74* (0.80, 2.47)	0.002	0.38 (-0.11, 0.76)	0.124	0.21 (-0.38, 0.67)	0.473
	Male	1.60* (0.61, 2.33)	0.007	0.74* (0.12, 1.24)	0.021	0.73* (0.05, 1.28)	0.036
SA	Both	-2.08* (-2.53, -1.48)	< 0.001	-1.43* (-1.55, -1.36)	< 0.001	-1.32* (-1.43, -1.26)	< 0.001
	Female	-1.72* (-2.01, -1.46)	< 0.001	-1.83* (-1.98, -1.73)	< 0.001	-1.77* (-1.85, -1.68)	< 0.001
	Male	-2.13* (-2.65, -1.45)	< 0.001	-1.21* (-1.29, -1.14)	< 0.001	-1.11* (-1.19, -1.03)	< 0.001
SAEAO	Both	-2.26* (-2.60, -1.92)	< 0.001	-3.02* (-3.13, -2.91)	< 0.001	-3.11* (-3.23, -3.00)	< 0.001
	Female	-2.02* (-2.56, -1.56)	< 0.001	-3.81* (-3.92, -3.70)	< 0.001	-3.97* (-4.06, -3.87)	< 0.001
	Male	-2.28* (-2.63, -1.93)	< 0.001	-2.53* (-2.65, -2.39)	< 0.001	-2.51* (-2.62, -2.41)	< 0.001
SSA	Both	-2.91* (-4.18, -2.01)	0.002	-2.44* (-3.44, -1.40)	< 0.001	-2.23* (-3.13, -1.29)	< 0.001
	Female	-3.18* (-4.38, -1.95)	< 0.001	-2.34* (-3.29, -1.34)	< 0.001	-2.23* (-3.17, -1.25)	< 0.001
	Male	-2.82* (-3.66, -1.98)	< 0.001	-2.44* (-3.45, -1.37)	< 0.001	-2.16* (-3.06, -1.22)	< 0.001

Note: Average Annual Percent Change (AAPC) with 95% confidence intervals (CIs) and corresponding *p-values* in age-standardized incidence rates (ASIR), age-standardized DALY rates (ASDR), and age-standardized mortality rates (ASMR) from 1990 to 2021 are shown, stratified by sex and Global Burden of Disease (GBD) regions. Statistically significant changes ($p < 0.05$) are indicated by an asterisk (*). Region abbreviations: CEEECA - Central Europe, Eastern Europe, and Central Asia; HI - High-income countries; LAC - Latin America and the Caribbean; NAME - North Africa and the Middle East; SA - South Asia; SAEAO - Southeast Asia, East Asia, and Oceania; SSA - Sub-Saharan Africa.

According to the longitudinal multilevel model (Table 4), no statistically significant temporal trends were observed in less developed regions-the reference group-for any of the burden metrics, with coefficients of 2.97 ($p = 0.398$) for ASIR, -12.64 ($p = 0.257$) for ASDR, and -0.22 ($p = 0.207$) for ASMR. In more developed regions, the estimated time trends-calculated as the sum of the main time effect and the interaction term-were also not statistically significant, yielding values of -0.63 for ASIR, 2.46 for ASDR, and 0.01 for ASMR. Moreover, the interaction terms between time and development status were not statistically significant across all metrics, indicating that the rate of change in ASIR, ASDR, and ASMR over time did not significantly differ between more and less developed regions.

