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RESEARCH ARTICLE

Long-Term Trends in Self-Harm Mortality Across the World's Countries: Associations with Human Development, Democracy, and Income Inequality

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Introduction: Self-harm mortality remains a public health concern. Monitoring long-term trends across countries informs prevention strategies.
Aim: To examine global trends in self-harm mortality rates (SHMR) from 1990 to 2023 and determine whether countries followed distinct trajectories according to socioeconomic characteristics.
Methods: Age-standardized SHMRs for 204 countries were obtained from the Global Burden of Disease Study. Latent Growth Models estimated temporal trends and compared trajectories according to Human Development Index (HDI), democratic governance (V-Dem), and income inequality (Gini). Exploratory Growth Mixture Modeling (GMM) identified latent classes of countries with similar longitudinal trajectories.
Results: Global SHMR declined significantly between 1990 and 2023 (b = −0.074/year, p < .001), with the steepest reductions observed in Europe and Central Asia. Countries classified as having higher HDI and lower income inequality exhibited significantly steeper declines in SHMR, whereas differences according to democratic governance were not statistically significant. Sensitivity analyses using time-varying socioeconomic indicators showed that annual HDI became increasingly associated with lower SHMR over time, whereas annual Gini and V-Dem had limited or inconsistent associations, with the declining SHMR trend remaining robust after adjustment for Gini and V-Dem. GMM identified three distinct trajectory classes characterized by low, intermediate, and high baseline SHMR with corresponding gradual, moderate, and steep declines.
Conclusions: Global SHMR declined substantially over the study period but followed heterogeneous trajectories across countries. Countries classified by higher human development and lower income inequality exhibited steeper historical declines in SHMR, while GMM suggested that regional and historical contexts also contributed to long-term trajectory differences.

Keywords: self-harm mortality, global health, Human Development Index, income inequality, democracy

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Introduction

According to recent global estimates, more than 700,000 people die by suicide each year, making intentional self-harm a major global public health concern (World Health Organization, 2025). Although global self-harm mortality rates (SHMR) have generally declined over recent decades, substantial variation persists across countries and regions, reflecting differences in social, cultural, economic, political, and health-system contexts (Lange et al., 2023).

Throughout this manuscript, the term self-harm is used as an umbrella term for intentional self-injurious behavior. Analyses are restricted to deaths due to intentional self-harm; accordingly, *SHMR* refers to the age-standardized mortality rate (per 100,000 population) due to intentional self-harm, as classified according to the International Classification of Diseases (ICD; WHO, 2022). Previous studies have described temporal trends in SHMR within individual countries, specific regions, or methods of self-harm (Chang et al., 2014; Ghodsi et al., 2020; Ilic et al., 2022; McKeown et al., 2006). However, comprehensive longitudinal analyses covering all countries worldwide remain limited (Naghavi, 2019; Weaver et al., 2025). Examining groups of countries with similar temporal trajectories may provide additional insight into the contextual factors associated with changes in SHMR.

A growing body of research suggests that macro-level social, economic, and political conditions influence population patterns of self-harm mortality (Chon, 2018; de Bruin et al., 2020; Lorant et al., 2018; Lorant et al., 2005). Socioeconomic development, commonly measured using the Human Development Index (HDI), has shown a complex relationship with SHMR. While some studies suggest that higher HDI is associated with lower suicide rates because of better healthcare, education, and living standards (Lorant et al., 2018), others indicate that this relationship may be non-linear. For example, Shah (2009) reported an inverted U-shaped association between HDI and elderly suicide rates, with lower rates observed at both low and high levels of human development.

Democratic governance may influence suicide rates by shaping institutional stability, civil liberties, and government accountability, thereby affecting social cohesion and perceived security (Przeworski et al., 2000; Sen, 2017). Nevertheless, evidence on the democracy-suicide relationship is inconsistent. Some studies report higher suicide rates in more democratic settings, while others find no significant association or focus on related political conditions rather than democracy per se (Chon, 2018; de Bruin et al., 2020; Lester, 1999).

Income inequality has been examined alongside other macroeconomic indicators as a potential determinant of suicide mortality. Panel and ecological studies, including those conducted in Iran and Brazil, have suggested that income inequality is a risk factor for suicide, although the strength of this association appears to vary across countries and income groups (Machado et al., 2015; Veisani et al., 2019). Recent cross-national research has likewise suggested that the association between income inequality and suicide is context dependent, with a different pattern observed in lower-income countries (Lyu et al., 2025). However, Andres (2005) found that economic growth, rather than income inequality, was associated with suicide mortality.

Although several studies have investigated socioeconomic correlates of SHMR, global longitudinal evidence integrating these indicators remains limited. Moreover, little is known about whether countries follow distinct longitudinal patterns of self-harm mortality beyond those explained by these broad socioeconomic indicators. Therefore, this study had two objectives. First, we examined global trends in SHMR across 204 countries between 1990 and 2023 and evaluated their associations with HDI, democratic governance (V-Dem), and the Gini index. Second, we identified empirically derived groups of countries with similar SHMR trajectories and assessed whether these latent trajectory classes provided additional insights beyond conventional socioeconomic classifications.

Methods

Data and Measures

Data pertaining to SHMR were collected from the GBD 2023 Results Tool, curated by the Institute for Health Metrics and Evaluation (IHME), available from https://vizhub.healthdata.org/gbd-results/. IHME harmonizes mortality estimates by integrating data from national vital registration systems and other available sources, correcting for incomplete registration, redistributing ill-defined causes of death, and applying standardized statistical modeling procedures. Consequently, SHMR estimates represent a combination of directly observed mortality data and modeled estimates, with the relative contribution varying across countries and years according to data availability and quality. The dataset was accessed on November 1, 2025. No individual-level data were accessed,

and the dataset did not contain any information that could identify individual participants during or after data collection.

We defined self-harm mortality as age-standardized rate per 100,000 population due to intentional self-harm. The analyzed mortality estimates are primarily based on ICD-10 X60-X84 (WHO, 1992); ICD-11 (WHO, 2022) terminology is cited only as a contemporary classificatory reference. The dataset included 204 countries between 1990 and 2023. The primary outcome was the age-standardized SHMR (per 100,000 population) for each country. The longitudinal trends of SHMR were explored in different groups of countries based on their HDI, V-Dem, and Gini index.

The HDI is a composite measure of health, education, and income that ranges from 0 (lowest) to 1 (highest) human development (Roser, 2014). HDI was used as a proxy for overall socioeconomic development. Countries were classified as having high (HDI ≥ 0.70) or low/medium (HDI < 0.70) human development according to the United Nations Development Programme (UNDP) classification (Dasic et al., 2020). Democratic governance was assessed using the V-Dem, Liberal Democracy Index, which ranges from 0 (lowest) to 1 (highest) democracy quality (Coppedge et al., 2022). Countries were categorized into high (≥ 0.72) and low (< 0.72) democracy groups based on the median V-Dem value. Income inequality was assessed using the Gini index, which ranges from 0 (perfect equality) to 1 (perfect inequality) (Castaneda Aguilar et al., 2022). Countries were similarly categorized into high (≥ 0.37) and low (< 0.37) inequality groups using the median Gini value. These categorizations were used to facilitate subgroup comparisons rather than to define natural thresholds. For each country, the latest available HDI, V-Dem, and Gini values (typically from 2023) were used as static country characteristics to define comparison groups in the primary analyses. Hereafter, these are referred to as the countries' latest available socioeconomic characteristics.

To complement the predefined HDI, V-Dem, and Gini subgroup analyses, exploratory Growth Mixture Modeling (GMM), a data-driven approach to identify latent classes of countries with similar longitudinal SHMR trajectories, was performed. Unlike subgroup analyses based on external socioeconomic indicators, GMM classifies countries according to their observed SHMR trajectories and may therefore reveal heterogeneity not captured by predefined classifications.

This study was approved by the Research Ethics Committee at Shahid Beheshti University of Medical Sciences (Approval Number: IR.SBMU.RETECH.REC.1401.300).

