

Temporal Patterns, Gender Disparities & Future Projections of Suicide Rates (A Statistical Analysis Across Selected WHO Regions and Nigeria (2000–2021))

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Abstract—This study examined the temporal patterns, gender disparities, and future projections of suicide rates across selected WHO regions and Nigeria between 2000 and 2021 using descriptive statistics, trend analysis, moving averages, volatility measures, and ARIMA forecasting techniques. Suicide remains a major global public health challenge, with clear regional and gender-based differences that continue to shape mortality patterns worldwide. The findings revealed substantial regional variation in suicide rates. Europe recorded the highest mean total suicide rate (34.04 per 100,000 population), while the Eastern Mediterranean region recorded the lowest (5.34). Although most regions showed a gradual decline in suicide rates over time, the pace of decline differed considerably. Europe and the Eastern Mediterranean exhibited strong downward trends, whereas Africa showed only slight changes over the study period. The study also confirmed persistent gender inequality in suicide mortality across all regions. Male suicide rates consistently exceeded female rates, with Europe recording the widest gender gap (20.30). Nigeria displayed a distinct pattern characterized by moderate suicide rates but widening gender disparity over time, as the male-to-female suicide ratio increased steadily throughout the study period. This suggests that while overall suicide levels in Nigeria remained relatively stable, male vulnerability to suicide became increasingly pronounced. Forecasting using the ARIMA (0,2,2) model projected that Nigeria's suicide rates are likely to remain relatively stable up to 2030, with only a slight downward movement if current conditions persist. The study concludes that suicide mortality is influenced by complex social, demographic, and structural factors, and that reducing the burden of suicide will require stronger mental health systems, improved suicide surveillance, gender-sensitive interventions, and proactive long-term public health policies.

Keywords—Suicide Rate, Gender Disparity, Time Series Analysis, Forecasting, Volatility.

I. INTRODUCTION

Suicide remains one of the leading global public health concerns, contributing significantly to mortality and psychological burden across societies. According to the World Health Organization, hundreds of thousands of suicide-related deaths occur annually worldwide, with substantial social, economic, and mental health consequences. Beyond the direct loss of life, suicide affects families, communities, productivity, and healthcare systems.

Global suicide patterns vary considerably across regions, genders, and socioeconomic environments. Previous studies have shown that suicide mortality is influenced by a complex interaction of psychological vulnerability, economic hardship, social conditions, demographic factors, and access to mental health services. Significant regional disparities also exist between developed and developing countries, reflecting differences in healthcare systems, cultural attitudes, and reporting structures.

One of the most persistent findings in suicide research is gender inequality in suicide mortality. Males consistently record higher suicide rates than females across most global regions, although the magnitude of the disparity differs considerably between countries and cultures. Understanding these gender differences is important for designing targeted public health interventions and mental health policies.

In recent years, researchers have increasingly emphasized the importance of temporal analysis in suicide studies. Suicide rates evolve over time due to economic transitions, demographic changes, public health interventions, and societal shifts. However,

many existing studies rely heavily on descriptive or cross-sectional approaches and provide limited insight into long-term temporal dynamics and future projections.

The African context, particularly Nigeria, remains underrepresented in global suicide literature due to underreporting, cultural stigma, legal concerns, and weak mortality surveillance systems. Despite these limitations, Nigeria represents an important case study because of its large population, socioeconomic diversity, and growing mental health concerns.

This study extends previous research by integrating descriptive analysis, gender inequality measures, trend analysis, volatility assessment, and time series forecasting to examine suicide patterns across selected WHO regions and Nigeria between 2000 and 2021. The study further applies ARIMA forecasting techniques to project future suicide trends up to 2030.

II. OBJECTIVES OF THE STUDY

The study aims to:

1. Examine temporal trends in suicide rates across selected WHO regions and Nigeria.
2. Analyze gender disparities in suicide mortality using gender gap and gender ratio measures.
3. Compare suicide patterns between Nigeria and selected global regions.
4. Forecast future suicide trends using ARIMA time series models.