Figure 3 and Table S7 illustrate the spatial clustering of self-harm and interpersonal violence burden using Local Moran's I statistics across ASIR, ASDR, and ASMR. The Republic of Iraq and the Central African Republic emerged as consistent hotspots for both ASIR and ASDR, indicating a high burden surrounded by similarly high-burden neighbors. Additionally, the Central African Republic was identified as the sole hotspot for ASMR. In contrast, several countries in the Eastern Mediterranean and Sub-Saharan Africa-including Armenia, Azerbaijan, Georgia, Jordan, and Angola-were identified as significant coldspots across all three measures, indicating persistently low burden in spatially clustered regions. The current study offers a detailed and updated assessment of global and regional patterns in the burden of self-harm and interpersonal violence, drawing on three decades of data and future projections. Trend analyses based on average annual percent change revealed an overall global decline in ASIR, ASDR, and ASMR, with especially pronounced reductions in several super-regions, such as those in SSA. However, divergent patterns were noted in specific regions, including increases in NAME, indicating region-specific shifts in burden. Projections through the next two decades suggest continued regional disparities. While ASIR is expected to decline in many regions, projections for global ASDR and ASMR indicate a pattern of relative stability rather than further reduction, highlighting the risk of stagnation without renewed intervention efforts. Findings from the multilevel longitudinal model showed no statistically significant differences in temporal trends between more and less developed regions, suggesting that national development level alone does not explain the observed dynamics in burden evolution. Spatial autocorrelation analyses identified clear geographic clustering, with persistent hotspots in countries marked by high burden surrounded by similarly affected neighbors, and cold spots in regions with consistently low burden.

Table 3. Projected Age-Standardized Incidence, DALY, and Death Rates per 100,000 Population for Self-Harm and Interpersonal Violence by Region and Sex in 2022 and 2040

Measure	Location	Year	Female	Male	Both
ASIR	CEEECA	2022	363.97	880.89	632.92
		2040	262.61	870.46	472.55
	Global	2022	469.27	1222.17	837.47
		2040	469.27	1222.17	837.47
	HI	2022	350.23	588.52	469.26
		2040	320.51	515.06	417.51
	LAC	2022	193.06	1306.04	695.50
		2040	130.08	1434.80	804.09
	NAME	2022	891.09	2338.39	1638.79
		2040	891.09	2338.39	1638.79
	SA	2022	306.00	646.15	481.49
		2040	191.24	643.80	480.13
	SAEAO	2022	292.32	558.88	433.71
		2040	157.53	558.88	433.71
	SSA	2022	335.64	1317.58	827.28
		2040	372.17	1317.58	827.28
ASDR	CEEECA	2022	468.66	1330.27	898.76
		2040	468.66	1330.27	898.76
	Global	2022	411.78	1598.34	1039.05
		2040	411.78	1535.90	1039.05
	HI	2022	343.50	1067.68	708.42
		2040	280.51	927.42	611.80
	LAC	2022	482.13	3156.36	1772.28
		2040	482.13	3396.05	1772.28
	NAME	2022	547.38	1848.97	1221.50
		2040	547.38	1848.97	1221.50
	SA	2022	598.33	971.26	782.82
		2040	358.80	704.96	515.32
	SAEAO	2022	264.77	524.63	402.28
		2040	-124.96	125.45	12.16
	SSA	2022	587.92	2060.51	1298.70
		2040	587.92	2060.51	1298.70
ASMR	CEEECA	2022	10.46	28.15	19.22
		2040	10.46	28.15	19.22
	Global	2022	8.28	37.98	22.43
		2040	8.28	37.98	22.43
	HI	2022	7.82	24.97	16.08
		2040	7.34	23.92	15.46
	LAC	2022	9.30	58.92	33.15
		2040	8.83	58.92	33.15
	NAME	2022	6.38	23.47	15.24
		2040	6.38	23.47	15.24
	SA	2022	10.05	18.71	14.37
		2040	10.05	18.71	14.37
	SAEAO	2022	13.31	18.01	15.66
		2040	10.34	15.89	13.08
	SSA	2022	14.45	56.38	34.84
		2040	12.77	48.77	30.20

Note: Projected rates of incidence, disability-adjusted life years (DALYs), and deaths per 100,000 population for self-harm and interpersonal violence are shown for the years 2022 and 2040, stratified by sex and Global Burden of Disease (GBD) regions. All values represent modeled estimates derived from trends observed between 1990 and 2021. Region abbreviations: CEEECA - Central Europe, Eastern Europe, and Central Asia; HI - High-income countries; LAC - Latin America and the Caribbean; NAME - North Africa and the Middle East; SA - South Asia; SAEA0 - Southeast Asia, East Asia, and Oceania; SSA - Sub-Saharan Africa.