Statistical Methods

All analyses were conducted using age-standardized SHMR to ensure comparability across countries and over time. SHMR values were analyzed longitudinally from 1990 to 2023 at five-year intervals. To provide a coherent longitudinal modeling strategy, we first estimated a latent growth model (LGM) to characterize the average global trajectory of SHMR over time. This model serves as the baseline structural framework for assessing overall temporal change, with the intercept representing the estimated baseline level in 1990 and the slope reflecting the average rate of change across the study period. In addition to overall modeling, LGM analyses were repeated within strata defined by HDI, V-Dem, and Gini coefficient categories. To evaluate whether the primary findings depended on categorizing socioeconomic indicators, supplementary LGMs were estimated with HDI, V-Dem, and Gini entered separately as continuous time-varying covariates. Because of substantial and uneven missingness in the longitudinal socioeconomic data, HDI, V-Dem, and Gini were each evaluated in separate models. These analyses addressed a different question from the primary models. Unlike the primary analyses, which compared historical SHMR trajectories among countries retrospectively grouped according to their latest available socioeconomic characteristics, the time-varying models examined contemporaneous country-level association between each socioeconomic indicator and SHMR at the observed time points while simultaneously estimating the residual temporal trend after accounting for that indicator. Because the models did not decompose time-varying socioeconomic indicators into within-country and between-country components, the corresponding coefficients should not be interpreted as purely within-country effects or as evidence that changes in the socioeconomic indicators caused changes in SHMR. Accordingly, the latent slope in these models should be interpreted as the residual annual change in SHMR after adjustment for the corresponding time-varying socioeconomic indicator rather than the causal effect of the indicator itself.

To investigate heterogeneity in longitudinal SHMR trajectories beyond predefined country groupings, we subsequently fitted GMMs. Whereas the LGM estimated the average trajectory for the overall population or prespecified subgroups, GMM identified latent classes of countries with similar longitudinal SHMR patterns without requiring prior classification. Because no strong theoretical basis exists for the expected number of global SHMR trajectory classes, the analyses were considered exploratory and hypothesis-generating. Therefore, models with

one to six latent classes were estimated and compared. To improve model stability and convergence, all models included a quadratic time effect, while only the intercepts and linear slopes were allowed to vary across latent classes. Random effects were specified for the linear slope, and time was centered prior to model estimation to improve numerical stability. Heteroscedastic residual variances across latent classes were permitted. The optimal number of latent classes was determined using the Bayesian Information Criterion (BIC), together with entropy, average posterior probabilities (AvePP), class sizes, and substantive interpretability. Preference was given to models with good statistical fit, adequate classification accuracy, clinically meaningful trajectories, and no extremely small latent classes. Coefficients reported from the LGM and GMM are unstandardized. Linear slope (b) coefficients are expressed as changes in age-standardized SHMR (deaths per 100,000 population) per year; quadratic coefficients represent the change in the linear rate of change per squared year.

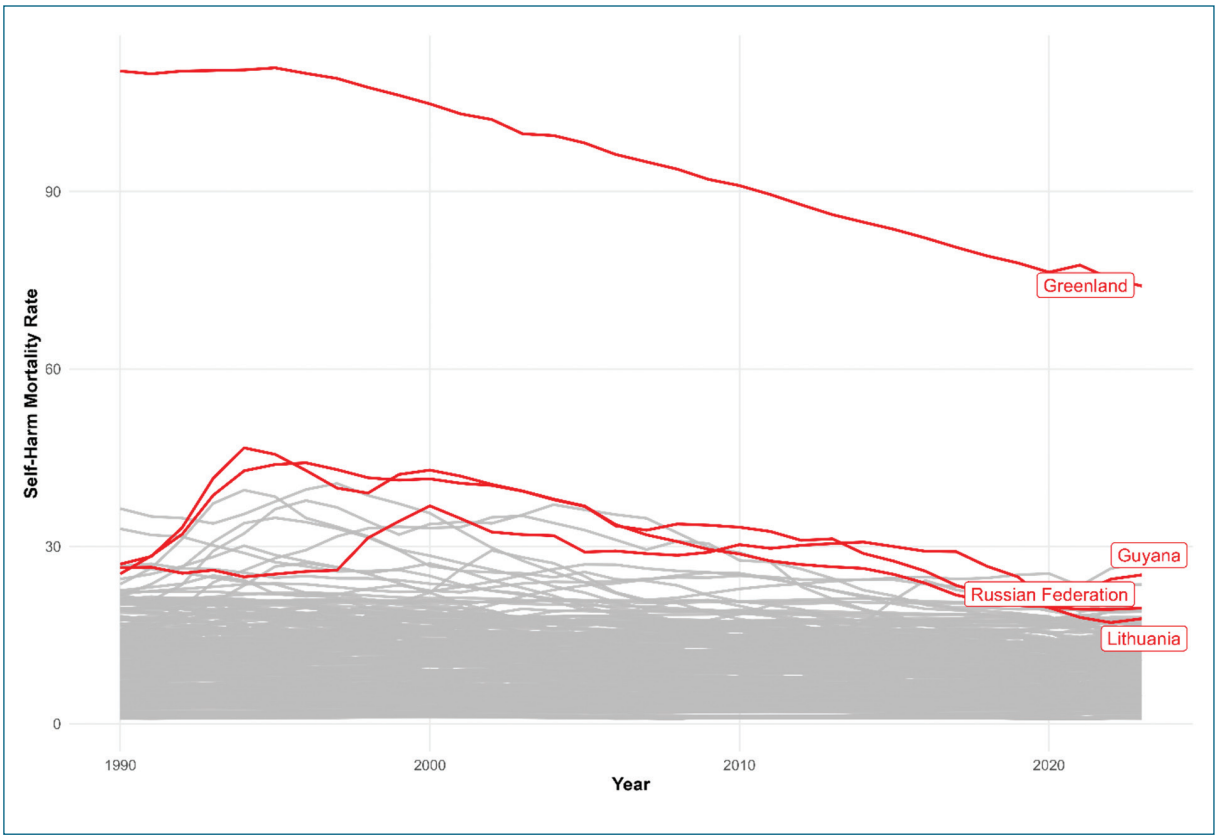
All statistical analyses were conducted using RStudio (version 2026.05.0) and Mplus.

Results

Figure 1 illustrates the temporal trends in SHMR across 204 countries from 1990 to 2023. Countries with mean values exceeding two standard deviations above the global mean were highlighted, representing those with persistently high SHMR.

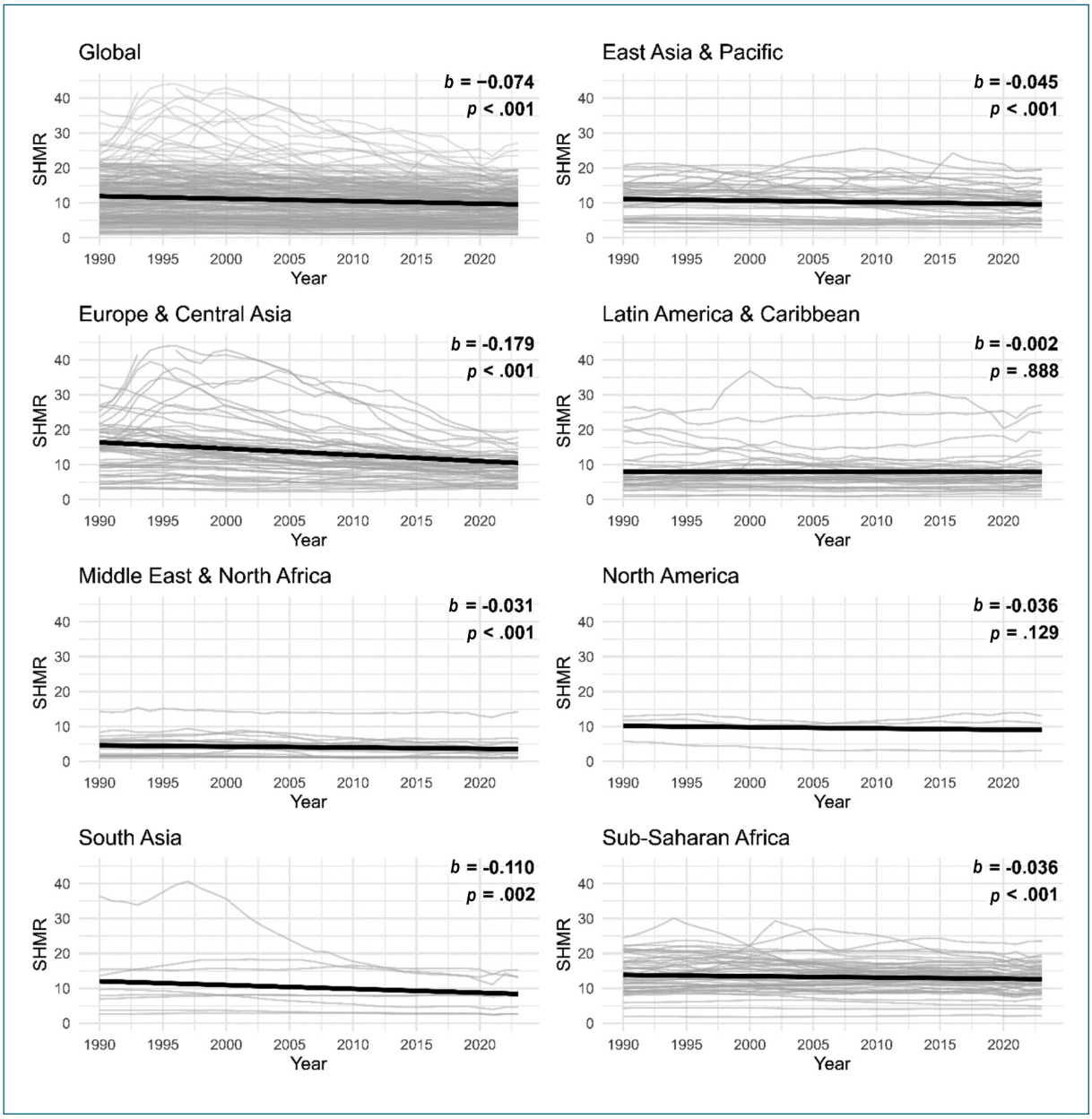
Figure 2 depicts the temporal trends in SHMR across various regions from 1990 to 2023. As the figure indicates, the global temporal trend shows a statistically significant reduction in mean SHMR over the decades (b = −0.074; p < .001). Europe and Central Asia showed the steepest decline (b = −0.179, p < .001), followed by South Asia (b = −0.110, p = .002). East Asia and the Pacific, Middle East and North Africa, and Sub-Saharan Africa show small declining trends, too.