III. LITERATURE REVIEW

Suicide has been widely studied from sociological, psychological, demographic, and epidemiological perspectives. Existing literature shows that suicide is a multifactorial phenomenon influenced by social integration, economic conditions, demographic transitions, and public health systems.

The sociological perspective emphasizes that suicide is shaped by broader societal conditions rather than purely individual behavior. Empirical studies have demonstrated that social transformation, modernization, and economic instability significantly influence suicide patterns over time. Studies conducted in Eastern Europe, for instance, revealed substantial shifts in suicide mortality following political and socioeconomic transitions.

Recent global studies have increasingly focused on spatiotemporal analysis of suicide mortality. Rotejanaprasert et al. (2020) reported a gradual global decline in suicide rates between 2000 and 2019 but identified persistent regional disparities and high-risk clusters. Similarly, Sha et al. (2024) observed that suicide mortality differs considerably across socioeconomic groups, age categories, and genders, with males generally recording higher suicide rates than females.

Research within Africa remains relatively limited because of poor mortality surveillance systems and underreporting. Van Der Walt et al. (2023) found that although suicide mortality across Africa remained relatively stable over time, substantial subregional and gender disparities persisted. The study also highlighted the uncertainty associated with suicide statistics in many African countries.

Several studies further emphasize the role of external crises and societal shocks in shaping suicide dynamics. Ha (2024) argued that suicide patterns during disasters and crises may either increase, decrease, or fluctuate depending on the resilience and social structure of affected populations.

Despite these contributions, many previous studies remain limited by their reliance on descriptive methods and the absence of predictive modelling. Few studies adequately explore the evolution of gender disparities over time or apply time series forecasting techniques to project future suicide trends. Additionally, Nigeria remains underrepresented in existing literature due to persistent data limitations.

This study addresses these gaps by integrating time series analysis, gender inequality metrics, volatility analysis, and ARIMA forecasting within a comparative regional framework that includes Nigeria.

IV. METHODOLOGY

This study adopted a quantitative longitudinal research design to examine temporal trends, gender disparities, and future projections of suicide rates across selected WHO regions and Nigeria between 2000 and 2021. The analysis relied entirely on secondary data obtained from the World Bank Open Data platform, using suicide mortality indicators compiled in collaboration with the World Health Organization.

The dataset consisted of annual suicide rates per 100,000 population for males, females, and total population across selected WHO regions and Nigeria. Additional variables were constructed to support the analysis, including gender gap, gender ratio, and logarithmic gender ratio measures. The gender gap was computed as the difference between male and female suicide rates, while the gender ratio measured the relative disparity between male and female mortality.

Data preparation and analysis were conducted using Python within a Jupyter Notebook environment. The datasets were cleaned, merged, and transformed into a structure suitable for time series analysis. Missing observations and inconsistencies were addressed to ensure data reliability and consistency across regions. Descriptive statistics were first applied to summarize suicide patterns across regions and genders. The mean suicide rate was used to compare overall suicide levels between regions, while standard deviation was employed to assess volatility and stability over time. Trend analysis was performed using correlation analysis between time and suicide rates in order to determine the direction and strength of temporal changes. Positive correlation values indicated increasing trends, while negative values represented declining suicide patterns over time. Gender inequality analysis focused on both absolute and relative measures of disparity. The study employed gender gap and gender ratio indicators to evaluate differences between male and female suicide rates across regions and over time.

To examine temporal dynamics and generate future projections, time series analysis was conducted using the Autoregressive Integrated Moving Average (ARIMA) framework. Stationarity of the series was assessed through graphical inspection and differencing procedures. Since the original suicide rate series exhibited non-stationary behaviour, differencing was applied until stationarity was achieved. The general ARIMA forecasting model used in the study is expressed as:

$$Y_t = c + \sum_{i=1}^p \phi_i Y_{t-i} + \sum_{j=1}^q \theta_j \varepsilon_{t-j} + \varepsilon_t$$

where Y_t represents the suicide rate at time t , c is a constant term, ϕ_i represents autoregressive coefficients, θ_j denotes moving average coefficients, and ε_t is the error term.