Table 4. Longitudinal Multilevel Model Assessing the Association of Time and Development Status with Burden Metrics of Self-Harm and Interpersonal Violence

Metric	Predictors	Parameters	Estimates (95% CI)	*P-value*
ASIR	Intercept	------	928.67 (587.25, 1270.09)	0.001
	Time	------	2.97 (-3.92, 9.87)	0.398
	Development status	More developed vs. less developed	-68.26 (-420.96, 284.44)	0.704
	Time * Development status	Time * (More developed vs. less developed)	-3.60 (-17.68, 10.49)	0.617
ASDR	Intercept	------	1675.84 (1189.56, 2162.12)	< 0.001
	Time	------	-12.64 (-34.50, 9.22)	0.257
	Development status	More developed vs. less developed	-673.97 (-1700.15, 352.21)	0.199
	Time * Development status	Time * (More developed vs. less developed)	15.10 (-29.90, 60.09)	0.511
ASMR	Intercept	------	28.35 (20.10, 36.61)	< 0.001
	Time	------	-0.22 (-0.56, 0.12)	0.207
	Development status	More developed vs. less developed	-8.64 (-24.99, 7.70)	0.300
	Time * Development status	Time * (More developed vs. less developed)	0.23 (-0.48, 0.93)	0.531

Note: A longitudinal multilevel model was applied to assess the association of time (from 1990 to 2021), development status (more developed vs. less developed), and their interaction with age-standardized incidence rates (ASIR), disability-adjusted life year rates (ASDR), and mortality rates (ASMR) for self-harm and interpersonal violence. Fixed-effect estimates are presented with 95% confidence intervals (CIs) and *p-values*. The interaction term indicates whether time trends differed significantly between more and less developed regions.

Multiple independent studies validate the worldwide decrease in self-harm and interpersonal violence burden highlighted in our study. For example, Zhou et al. (2024) reported significant declines in ASIR, ASDR, and ASMR throughout the world in their review of the GBD 2019 study, which is consistent with our findings. In the same cohort study, Zhao et al. (2024) performed a 30-year global review and reported a decrease in the age-standardized mortality and disability rates due to self-harm and interpersonal violence related to high temperatures; however, the total number of deaths and DALYs lost had increased, emphasizing the ongoing need for proactive measures. In yet another study, Tan et al. (2025) reported a decrease in self-harm, mortality, and DALY rates globally among adolescents aged 10-24 years from 1990 to 2021, with AAPCs of -1.40, -1.78, and -1.79, respectively. However, the study pointed out that some areas were experiencing increasing burdens of self-harm, highlighting the pressing need for targeted prevention efforts tailored to young people (Tan et al., 2025). These compelling pieces of evidence consolidate the findings of this study and underline the importance of targeted policy interventions.

Although many self-harm and violence rates are declining worldwide, our trend analyses based on AAPC showed significant regional differences, especially in certain super-regions like SSA, which showed marked improvement. Zhou et al. (2024) highlighted that many low and lower-middle Socio-Demographic Index (SDI) areas seem to be lagging in their progress, likely due to greater awareness and investment in preventive programs and public health. However, other regions exhibited divergent trends; most remarkably, increasing rates in the NAME region, which was also noted by Tan et al. (2025) among young adults. This increase may be driven by restrictive sociopolitical factors, stigma around mental health, and an absence of cultural appropriateness in care.