Figure 1. Country-Level Trajectories of Age-Standardized Self-Harm Mortality Rates, 1990–2023



Note. Countries with extreme long-term self-harm mortality rates (±2 standard deviation from the global mean during 1990–2023) are highlighted.

Figure 2. Regional Trends in Age-Standardized Self-Harm Mortality Rates, 1990–2023



Note. SHMR = self-harm mortality rate. Greenland was omitted from the Europe & Central Asia panel for graphical display only because its age-standardized self-harm mortality rate decreased from 110.4 to 74.0 per 100,000 population during the study period, resulting in a scale that obscured the trajectories of the remaining countries. It was retained in all statistical analyses and in the estimation of the regional slope.

To examine global trends in SHMR, LGM models were used to estimate both baseline levels in 1990 and change over time (1990–2023). For the primary analyses, countries were grouped according to their latest available HDI, V-Dem, and Gini values. These variables were used as static descriptive characteristics to compare historical SHMR trajectories and were not interpreted as causal determinants of trends (Table 1).

Countries classified as having high HDI had a higher estimated SHMR at baseline (1990) and experienced a steeper decline over the study period (b = −0.184) than countries classified as having low HDI (b = −0.046). The difference in trajectory between the two groups was statistically significant (p < .001).

A weaker pattern was observed for democratic governance. Countries classified as having higher V-Dem scores also had higher estimated baseline SHMR and showed a moderate decline over time (b = −0.145), whereas coun-

tries in the lower V-Dem group had a somewhat smaller decline (b = −0.101). However, the difference between the two trajectories was not statistically significant (p = .416).

The largest difference was observed for income inequality. Countries classified as having lower Gini indices had higher estimated SHMR in 1990 and subsequently showed a marked decline over time (b = −0.205). In contrast, countries classified as having higher Gini indices exhibited only a modest decline (b = −0.035). The difference between the two trajectories was statistically significant (p < .001).

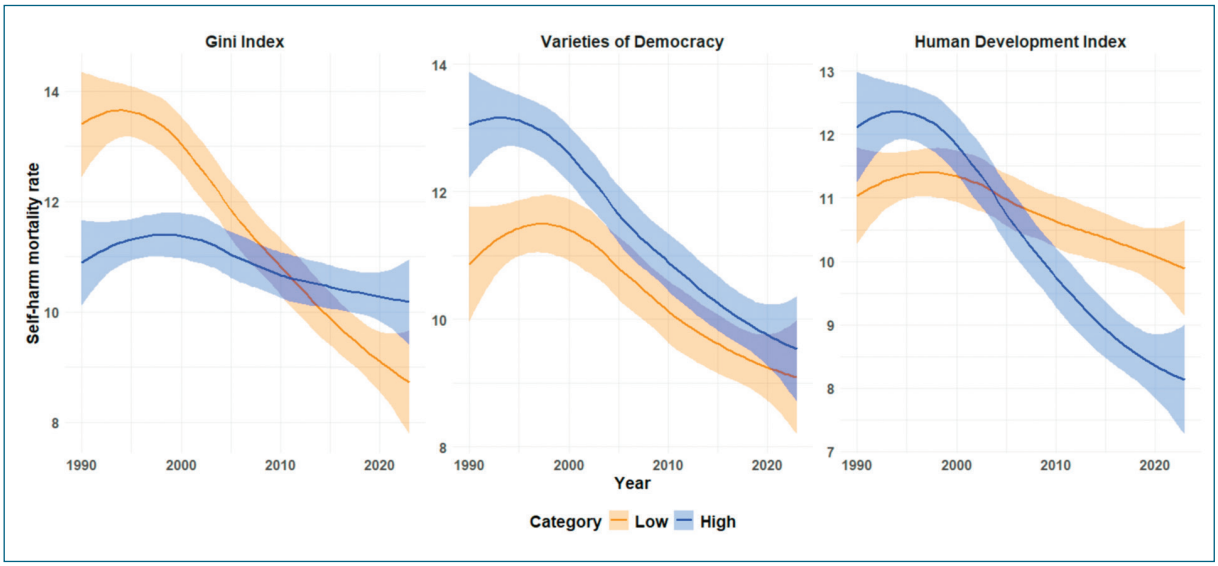
Across all subgroup analyses, countries with higher estimated baseline SHMR generally exhibited steeper subsequent declines. For example, countries that were classified as having higher HDI or lower income inequality also had higher average SHMR in 1990 but experienced larger reductions over the following three decades than their comparison groups. Figure 3 presents SHMR trajectories stratified by HDI, V-Dem, and Gini categories.

Table 1. Latent Growth Model Estimates of Self-Harm Mortality Trajectories Among Countries Grouped According to Latest Available Socioeconomic Characteristics Including Human Development, Democracy Quality, and Income Inequality

Factor	Group	Starting Level (1990)	Trend (Change per Year)	Group Difference
Human Development	High HDI[a]	13.58	−0.184	p < .001
	Low HDI	11.59	−0.046	
Democracy Quality	High V-Dem[b]	13.88	−0.145	p = .416
	Low V-Dem	12.24	−0.101	
Income Inequality	Low Gini[c]	15.02	−0.205	p < .001
	High Gini	11.43	−0.035	

Note. [a] Human Development Index; [b] Varieties of Democracy; [c] Gini coefficient.

Figure 3. Age-Standardized Self-Harm Mortality Trajectories Stratified by Human Development, Democratic Governance, and Income Inequality (Gini Index)



Note. Countries were classified as having high (HDI ≥ 0.70) or low (HDI < 0.70) human development according to the United Nations Development Program classification. V-Dem and Gini groups were classified as high (V-Dem ≥ 0.72; Gini ≥ 0.37) or low (V-Dem < 0.72; Gini < 0.37) based on their respective median values.

Sensitivity analyses using continuous time-varying socioeconomic indicators are presented in Appendix Table 1. After adjustment for annual HDI, the SHMR slope was positive but not statistically significant (+0.102 per year; p = .278). The annual HDI coefficients were not significant during the early years of follow-up but became increasingly negative and were mostly statistically significant during the middle and later years. After adjustment for annual Gini, the residual SHMR slope remained significantly negative (−0.170 per year; p < .001), while the time-varying Gini coefficients were significantly negative primarily during the early years and were largely non-significant thereafter. After adjustment for annual V-Dem, the residual SHMR slope also remained signifi-

cantly negative (−0.165 per year; p = .001), whereas the annual V-Dem coefficients were generally small and non-significant throughout follow-up. These analyses provide complementary information on contemporaneous country-level associations between socioeconomic indicators and SHMR at different time points, while the residual slopes describe the temporal trend remaining after accounting for each indicator.