Several ARIMA models were evaluated using Akaike Information Criterion (AIC), Bayesian Information

Criterion (BIC), residual diagnostics, and forecasting stability. Based on these criteria, the ARIMA(0,2,2) model was selected as the most suitable forecasting model for Nigeria's suicide rate series.

Diagnostic checking was performed to ensure model adequacy. Residual plots and autocorrelation diagnostics were examined to confirm that the residuals behaved like white noise and that the model adequately captured the structure of the data.

Forecasts were generated up to the year 2030 to provide insight into possible future suicide patterns if current trends persist. Graphical visualization techniques, including trend plots and comparative regional charts, were also used throughout the analysis to improve interpretation and presentation of findings. All statistical analyses were performed using Python libraries including Pandas, NumPy, Matplotlib, and Statsmodels. Since the study relied exclusively on publicly available secondary data, no ethical risks involving human participants or confidential information were present.

V. RESULTS PRESENTATION

Using the equations as displayed in chapter three, the empirical findings of the study based on the analysis of the suicide rates across selected region including Nigeria, over the period 2000–2021 (Dataset at the Appendix) is as;

3.1 Descriptive Overview of Suicide Rates

Table 1: Mean Suicide Rates and Gender Gap Across Regions (2000–2021) of Suicide mortality rate, male (per 100,000 male population)

Region	Male Rate	Female Rate	Total Rate	Gender Gap
Africa	10.23638	3.232918	13.4693	7.003462
Eastern Mediterranean	3.43565	1.899472	5.335122	1.536179
Europe	27.16837	6.871463	34.03983	20.29691
Nigeria	8.095	1.665455	9.760455	6.429545
South-East Asia	15.41976	12.21145	27.6312	3.208311
Western Pacific	12.29749	8.126355	20.42384	4.171132

To establish a foundational understanding of the data, the mean suicide rates across regions were computed. The mean provides a summary measure of the general level of suicide within each region over the study period.

The results reveal substantial variation in suicide rates across regions. Europe records the highest average

total suicide rate at 34.04, significantly exceeding all other regions. This is accompanied by a large gender gap of 20.30, indicating that male suicide rates are markedly higher than female rates in the region.

South-East Asia follows with a relatively high mean total rate of 27.63, although the gender gap is considerably smaller at 3.42, suggesting a more balanced distribution between males and females. In contrast, the Eastern Mediterranean region records the lowest average total rate of 5.34, reflecting comparatively lower suicide prevalence.

Nigeria presents a different profile. While its mean total suicide rate of 9.76 is lower than most regions, the gender gap of 6.43 indicates a notable disparity between male and female suicide rates. This suggests that even in regions with lower overall rates, gender inequality remains pronounced.

These observed differences are consistent with global patterns reported by the World Health Organization (2014), which emphasizes significant regional and gender variations in suicide mortality.

3.2 Time Series Analysis of Suicide Rates

Understanding how suicide rates evolve over time is central to this study. This section addresses the first research question by examining temporal patterns using both graphical and statistical methods.

3.2.1 Trend Visualization Across Key Indicators

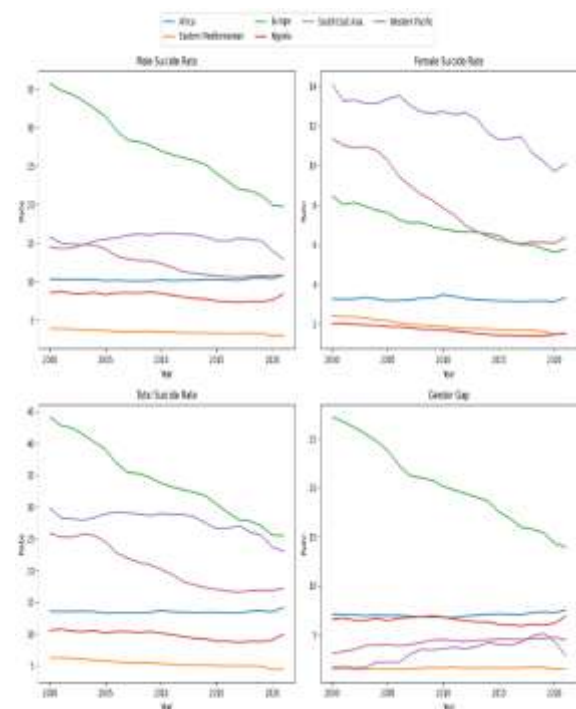


Fig 1 Combined Time Series Plot of Male Rate, Female Rate, Total Rate, and Gender Gap (2000–