In regions such as NAME, several interacting factors likely contribute to the observed increases in self-harm and interpersonal violence. Prolonged political instability and armed conflicts in countries like Syria, Iraq, and Libya have led to widespread displacement, economic hardship, and weakened health systems, all of which exacerbate mental health stressors and reduce access to care. In parallel, persistent stigma surrounding mental illness, especially among women, discourages help-seeking and amplifies psychological distress. Gender-based violence remains prevalent and underreported in many of these settings, further elevating self-harm risk among women.

Furthermore, Zhao et al. (2024) highlighted that even in regions that are socioeconomically and environmentally vulnerable, absolute numbers of deaths and DALYs may continue to rise, complicating regional progress, even as age-standardized rates decline. These findings are notably corroborated by the thorough GBD 2019 synthesis by Vos et al. (2020), which shows significant heterogeneity across 204 countries. Some low-and middle-SDI regions, such as parts of NAME and South Asia, saw stable or rising rates of violence and self-harm, while high-SDI regions saw steady declines (Vos et al., 2020). These findings emphasise how uneven global progress is and how urgent it is to develop region-specific, context-sensitive strategies that tackle the structural, cultural, and socioeconomic factors that underlie interpersonal violence and self-harm globally.

While there have been some improvements globally, our forecasts indicate a plateau for global reductions of self-harm and interpersonal violence since overall ASIR, ASDR, and AMR are expected to remain stable by 2040. The findings are broadly supported by Tan et al. (2025) noted the downward trends in global self-harm mortality and incidence before 2019, but observed higher rates or increases in some regions, particularly parts of the Eastern Mediterranean, which echoes our results in the NAME region. Similarly, Wang et al. (2025) provided a more concrete example of the stagnation, in this case mostly attributed to alcohol. Specifically, using GBD 2021 data, the investigators documented the declines of self-harm and interpersonal violence attributable to high alcohol consumption had declined globally since 1990; however, they noted decline stalled during the COVID-19 pandemic, providing modest annual projections of declines thereafter (17% self-harm, etc.) (Wang et al., 2025a).

Understanding how national development relates to the burden of self-harm and interpersonal violence has been the focus of several recent investigations. However, only a limited number of studies have explicitly considered the SDI in this context, and most have focused on specific subtypes of either interpersonal violence or self-harm rather than addressing both comprehensively (An et al., 2025; Cao et al., 2024; Hu et al., 2024; Wang et al., 2025b; Xiong et al., 2025; Zhou et al., 2024). For example, Zhou et al. (2024) used data from the GBD 2019 and SDI-based country groupings to assess trends in self-harm and interpersonal violence. They reported higher incidence and DALY rates in countries with high and low-middle SDI levels, although their approach was primarily descriptive and based on broad categorical groupings. In a separate study, Cao et al. (2024) analyzed interpersonal violence against women using GBD 2019 data. They disaggregated violence into four specific categories: physical violence by firearm, physical violence by other means, physical violence by sharp object, and sexual violence. Age-standardized prevalence rates for each category were examined across SDI quintiles using joinpoint regression, revealing increases in both high and low SDI regions (Cao et al., 2024). Similarly, Xiong et al. (2025) investigated the global burden of intimate partner violence (IPV) among women, also using GBD 2019 data. Their findings showed that IPV-related deaths and DALYs were highest in low-SDI countries, particularly among younger women and in Sub-Saharan Africa (Xiong et al., 2025). While these studies provide valuable insights into the relationship between development and violence, their reliance on SDI quintiles, limited population scope, and primarily descriptive or non-inferential methodologies constrains the generalizability of their conclusions. In contrast, our study is the first to longitudinally assess the relationship between the

HDI and the burden of both self-harm and interpersonal violence over time. Previous research, where available, has only explored this relationship cross-sectionally at a single time point. By leveraging the most recent GBD 2021 data and applying a multilevel longitudinal modeling approach with HDI as a continuous predictor, we enabled a more nuanced and inferential exploration of burden trajectories across the full development spectrum. Our findings revealed no statistically significant differences in temporal trends between more and less developed countries, suggesting that while HDI is a valuable summary measure of national development, it may not fully capture the broader sociostructurally and contextual determinants influencing these outcomes. Future research could build upon our findings by integrating additional dimensions-such as governance quality, social inequality, cultural norms, and conflict exposure-alongside HDI to more comprehensively understand the global patterns of self-harm and interpersonal violence.