In the next step, an initial exploratory GMM including all 204 countries yielded a five-class solution, in which Lebanon and Greenland each formed singleton latent classes because their SHMR trajectories differed markedly from those of all other countries. Following this exploratory step, these two influential outliers were excluded, and the GMM was re-estimated. Model comparison supported a three-class solution as the optimal representation of global longitudinal SHMR trajectories. The BIC values for the one- through six-class models were 7065.7, 6936.3, 6899.3, 6901.8, 6906.4, and 6912.2, respectively, with the lowest BIC observed for the three-class model. Classification quality was good, with average posterior probabilities ranging from 0.885 to 0.910 across the three classes, indicating high certainty in class assignment. Class sizes were sufficiently large to support meaningful interpretation, and no singleton classes remained after exclusion of the two influential outliers.

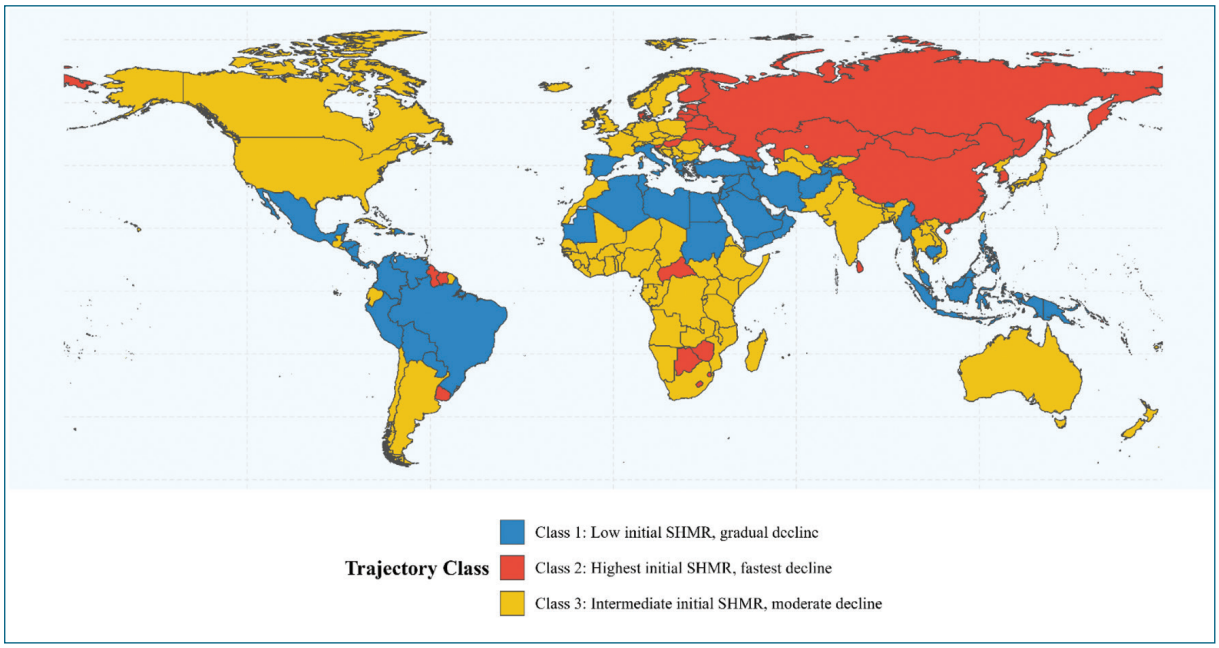
The three latent classes differed primarily in their baseline mortality and rates of decline (Table 2). Class 1 was characterized by the lowest estimated baseline SHMR (intercept = 5.65) and a gradual annual decline (linear b = −0.037). Class 2 exhibited the highest baseline mortality (intercept = 22.81) together with the steepest decline over time (linear b = −0.176). Class 3 showed intermediate baseline mortality (intercept = 12.37) and a moderate rate of decline (linear b = −0.116). A common negative quadratic coefficient (−0.0027) indicated modest downward curvature in the trajectories across all classes. Figure 4 illustrates the geographic distribution of countries across the three latent trajectory classes, and Figure 5 depicts the estimated longitudinal SHMR trajectories for these classes identified by the GMM.

Table 2. Country Membership of the Three-Class Growth Mixture Model Identified in the Analysis Excluding Lebanon and Greenland

Trajectory class	Countries (n)	Estimated baseline SHMR (Intercept)[a]	Annual linear change (Slope)[b]	Clinical interpretation
Class 1	69	5.65	−0.037	Low initial SHMR with a gradual decline
Class 2	29	22.81	−0.176	Highest initial SHMR with the fastest decline
Class 3	104	12.37	−0.116	Intermediate initial SHMR with a moderate decline

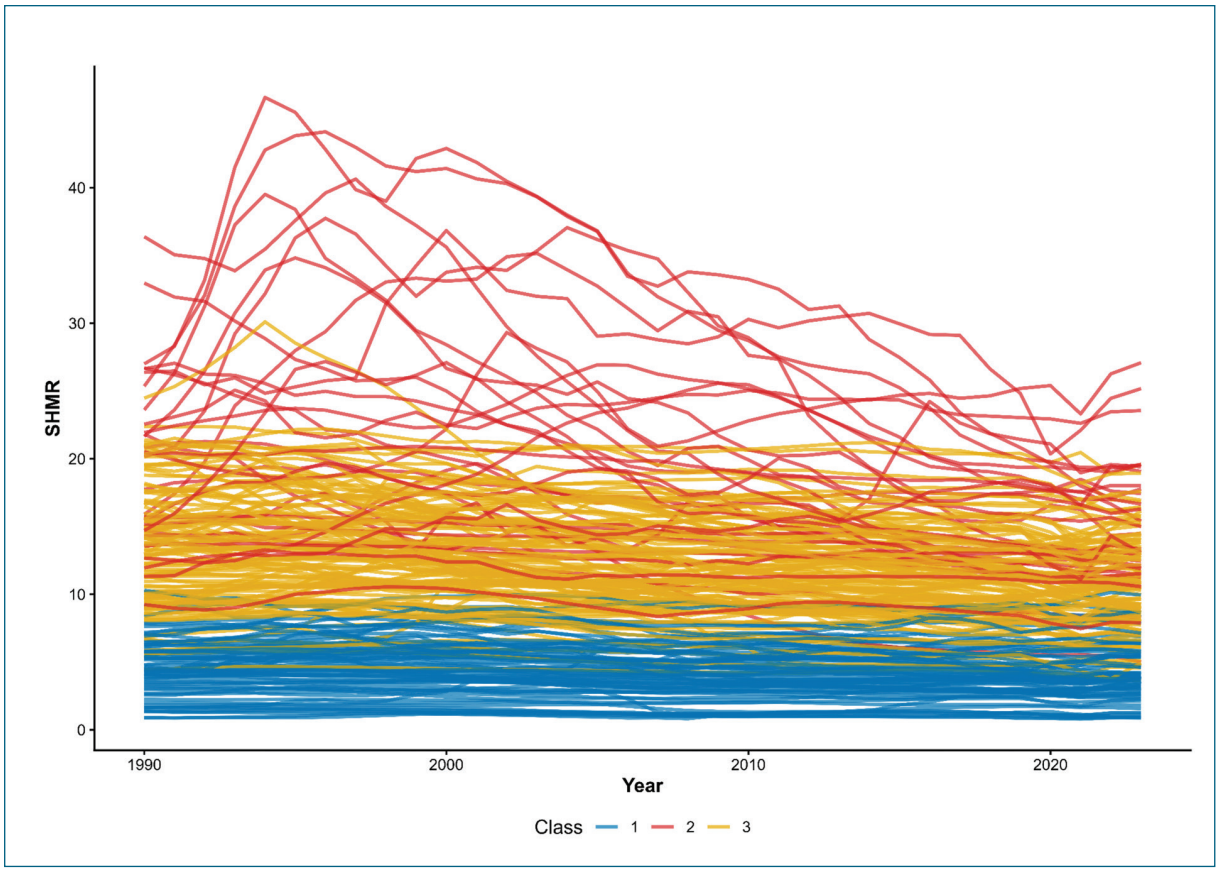
Note. [a] SHMR = self-harm mortality rate. Intercepts represent estimated self-harm mortality rates at the centered baseline time point.
[b] Linear slopes represent the average annual change in mortality rate.
More negative slopes indicate faster declines. A common quadratic time effect (b = −0.0027) was estimated across all latent classes, indicating modest downward curvature in the trajectories.
Class 1: Afghanistan, Albania, Algeria, American Samoa, Antigua and Barbuda, Armenia, Azerbaijan, Bahamas, Bahrain, Barbados, Belize, Bermuda, Bhutan, Bolivia, Brazil, Brunei, Cambodia, Colombia, Costa Rica, Cyprus, Dominica, Dominican Republic, Egypt, England, Georgia, Greece, Grenada, Honduras, Indonesia, Iran, Iraq, Israel, Italy, Jamaica, Jordan, Kuwait, Libya, Malaysia, Maldives, Malta, Mauritania, Mexico, Myanmar, Nicaragua, Oman, Palestine, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Puerto Rico, Qatar, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sao Tome and Principe, Saudi Arabia, Spain, Sudan, Syria, Tajikistan, Timor, Tonga, Tunisia, Turkey, United Arab Emirates, Venezuela, Yemen.
Class 2: Belarus, Botswana, Central African Republic, China, Denmark, Estonia, Eswatini, Finland, Guam, Guyana, Hungary, Kazakhstan, Kiribati, Latvia, Lesotho, Lithuania, Marshall Islands, Mongolia, Nauru, Russia, Slovenia, Solomon Islands, South Korea, Sri Lanka, Suriname, Ukraine, Uruguay, Vanuatu, Zimbabwe.
Class 3: Andorra, Angola, Argentina, Australia, Austria, Bangladesh, Belgium, Benin, Bosnia and Herzegovina, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Cape Verde, Chad, Chile, Comoros, Congo, Cook Islands, Cote d'Ivoire, Croatia, Cuba, Czechia, Djibouti, Ecuador, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, France, Gabon, Gambia, Germany, Ghana, Guatemala, Guinea, Guinea-Bissau, Haiti, Iceland, India, Ireland, Japan, Kenya, Kyrgyzstan, Laos, Liberia, Luxembourg, Madagascar, Malawi, Mali, Mauritius, Moldova, Monaco, Montenegro, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Niger, Nigeria, Niue, North Korea, North Macedonia, Northern Ireland, Northern Mariana Islands, Norway, Pakistan, Palau, Poland, Portugal, Romania, Rwanda, Samoa, San Marino, Scotland, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Somalia, South Africa, South Sudan, Sweden, Switzerland, Taiwan, Tanzania, Thailand, Togo, Tokelau, Trinidad and Tobago, Turkmenistan, Tuvalu, Uganda, United States, Uzbekistan, Vietnam, Wales, Zambia.