2021) of Suicide mortality rate, male (per 100,000 male population)

The trend visualization presents four key indicators simultaneously: male suicide rate, female suicide rate, total suicide rate, and gender gap. This combined representation provides a comprehensive view of how suicide dynamics evolve over time within each region. A clear pattern emerges from the visualization. Across most regions, the male suicide rate consistently exceeds the female rate, which directly drives the observed gender gap. The total suicide rate closely follows the movement of the male rate, reflecting the dominant contribution of male suicides to overall mortality.

Over time, many regions exhibit a gradual decline in total suicide rates, particularly in Europe and the Eastern Mediterranean. This decline is mirrored in both male and female rates, although the reduction is more pronounced among males. Consequently, in some regions, the gender gap shows signs of narrowing, while in others it remains relatively stable. Nigeria follows a more stable trajectory. Both male and female rates show limited fluctuations over time, resulting in a relatively steady total rate. However, the gender gap remains consistently visible, indicating persistent inequality despite overall stability.

The inclusion of all four indicators in a single visualization is particularly useful, as it allows for simultaneous assessment of level, trend, and disparity. This aligns with the study's objective of moving beyond isolated analysis toward a more integrated understanding of suicide patterns.

3.2.2 Trend Direction Analysis

Table 2: Correlation Between Year and Total Suicide Rate of Suicide mortality rate, male (per 100,000 male population)

Region	Correlation (Year vs Total Rate)
Africa	0.255927132
Eastern Mediterranean	-0.974072323
Europe	-0.992136246
Nigeria	-0.992136246
South-East Asia	-0.785888771
Western Pacific	-0.955866868

To complement the visual analysis, the correlation between time (year) and total suicide rate was computed to quantify the direction of trends.

The results show strong negative correlations for several regions. Europe exhibits a correlation of -0.992, while Nigeria records -0.992, indicating a very strong downward trend in suicide rates over time. Similarly, the Eastern Mediterranean region shows a strong negative correlation of -0.974, confirming a consistent decline.

In contrast, Africa shows a weak positive correlation of 0.256, suggesting a slight upward movement, although the trend is not strong.

These findings indicate that suicide rates are not static but evolve significantly over time. Consequently, the null hypothesis that there is no significant trend in suicide rates is rejected.

3.3 Trend Refinement and Variability Analysis

While the raw time series provides an initial understanding of suicide patterns, it may obscure underlying long-term movements due to short-term fluctuations. To address this, the study refines the trend analysis using smoothing techniques and evaluates the variability of suicide rates across regions.

3.3.1 Smoothed Trend Analysis Using Moving Averages

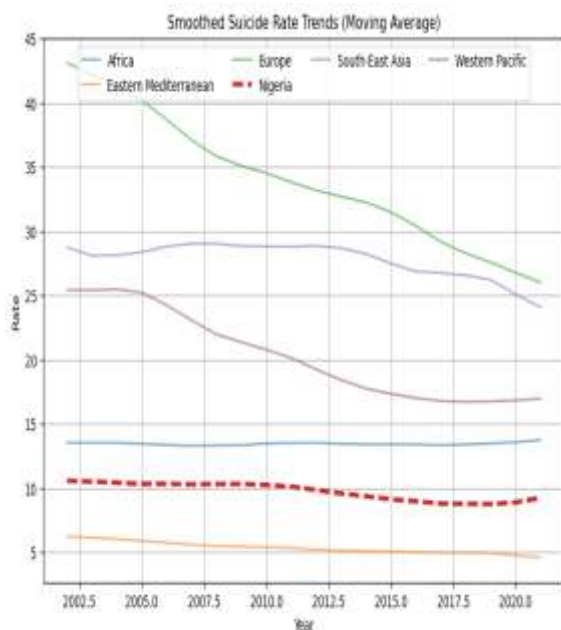


Fig 2: Smoothed Suicide Rate Trends Across Regions Using Moving Average (2000–2021) of Suicide mortality rate, male (per 100,000 male population)

The moving average plot presented in Figure 2 provides a refined visualization of long-term suicide trends by reducing short-term fluctuations in the data. The smoothing process makes it easier to observe the underlying trajectory of suicide rates across the selected regions and Nigeria.