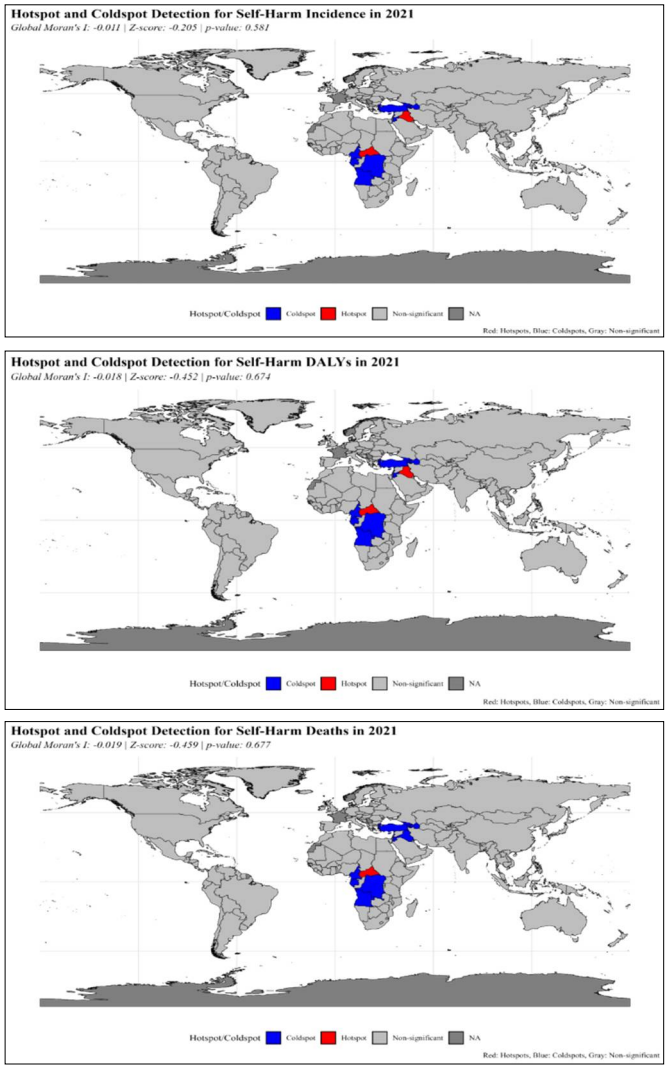

Figure 3. Global Spatial Clustering of Age-Standardized Incidence, DALY, and Mortality Rates for Self-Harm and Interpersonal Violence

Previous studies investigating the geographic distribution of violence-related outcomes have largely focused on specific subtypes or localized contexts. For instance, analyses of intimate partner violence (IPV) in China revealed distinct spatial clustering patterns across provinces (Zhang et al., 2025), while a study in Port-au-Prince, Haiti, identified urban firearm injury hotspots using spatial scan statistics (Burlotos et al., 2023). Similarly, a Brazilian study mapped community and domestic violence in a single mid-sized city, linking violence hotspots to low-income neighborhoods (Barbosa et al., 2019). A recent nationwide survey in China further demonstrated high IPV prevalence (45.8%) with high clustering in eastern provinces such as Zhejiang and Jiangxi (Zhang et al., 2025). Moreover, a recent systematic review of geospatial studies on violence against children and adolescents highlighted critical methodological gaps in the literature, including the overuse of administrative data, lack of model validation, and geographical bias toward high-income countries (Shinyemba et al., 2024). While these studies provide valuable localized insights into specific forms of violence, they do not offer a unified picture of the broader burden of self-harm and interpersonal violence across diverse regions. In contrast, our study contributes a comprehensive spatial assessment using Local Moran's I applied to global burden metrics (ASIR, ASDR, and ASMR). We identified persistent hotspots-such as Iraq and the Central African Republic-and cold spots-such as Armenia, Jordan, and Angola-providing robust evidence of geographically clustered risk across both self-inflicted and externally directed violence. This is the first study to identify and report country-level hotspots and cold spots of self-harm and interpersonal violence using spatial autocorrelation analysis, whereas previous work has mainly focused on specific subtypes or localized populations.