Figure 4. Geographic Distribution of Countries Across the Three Latent Self-Harm Mortality Trajectory Classes Identified by Growth Mixture Model



Note. SHMR = self-harm mortality rate.

Figure 5. Country-Level Trajectories of Age-Standardized Self-Harm Mortality Rates, Colored by Latent Trajectory Class Identified By Growth Mixture Model, 1990–2023



Note. SHMR = self-harm mortality rate.

To facilitate interpretation of the latent trajectory classes identified by the GMM, we subsequently summarized the average socioeconomic characteristics of countries assigned to each class. Based on descriptive summaries, the three classes showed broadly similar HDI and income inequality profiles, whereas the clearest differences were observed for V-Dem. Table 3 summarizes the mean socioeconomic characteristics of each latent trajectory class. Countries exhibiting the largest improvements in HDI, V-Dem, and Gini within each class are presented separately in Appendix Table 2.

Countries assigned to Class 1 generally comprised Southern European, Middle Eastern, Latin American, and several Asian countries. These countries were characterized by relatively low baseline SHMRs and comparatively modest declines over time.

Class 2 consisted predominantly of post-Soviet and Baltic countries together with several Asian countries. This class exhibited the highest baseline SHMRs but also the steepest reductions over time. Appendix Table 2 shows that several countries within each latent class experienced particularly large improvements in one or more socioeconomic indicators. For example, China showed one of the largest improvements in HDI within Class 2, whereas substantial improvements in democratic governance were observed in countries such as Timor-Leste (Class 1) and Malawi (Class 3).

Class 3 included many Western European, North American, and Oceanian countries but also numerous countries from Africa and Asia. Although this class contained many highly developed countries, it also included several developing countries that experienced substantial improvements in HDI and democratic governance over the study period.

Table 3. Mean Socioeconomic Characteristics of the Three Latent Self-Harm Mortality Trajectory Classes Identified by Growth Mixture Modeling

Class	Observed SHMR trajectory	HDI[a] 1990	HDI 2023	ΔHDI	V-Dem[b] 1990	V-Dem 2023	ΔV-Dem	Gini[c] 1990	Gini 2023	ΔGini
1	Low baseline, gradual decline	0.62	0.74	+0.12	0.51	0.60	+0.09	0.41	0.38	−0.03
2	Highest baseline, steepest decline	0.63	0.74	+0.11	0.71	0.72	+0.01	0.39	0.36	−0.02
3	Intermediate baseline, moderate decline	0.57	0.70	+0.13	0.59	0.70	+0.11	0.40	0.37	−0.03

Note. SHMR = self-harm mortality rate. [a] Human Development Index; [b] Varieties of Democracy; [c] Gini coefficient (income inequality).

Discussion

This study examined longitudinal changes in SHMR across 204 countries between 1990 and 2023 and identified subgroups of countries with similar longitudinal mortality trajectories. In addition to describing the global trajectory of SHMR, we examined differences in long-term mortality trends among countries classified according to their latest available HDI, V-Dem, and Gini values and further evaluated these findings using supplementary LGM with time-varying socioeconomic indicators. When interpreted together, the two modeling approaches provided complementary information.

As our results show, SHMR declined globally throughout the study period, although the magnitude of decline differed across regions and socioeconomic groups. These findings are broadly consistent with previous multinational studies (Naghavi, 2019; Weaver et al., 2025).

Our findings suggest that countries classified as having higher HDI and lower income inequality exhibited steeper long-term reductions in SHMR, whereas differences according to democratic governance were not statistically significant. Because these socioeconomic groups were defined using their most recent available values, these findings should be interpreted as descriptive comparisons of historical SHMR trajectories among countries that ultimately differed in their socioeconomic characteristics rather than as evidence that HDI, democratic governance, or income inequality caused the observed changes in SHMR. Furthermore, because this was an ecological study, the observed associations are correlational and do not permit causal inference. Other unmeasured structural, cultural, and health-system factors may also influence SHMR trajectories across countries (Rajkumar, 2023). Our findings are in line with previous ones related to economic uncertainty (Claveria, 2022; Er et al., 2023). However, the present study provides a more nuanced picture.

In our primary analyses, countries classified as having higher HDI exhibited substantially steeper long-term declines in SHMR than countries classified as having lower HDI. The supplementary time-varying analyses

provided additional information on the contemporaneous association between annual HDI and SHMR at different time points. Although annual HDI was not significantly associated with SHMR during the early years of follow-up, its association became increasingly negative and statistically significant during the middle and later years, indicating a stronger contemporaneous country-level association between HDI and SHMR at later time points. Furthermore, after accounting for annual HDI, the residual temporal trend in SHMR was no longer statistically significant. However, this finding should not be interpreted as evidence that improvements in HDI caused or explained the decline in SHMR. Rather, the results indicate that the contemporaneous country-level association between HDI and SHMR became more pronounced at later time points, while the overall temporal trend was attenuated after inclusion of annual HDI in the model. However, because these longitudinal analyses required separate models owing to substantial and uneven missingness in the socioeconomic data, this interpretation should be regarded as exploratory and taken with appropriate caution. The relationship between suicide and HDI is complex and may be non-linear. Previous studies have reported both positive and inverted U-shaped associations between HDI and suicide rates, particularly among older adults (Cabello-Rangel et al., 2020; Dela Cruz, 2019; Shah, 2009). Our findings suggest that countries classified as having higher HDI exhibited steeper declines in SHMR over time, although the mechanisms underlying this association remain uncertain and warrant further investigation.