A major pattern observed from the figure is the general downward movement in suicide rates across most regions over the study period. Europe maintains the highest suicide rate throughout the period but also exhibits one of the most noticeable declines, decreasing steadily from values above 43 in the early 2000s to approximately 26 by 2021. This suggests a substantial long-term reduction in suicide mortality within the region.

South-East Asia also records relatively high suicide rates (mean of 15.41976) but follows a consistent declining trend over time. The gradual reduction observed in the region indicates sustained improvement rather than short-term fluctuation.

The Eastern Mediterranean region consistently records the lowest suicide rates across the study period, with only mild variations over time. This reflects a relatively stable pattern compared with other regions. Nigeria, represented by the red dashed line, displays a distinct trajectory. Unlike regions with steep declines, Nigeria's suicide rate remains comparatively stable throughout the period, fluctuating within a narrow range around 9 to 10.5, indicating that the economy relatively was not improved to lower suicide rate. Although a slight decline is visible between 2012 and 2018, the trend begins to stabilize again toward the later years.

The smoothed trends therefore reveal two important insights. First, while several regions are experiencing long-term reductions in suicide rates, the pace and magnitude of decline vary substantially across regions. Second, Nigeria demonstrates relative stability rather than significant decline, suggesting that suicide patterns in the country may be more persistent over time.

The moving average approach is particularly valuable in this study because it allows long-term structural patterns to become more visible, thereby improving the interpretation of temporal changes in suicide mortality.

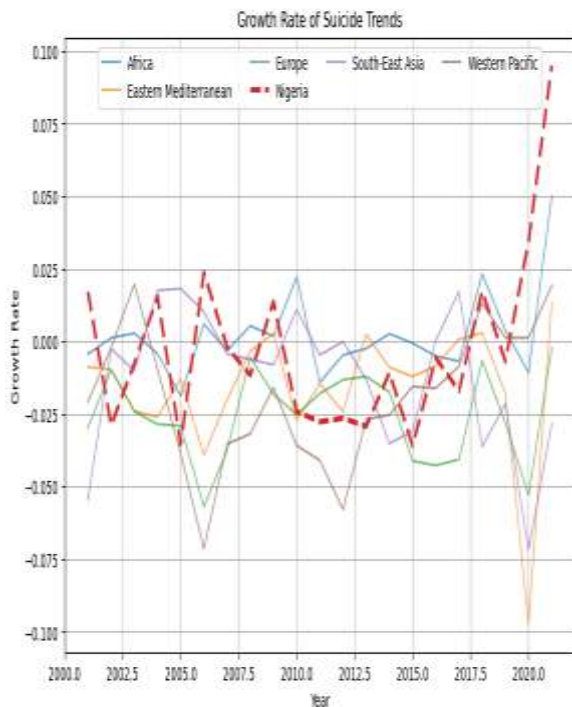


Fig 3: Smoothed Comparison of Regional Suicide Trends of Suicide mortality rate, male (per 100,000 male population)

The moving average technique is employed to smooth out irregular fluctuations and highlight the underlying trajectory of suicide rates. This is particularly important in time series analysis, where short-term variations can distort the perception of long-term patterns.

The smoothed results reinforce the patterns observed in the raw data but provide greater clarity. In Europe, the moving average reveals a steady and sustained decline, confirming that the observed downward trend is not driven by temporary fluctuations but represents a consistent long-term reduction. A similar pattern is observed in the Eastern Mediterranean region, where the decline appears gradual but persistent.

In contrast, Africa displays a relatively flat smoothed trajectory, indicating that despite minor year-to-year changes, there is no strong long-term movement in suicide rates. This aligns with the weak positive correlation earlier observed.