3.1 Strengths and Limitations

This study has several notable strengths. It provides the most up-to-date and comprehensive analysis of global and regional trends in the burden of self-harm and interpersonal violence using the latest GBD 2021 data, covering a wide temporal span (1990–2021) and offering projections through 2040. Furthermore, it is the first study to longitudinally assess the relationship between HDI and these outcomes using advanced multilevel modeling, and to conduct a global spatial clustering analysis to identify country-level hotspots and cold spots of both self-harm and interpersonal violence.

Our analysis relied entirely on GBD 2021 estimates, which, despite being the most comprehensive global health dataset available, may be influenced by variability in data quality, especially in low-and middle-income countries. To mitigate this, we used the most updated GBD release (2021) that incorporates multiple improvements in modeling and estimation methods compared to previous versions, and we emphasized uncertainty intervals throughout our reporting to reflect potential data imprecision. Second, while Joinpoint regression and multilevel modeling provided robust analyses

of temporal trends, these methods cannot fully account for unmeasured confounders such as political instability, health system changes, or cultural factors. To address this, we complemented trend analyses with spatial clustering assessments (Local Moran's I) to detect geographic patterns that may indirectly capture broader social or structural influences. Third, our future projections through 2040 are based on extrapolation from historical trends without incorporating potential disruptive events like pandemics or economic crises. To mitigate this limitation, we transparently stated that projections assume continuity of past trends and provided uncertainty intervals for all forecasted estimates to account for modeling variability. Finally, while spatial autocorrelation analysis revealed meaningful geographic clusters, it could not identify the specific drivers behind high-or low-burden areas. To partially mitigate this, we cross-referenced our findings with relevant literature discussing sociopolitical and structural determinants in hotspot and cold spot countries, providing a broader context for interpretation.

4. Conclusion

This comprehensive global analysis highlights substantial progress in reducing the burden of self-harm and interpersonal violence over the past three decades, particularly in several low-and middle-income regions. However, divergent trends in specific areas, such as the Middle East and North Africa, highlight the persistent need for region-specific, context-sensitive interventions. Although national development status did not significantly modify temporal trends, pronounced geographic disparities persist, suggesting that broader sociocultural, economic, and governance-related factors may be critical determinants. While global incidence rates are projected to decline modestly through 2040, disability and mortality burdens are likely to plateau, emphasizing the urgency of reinvigorated prevention strategies. Targeted investments in mental health promotion, violence prevention, and equitable health system strengthening are essential to sustain and accelerate progress. Future research should integrate additional social, political, and environmental indicators to better inform comprehensive, evidence-based public health responses at national and regional levels.

Authors' Contributions

Fatemeh Masaebi: Conceptualization; data curation; formal analysis; visualization; software development. **Zohre Farahmandkia:** Writing the original draft; review; and editing. **Mehdi Azizmohammad Looha, Naghmeh Asadimanesh, and Hossein Mohebbi:** Methodology development; investigation; and critical review of the manuscript. **Mohammad Reza Mehrasbi:** Supervision; project administration; corresponding author; final approval of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

No conflict of interest has been declared by the authors.

Acknowledgments

We sincerely thank all our colleagues for their valuable contributions and support in completing this project.

Ethical considerations

This study was approved by the Ethical Committee of Zanjan University of Medical Sciences (Code: IR.ZUMS.REC.1404.014).

Using Artificial Intelligence

The current research was conducted without the use of artificial intelligence techniques.

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