Our primary analyses showed no statistically significant difference in long-term SHMR trajectories between countries classified as having higher and lower levels of democratic governance. Although countries with higher V-Dem scores exhibited a somewhat steeper decline in SHMR than countries with lower scores, this difference was not statistically significant. These findings differ from those of Chon (2018), who reported a positive association between democracy and suicide rates in a cross-national study. The discrepancy may reflect differences in study design, as our analyses focused on long-term changes in age-standardized mortality trajectories over three decades, whereas Chon (2018) examined cross-sectional associations between democracy and suicide rates. The supplementary time-varying analyses further supported this conclusion, the estimated contemporaneous associations between annual V-Dem and SHMR were generally small and non-significant, and the residual temporal decline remained largely unchanged after adjustment for democratic governance. Taken together, the findings from both modeling approaches provide little evidence that temporal changes in democratic governance substantially contributed to global SHMR trends. Evidence from cross-national panel analyses suggests that democratic experience is associated with improvements in some health outcomes, but its relationship with mortality is heterogeneous and cause-specific, providing limited support for a strong, uniform contribution of temporal changes in democratic governance to global SHMR trends (Bollyky et al., 2019).

Our primary analyses indicated that countries classified as having lower income inequality experienced substantially steeper long-term declines in SHMR than countries classified as having higher income inequality. Previous studies have likewise reported that favorable economic conditions, including higher income levels and economic growth, are generally associated with lower suicide mortality, whereas greater income inequality has been linked to increased suicide risk (Andres, 2005; Kõlves et al., 2013; Machado et al., 2015). Nevertheless, these associations may vary across populations and age groups (Andres, 2005; Chen et al., 2009).

The supplementary time-varying analyses suggested a more nuanced interpretation. Associations between annual Gini values and SHMR were concentrated primarily during the early years of follow-up and became largely non-significant thereafter, indicating that the difference observed in the primary analyses may partly reflect historical and regional clustering rather than a uniform longitudinal effect of income inequality itself. This interpretation is further supported by the GMM results, which showed that countries with similar SHMR trajectories also shared common historical and regional contexts. In particular, the trajectory class characterized by the highest baseline SHMR consisted predominantly of post-Soviet countries that experienced marked declines during periods of profound social and economic transition. Rather, the observed trajectories were likely influenced by a combination of historical, regional, societal, and economic factors. Consistent with this interpretation, previous research in Eastern Europe found that changes in suicide rates were linked to socioeconomic disruptions associated with the post-Soviet transition, suggesting that observed mortality declines may reflect broader historical and regional processes rather than income inequality alone (Kõlves et al., 2013).

An additional consideration is that this association may partly reflect historical coincidence rather than a direct effect of income inequality. Several countries that were classified as having relatively lower contemporary Gini indices also experienced exceptionally high SHMR during the early 1990s because of unique historical circumstances, particularly the social and economic disruptions accompanying the post-Soviet transition. Their subsequently large declines therefore likely reflect recovery from these historically elevated baseline levels as well as

broader societal changes, underscoring the need to avoid ecological interpretations that attribute these trajectory differences to income inequality alone.

Furthermore, countries with higher baseline SHMR generally exhibited steeper subsequent declines over the study period, possibly reflecting greater scope for improvement following historically elevated mortality as well as the implementation of stronger public health, mental health, and suicide prevention initiatives. Although this pattern is compatible with convergence across countries, these ecological analyses do not permit causal inference.

The initial exploratory Growth Mixture Model identified Lebanon and Greenland as influential outlier trajectories because their longitudinal patterns differed markedly from those of all other countries. Lebanon showed an increasing self-harm mortality trajectory, which has been linked to the country's economic crisis, political instability, armed conflicts, and refugee-related pressures (Chahine et al., 2020; Khalil, 2019). In contrast, Greenland exhibited a marked decline over time, potentially reflecting the implementation of national suicide prevention initiatives and broader improvements in living conditions and healthcare (Bjerregaard et al., 2022; Iskander & Crosby, 2021). These two countries were excluded from the final clustering procedure. The resulting three-class solution yielded a more parsimonious and clinically interpretable solution.

Class 1 consisted primarily of Southern European, Middle Eastern, Latin American, and several Asian countries that maintained relatively low self-harm mortality throughout the study period and experienced gradual declines over time. Countries in this class generally showed steady improvements in human development, democratic governance, and income inequality, although the magnitude of change varied considerably. As shown in Appendix Table 2, some countries within this trajectory class, including Myanmar and Turkey, experienced particularly large improvements in HDI during follow-up. These examples illustrate the heterogeneity within the class rather than defining its overall characteristics. This interpretation is consistent with global self-harm trend analyses showing long-run declines but substantial regional variation, and with evidence that changes in social and economic conditions are linked to self-harm in complex, context-specific ways (Cairns et al., 2017; Naghavi, 2019; Xie et al., 2025).

Class 2 comprised predominantly post-Soviet and Baltic countries together with several Asian countries and showed the highest initial self-harm mortality followed by the steepest decline. This pattern is consistent with the well-documented suicide epidemic in many post-Soviet countries during the 1990s and the subsequent reductions associated with social and economic stabilization. The inclusion of China, which experienced the largest improvement in HDI, suggests that different forms of rapid societal transition can produce similar long-term mortality trajectories. Notably, this class did not exhibit the greatest average improvements in socioeconomic indicators, implying that broader historical and societal factors likely contributed to its distinctive pattern. This interpretation closely matches evidence from the post-Soviet transition literature, which links the 1990s spike and later decline in suicide mortality to macroeconomic disruption and stabilization (Brainerd, 2001; Kõlves et al., 2013), and it also parallels studies of China showing that suicide decline there accompanied rapid social change but could not be reduced to any single socioeconomic measure (Cai et al., 2022).

Class 3 was the largest and most heterogeneous class, including many Western European, North American, and Oceanian countries as well as numerous countries from Africa and Asia. Although it contained several highly developed countries, such as the Netherlands, it also included countries that experienced substantial gains in HDI and democratic governance. This diversity suggests that similar long-term declines in self-harm mortality can occur under different socioeconomic conditions and reinforces that trajectory class membership reflects shared mortality patterns rather than socioeconomic development alone. Our findings support GBD-based studies showing that the relationship between development and self-harm is regionally heterogeneous and changes over time, while global suicide mortality has broadly declined despite marked differences across countries and SDI levels (Barbalat & Liu, 2022; Weaver et al., 2025; Yan et al., 2024).

Taken together, the latent trajectory classes also suggest a process of convergence in global SHMR over time. Countries with the highest initial mortality, particularly those in Class 2, exhibited the steepest subsequent declines, whereas countries with initially lower mortality generally followed more gradual trajectories. In several countries, this pattern is consistent with a movement toward mortality levels closer to the broader global trajectory following periods of unusually high mortality rather than persistent divergence between countries. Although the present analyses were not designed to formally evaluate convergence, these findings suggest that convergence following historically elevated mortality is an important feature underlying several of the identified trajectory classes.

Importantly, these latent trajectory classes complement rather than replace the LGM findings. Whereas the primary LGM compared long-term SHMR trajectories among countries grouped by socioeconomic characteristics,

the GMM identified latent groups of countries sharing similar longitudinal mortality patterns. Taken together, these analyses indicate that countries with different socioeconomic profiles can exhibit distinct long-term SHMR trajectories, while the latent trajectory analysis further reveals regional and historical patterns that are not fully captured by predefined socioeconomic classifications. The findings therefore support interpreting socioeconomic characteristics and latent trajectory classes as complementary perspectives on the heterogeneity of global SHMR trends rather than as evidence that socioeconomic indicators account for a quantified proportion of between-country variation.

Strengths and Limitations

This study included all 204 countries over a 34-year period and combined complementary LGM and GMM approaches to characterize both average global trends and heterogeneous SHMR trajectories. However, SHMR estimates were obtained from the GBD database and may be affected by underreporting, differences in death registration, and model-based uncertainty. The ecological design precludes causal inference, and the supplementary time-varying analyses should be considered exploratory because of missing longitudinal socioeconomic data.

Conclusion, Implications, and Future Directions

Global SHMR declined substantially between 1990 and 2023, although trajectories varied considerably across countries. Countries classified as having higher HDI and lower income inequality exhibited steeper historical declines, whereas democratic governance showed no significant association. GMM further highlighted the importance of regional and historical contexts beyond socioeconomic indicators alone and suggested a pattern of convergence among countries with historically elevated SHMR. These findings provide a framework for future longitudinal studies and context-specific suicide prevention strategies.