Nigeria presents a distinct pattern. The smoothed trend shows minimal deviation over time, reinforcing the earlier observation of stability. However, the absence of significant decline suggests that progress in reducing suicide rates has been limited.

The use of moving averages in this context strengthens the reliability of trend interpretation by confirming whether observed changes are structural or merely random variations.

3.3.2 Variability and Stability of Suicide Rates

Table 3: Standard Deviation of Suicide Rates by Region of Suicide mortality rate, male (per 100,000 male population)

Region	STD
Africa	0.188929
Eastern Mediterranean	0.530538
Europe	5.763111
Nigeria	0.699962
South-East Asia	1.77686
Western Pacific	3.565644

To complement the trend analysis, the study examines the variability of suicide rates using standard deviation. This provides insight into the stability of suicide patterns over time.

The results indicate substantial differences across regions. Europe records the highest level of variability, with a standard deviation of 5.76, suggesting that although the general trend is downward, the path of decline involves notable fluctuations. This reflects a dynamic pattern where periods of rapid decline may be interspersed with temporary increases.

Nigeria, by contrast, records a relatively low standard deviation of 0.70, indicating a high degree of stability in suicide rates over the study period. While stability might initially appear desirable, in this context it also suggests a lack of significant improvement, as rates remain relatively unchanged over time.

Africa exhibits the lowest variability, with a standard deviation of 0.19, pointing to an almost constant pattern of suicide rates. This reinforces the earlier observation of a weak trend direction.

These findings highlight an important dimension of suicide analysis: regions differ not only in their levels and trends but also in the degree of fluctuation, which has implications for monitoring and intervention strategies.

3.4 Gender Disparities in Suicide Rates

This section addresses the second objective of the study by examining the magnitude and evolution of gender differences in suicide rates across regions.

3.4.1 Magnitude of Gender Disparity

Table 4: Mean Gender Gap Across Regions (2000–2021) of Suicide mortality rate, male (per 100,000 male population)

Region	Mean
Africa	7.003462
Eastern Mediterranean	1.536179
Europe	20.296906
Nigeria	6.429545
South-East Asia	3.208311
Western Pacific	4.171132

The gender gap provides a direct measure of disparity between male and female suicide rates. The results reveal that gender differences are substantial across all regions, although the magnitude varies significantly. Europe exhibits the largest gender gap, with an average value of 20.30, indicating that male suicide rates exceed female rates by a wide margin. This aligns with the earlier observation that Europe also has the highest overall suicide rates.

Africa and Nigeria show moderate levels of disparity, with gender gaps of 7.00 and 6.43, respectively. While these values are lower than those observed in Europe, they still represent meaningful differences, highlighting the persistent dominance of male suicide rates.

The Eastern Mediterranean region records the lowest gender gap at 1.54, suggesting a more balanced distribution between male and female suicide rates.

These results confirm that gender disparity is a universal feature of suicide patterns, consistent with global evidence reported by the World Health Organization (2014).

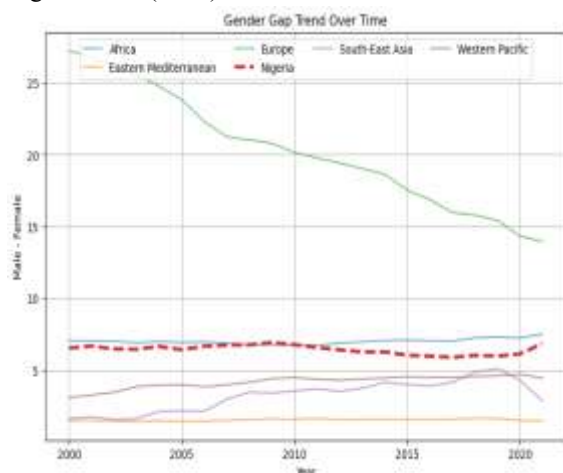


Fig 4: Trend in Gender Inequality Using Male-to-Female Suicide Ratio (2000–2021) of Suicide mortality rate, male (per 100,000 male population)

Figure 4 presents the evolution of gender inequality in suicide rates across the selected regions using the male-to-female suicide ratio. The ratio measures the extent to which male suicide rates exceed female suicide rates over time. A value greater than 1 indicates higher male suicide rates relative to females, while larger values represent wider gender disparities. A major pattern evident from the figure is that male suicide rates consistently exceed female rates across all regions throughout the study period. However, the magnitude and direction of inequality vary substantially across regions.