ABBREVIATIONS

SHMR: Self-Harm Mortality Rate
LGM: Latent Growth Models
GMM: Growth Mixture Models
HDI: Human Development Index
V-Dem: Varieties of Democracy

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Declaration of Interest Statement

The authors declare that they have no conflicts of interest related to the research, authorship, or publication of this manuscript.

Ethical Statement

This manuscript is the authors' original work.

The studies involving human participants were reviewed and approved by Research Ethics Committees of Vice-Chancellor in Research Affairs - Shahid Beheshti University of Medical Sciences; IR.SBMU.RETECH.REC.1401.300.

Data Availability Statement

Datasets presented in this article are available in a publicly accessible repository: GBD2023 dataset; https://vizhub.healthdata.org/gbd-results/

Declaration on Using Artificial Intelligence in Research and Manuscript Preparation

The authors used AI technologies in the preparation of the manuscript for final language editing and polishing of manuscript text, but not in their research. ChatGPT, 5.0 developed by OpenAI was used for enhancing clarity, grammar, and fluency of English writing in the manuscript. No content was generated; only existing text was refined. All scientific content, interpretations, and conclusions were authored and verified by the researchers. AI suggestions were reviewed and selectively applied by the authors.

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References

Andres, A. R. (2005). Income inequality, unemployment, and suicide: A panel data analysis of 15 European countries. *Applied Economics*, *37*(4), 439–451. https://doi.org/10.1080/0003684042000295304

Barbalat, G., & Liu, S. (2022). Socio-demographic development and burden of mental, substance use disorders, and self-harm: An ecological analysis using the Global Burden of Disease study 2019. *Australian & New Zealand Journal of Psychiatry*, *56*(12), 1617–1627. https://doi.org/10.1177/00048674211066764

Bjerregaard, P., Larsen, C. V. L., Olesen, I., Ottendahl, C. B., Backer, V., Senftleber, N., Christensen, M. M. B., Larsen, T. J., Byberg, S., & Hansen, T., Jorgensen, M. E. (2022). The Greenland population health survey 2018 – Methods of a prospective study of risk factors for lifestyle related diseases and social determinants of health amongst Inuit. *International Journal of Circumpolar Health*, *81*(1), Article 2090067. https://doi.org/10.1080/22423982.2022.2090067

Bollyky, T. J., Templin, T., Cohen, M., Schoder, D., Dieleman, J. L., & Wigley, S. (2019). The relationships between democratic experience, adult health, and cause-specific mortality in 170 countries between 1980 and 2016: An observational analysis. *The Lancet*, *393*(10181), 1628–1640. https://doi.org/10.1016/S0140-6736(19)30235-1

Brainerd, E. (2001). Economic reform and mortality in the former Soviet Union: A study of the suicide epidemic in the 1990s. *European Economic Review*, *45*(4–6), 1007–1019. https://doi.org/10.1016/S0014-2921(01)00108-8

Cabello-Rangel, H., Márquez-Caraveo, M. E., & Díaz-Castro, L. (2020). Suicide rate, depression and the Human Development Index: An ecological study from Mexico. *Frontiers in Public Health*, *8*, Article 561966. https://doi.org/10.3389/fpubh.2020.561966

Cai, Z., Chen, M., Ye, P., & Yip, P. S. (2022). Socio-economic determinants of suicide rates in transforming China: A spatial-temporal analysis from 1990 to 2015. *The Lancet Regional Health–Western Pacific*, *19,* Article 100341. https://doi.org/10.1016/j.lanwpc.2021.100341

Cairns, J.-M., Graham, E., & Bambra, C. (2017). Area-level socioeconomic disadvantage and suicidal behaviour in Europe: A systematic review. *Social Science & Medicine*, *192*, 102–111. https://doi.org/10.1016/j.socscimed.2017.09.034

Castaneda Aguilar, R. A., Diaz-Bonilla, C., Fujs, T. H. M. J., Jolliff, D., Lakner, C., Mahler, D. G., Nguyen, M. C., Schoch, M., Tetteh-Baah, S. K., Viveros Mendoza, M. C., Wu, H. & Y., N. (2022). *September 2022 Update to the Poverty and Inequality Platform (PIP): What's New.* Global Poverty Monitoring Technical Note; 24. World Bank. https://doi.org/10.1596/38023

Chahine, M., Salameh, P., Haddad, C., Sacre, H., Soufia, M., Akel, M., Obeid, S., Hallit, R., & Hallit, S. (2020). Suicidal ideation among Lebanese adolescents: Scale validation, prevalence and correlates. *BMC Psychiatry*, *20*, Article 304 . https://doi.org/10.1186/s12888-020-02726-6

Chang, S.-S., Chen, Y.-Y., Yip, P. S. F., Lee, W. J., Hagihara, A., & Gunnell, D. (2014). Regional changes in charcoal-burning suicide rates in East/Southeast Asia from 1995 to 2011: A time trend analysis. *PLoS Medicine*, *11*(4), Article e1001622. https://doi.org/10.1371/journal.pmed.1001622

Chen, J., Choi, Y. J., & Sawada, Y. (2009). How is suicide different in Japan? *Japan and the World Economy*, *21*(2), 140–150. https://doi.org/10.1016/j.japwor.2008.06.001

Chon, D. S. (2018). Democracy, autocracy, and direction of lethal violence: Homicide and suicide. *Homicide Studies*, *22*(4), 370–390. https://doi.org/10.1177/1088767918775465

Claveria, O. (2022). Global economic uncertainty and suicide: Worldwide evidence. *Social Science & Medicine*, *305*, Article 115041. https://doi.org/10.1016/j.socscimed.2022.115041

Coppedge, M., Gerring, J., Knutsen, C. H., Lindberg, S. I., Teorell, J., Altman, A., Bernhard, M., Cornell, A., Fish, M., & Gastaldi, L. (2022). *VDem [Country–Year/Country–Date] Dataset v12*. Varieties of Democracy (V-Dem) Project. https://doi.org/10.23696/vdemds22

Dasic, B., Devic, Z., Denic, N., Zlatkovic, D., Ilic, I. D., Cao, Y., Jermsittiparsert, K., & Van Le, H. (2020). Human Development Index in a context of human development: Review on the western Balkans countries. *Brain Behavior*, *10*(9), Article e01755. https://doi.org/10.1002/brb3.1755

de Bruin, A., Agyemang, A., & Chowdhury, M. I. H. (2020). New insights on suicide: Uncertainty and political conditions. *Applied Economics Letters*, *27*(17), 1424–1429. https://doi.org/10.1080/13504851.2019.1686453

Dela Cruz, R. M. (2019). *The Effects of Human Development and Income Inequality on Suicide Rates in 67 Countries* [Thesis]. University of the Philippines, School of Economics.

Er, S. T., Demir, E., & Sari, E. (2023). Suicide and economic uncertainty: New findings in a global setting. *SSM-Population Health*, *22*, Article 101387. https://doi.org/10.1016/j.ssmph.2023.101387

Ghodsi, Z., Moghaddam, S. S., Vezvaei, P., Yoosefi, M., Rezaei, N., Saadat, S., Sheidaei, A., Sharif-Alhoseini, M., Sadeghian, F., & Ahmadi, N., S. B. Jazayeri, Salamati, P., Khosravi, A., Moradi-Lakeh, M., Mokdad, A. H., O'Reilley, G., & Rahimi-Movaghar, V. (2020). The mortality rate from self-harm in Iran. *Public Health*, *186*, 44–51. https://doi.org/10.1016/j.puhe.2020.06.015

Ilic, I., Zivanovic Macuzic, I., Kocic, S., & Ilic, M. (2022). Worldwide suicide mortality trends by firearm (1990–2019): A joinpoint regression analysis. *PLoS One*, *17*(5), Article e0267817. https://doi.org/10.1371/journal.pone.0267817

Iskander, J. K., & Crosby, A. E. (2021). Implementing the national suicide prevention strategy: Time for action to flatten the curve. *Preventive Medicine*, *152*(1), Article 106734. https://doi.org/10.1016/j.ypmed.2021.106734

Khalil, R. B. (2019). The psychological wellbeing of the Lebanese society lies between incremental suicide rates and financial stress. *Asian Journal of Psychiatry*, *42*, 85–86. https://doi.org/10.1016/j.ajp.2019.04.002

Kõlves, K., Milner, A., & Värnik, P. (2013). Suicide rates and socioeconomic factors in Eastern European countries after the collapse of the Soviet Union: Trends between 1990 and 2008. *Sociology of Health & Illness*, *35*(6), 956–970. https://doi.org/10.1111/1467-9566.12011

Lange, S., Cayetano, C., Jiang, H., Tausch, A., & E Souza, R. O. (2023). Contextual factors associated with country-level suicide mortality in the Americas, 2000–2019: A cross-sectional ecological study. *The Lancet Regional Health–Americas*, *20,* Article 100450. https://doi.org/10.1016/j.lana.2023.100455

Lester, D. (1999). Does democracy increase suicide and homicide rates? *Psychological Reports*, *85*(2), Article 518. https://doi.org/10.2466/pr0.1999.85.2.518

Lorant, V., de Gelder, R., Kapadia, D., Borrell, C., Kalediene, R., Kovács, K., Leinsalu, M., Martikainen, P., Menvielle, G., & Regidor, E., Rodríguez-Sanz, M., Wojtyniak, B., Strand, B. H., Bopp, M., & Mackenbach, J. P. (2018). Socioeconomic inequalities in suicide in Europe: The widening gap. *The British Journal of Psychiatry*, *212*(6), 356–361. https://doi.org/10.1192/bjp.2017.32

Lorant, V., Kunst, A. E., Huisman, M., Costa, G., & Mackenbach, J. (2005). Socio-economic inequalities in suicide: A European comparative study. *The British Journal of Psychiatry*, *187*(1), 49–54. https://doi.org/10.1192/bjp.187.1.49

Lyu, J., Zhang, J., & Lamis, D. A. (2025). A worldwide study of the relationship between Gini coefficients and suicide rates. *International Journal of Environmental Research and Public Health*, *22*(7), Article 1110. https://doi.org/10.3390/ijerph22071110

Machado, D. B., Rasella, D., & Dos Santos, D. N. (2015). Impact of income inequality and other social determinants on suicide rate in Brazil. *PLoS One*, *10*(4), Article e0124934. https://doi.org/10.1371/journal.pone.0124934

McKeown, R. E., Cuffe, S. P., & Schulz, R. M. (2006). US suicide rates by age group, 1970–2002: An examination of recent trends. *American Journal of Public Health*, *96*(10), 1744–1751. https://doi.org/10.2105/AJPH.2005.066951

Naghavi, M. (2019). Global, regional, and national burden of suicide mortality 1990 to 2016: Systematic analysis for the Global Burden of Disease Study 2016. *British Medical Journal*, *364,* Article 194. https://doi.org/10.1136/bmj.l94

Przeworski, A., Alvarez, M. E., Cheibub, J. A., & Limongi, F. (2000). *Democracy and development: Political institutions and well-being in the world, 1950-1990*. Cambridge University Press.

Rajkumar, R. P. (2023). The association between nation-level social and economic indices and suicide rates: A pilot study. *Frontiers in Sociology*, *8*, Article 1123284. https://doi.org/10.3389/fsoc.2023.1123284

Roser, M. (2014). *Human Development Index (HDI).* Our World in Data.

Sen, A. (2017). Democracy as a universal value. In L. May (Ed.), *Applied ethics* (6th ed., pp. 107–117). Routledge.

Shah, A. (2009). The relationship between elderly suicide rates and the human development index: A cross-national study of secondary data from the World Health Organization and the United Nations. *International Psychogeriatrics*, *21*(1), 69–77. https://doi.org/10.1017/S1041610208007527

Veisani, Y., Delpisheh, A., Valizadeh, R., & Kikhavani, S. (2019). Income inequality by Gini-coefficient on suicide death in Iran: A review of national data. *Iranian Journal of Public Health*, *48*(8), 1512–1517.

Weaver, N. D., Bertolacci, G. J., Rosenblad, E., Ghoba, S., Cunningham, M., Ikuta, K. S., Moberg, M. E., Mougin, V., Han, C., & Wool, E. E. (2025). Global, regional, and national burden of suicide, 1990–2021: A systematic analysis for the Global Burden of Disease Study 2021. *The Lancet Public Health*, *10*(3), e189–e202. https://doi.org/10.1016/S2468-2667(25)00006-4

World Health Organization (1992). *ICD-10: International statistical classification of diseases and related health problems* (10th ed.).

World Health Organization (2022). *ICD-11: International statistical classification of diseases and related health problems* (11th ed.).

World Health Organization. (2025). *Suicide worldwide in 2021: Global health estimates.* https://www.who.int/publications/i/item/9789240110069

Xie, L., Tang, L., Liu, Y., Dong, Z., & Zhang, X. (2025). Global burden and trends of self-harm from 1990 to 2021, with predictions to 2050. *Frontiers in Public Health*, *13*, Article 1571579. https://doi.org/10.3389/fpubh.2025.1571579

Yan, N., Luo, Y., Mackay, L. E., Wang, Y., Wang, Y., Wang, Y., Shiferaw, B. D., Wang, J., Tang, J., Yan, W., Wang, Q., Gao, X., & Wang, W. (2024). Global patterns and trends of suicide mortality and years of life lost among adolescents and young adults from 1990 to 2021: A systematic analysis for the Global Burden of Disease Study 2021. *Epidemiology and Psychiatric Sciences*, *33*, Article e52. https://doi.org/10.1017/S2045796024000532

Appendix

Table 1. Sensitivity Analysis Using Latent Growth Models with Human Development Index, Democratic Governance, and Income Inequality Entered Separately as Continuous Time-Varying Covariates

Covariate	Self-harm mortality rates			Time-varying covariate effects			
	Initial Level (Intercept)	Annual Trend (Slope)	Slope p-value	Early years	Middle years	Late years	Overall pattern
HDI[a]	12.97	+0.102	.278	Non-significant	Increasingly negative	Mostly significant negative	Stronger inverse association in later years
Gini[b]	14.46	−0.170	<.001	Significant negative	Mostly non-significant	Mostly non-significant	Effect concentrated in early years
V-Dem[c]	14.51	−0.165	.001	Non-significant	Non-significant	Non-significant	No consistent annual association

Note. [a] Human Development Index; [b] Gini coefficient (income inequality) [c] Varieties of Democracy. Separate latent growth models were estimated for each socioeconomic indicator because of substantial and uneven missingness in the longitudinal covariates. Each indicator was entered as a continuous time-varying predictor of annual self-harm mortality rates. The table summarizes the overall pattern of the annual time-varying covariate coefficients rather than presenting individual yearly estimates. "Early", "middle", and "late" years refer to 1990–2000, 2001–2011, and 2012–2023, respectively. These exploratory sensitivity analyses were designed to examine contemporaneous country-level associations between socioeconomic indicators and SHMR across observed time points and were not intended to replicate the primary analyses comparing retrospectively defined socioeconomic groups.

Table 2. Distribution of Countries with the Largest Overall Changes in Human Development Index, Democratic Governance, and Income Inequality Across the Latent Self-Harm Mortality Rates Trajectory Classes

Class	Observed SHMR trajectory	Countries with the largest changes in HDI[a]	Countries with the largest changes in V-Dem[b]	Countries with the largest changes in Gini[c]
1	Low baseline, gradual decline	Myanmar (+0.25), Turkey (+0.24), Cambodia (+0.22)	Timor-Leste (+0.79), Albania (+0.75), Indonesia (+0.54)	Armenia (−0.19), Mauritania (−0.17)
2	Highest baseline, steepest decline	China (+0.28)	No country from this class was among the top 10	Lesotho (−0.18)
3	Intermediate baseline, moderate decline	Bangladesh (+0.26), Rwanda (+0.25), Morocco (+0.24), Thailand (+0.22), Angola (+0.22), Vietnam (+0.22)	Malawi (+0.77), El Salvador (+0.59), South Africa (+0.56), Guinea-Bissau (+0.52), Liberia (+0.51), Sierra Leone (+0.50), Angola (+0.48)	Malawi (−0.27), Haiti (−0.18), Kyrgyzstan (−0.17), Guinea (−0.17), Kenya (−0.17), Senegal (−0.16), El Salvador (−0.15)

Note. [a] Human Development Index; [b] Varieties of Democracy; [c] Gini coefficient (income inequality). SHMR = self-harm mortality rate. The listed countries represent the 10 countries with the largest overall changes in each socioeconomic indicator between 1990 and 2023 across all countries included in the study. Countries are presented according to the latent self-harm mortality trajectory class to which they were assigned.