Nigeria, represented by the red dashed line, records the highest and most rapidly increasing gender ratio over the study period. The ratio rises from approximately 4.3 in 2000 to above 5.5 by 2021, indicating that male suicide rates became increasingly dominant relative to female rates over time. This suggests a widening gender disparity in Nigeria despite the relatively stable overall suicide rate observed earlier.

Africa also demonstrates a persistently high gender ratio, although the trend shows a gradual decline over time, moving from values slightly above 4.2 toward approximately 3.4 by the end of the study period. This indicates that while male suicide rates remain considerably higher than female rates, the disparity may be narrowing within the broader African region. Europe maintains a relatively stable ratio around 3.2 to 3.4, suggesting that although the region records high suicide rates overall, the proportional difference between males and females changes only moderately over time.

The Eastern Mediterranean region records the lowest ratios throughout the study period, remaining close to 1.1–1.5, which indicates comparatively smaller gender differences in suicide rates.

An important implication of this figure is that changes in overall suicide rates do not necessarily correspond to reductions in gender inequality. Some regions may experience declining suicide rates while simultaneously maintaining or even increasing gender disparities.

The use of the male-to-female ratio in this study therefore provides an important analytical dimension by capturing relative inequality rather than relying solely on absolute suicide levels. This aligns with the broader objective of the study to move beyond

descriptive suicide statistics toward a more comprehensive understanding of gender dynamics in suicide mortality.

3.4.2 Temporal Evolution of Gender Disparity

Table 5: Correlation Between Year and Gender Gap of Suicide mortality rate, male (per 100,000 male population)

Region	Correlation (Year vs Total Rate)
Africa	0.724635392
Eastern Mediterranean	0.972364284
Europe	-0.978419538
Nigeria	0.95279994
South-East Asia	0.91121922
Western Pacific	0.974638427

Beyond measuring the magnitude of inequality, it is important to examine how gender disparities evolve over time. This is achieved through correlation analysis between year and gender gap.

The results indicate that in most regions, gender disparity is increasing over time, as evidenced by positive correlation values. This suggests that the difference between male and female suicide rates is widening, even in regions where overall suicide rates may be declining.

Europe presents a contrasting pattern, with a negative correlation, indicating a gradual reduction in gender disparity. This suggests that while overall suicide rates are declining, the reduction may be more pronounced among males than females.

These findings provide clear evidence against the null hypothesis of no gender disparity, confirming that gender differences are both significant and dynamic.

3.4.3 Nigeria in the Regional Context

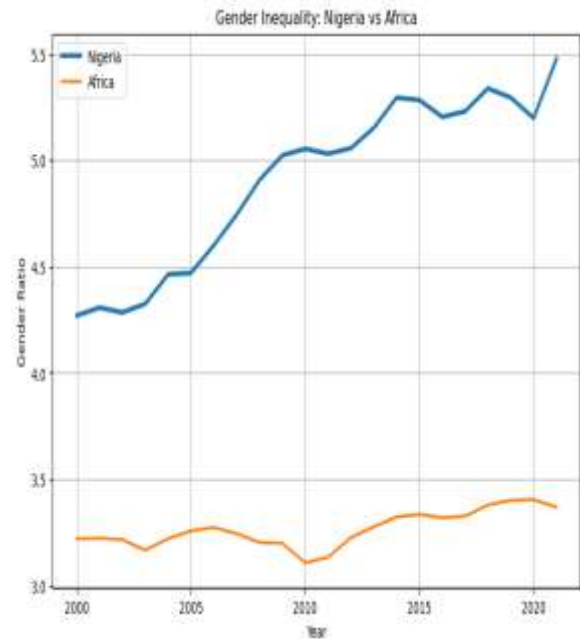


Fig 5: Comparative Trend of Gender Gap – Nigeria vs Africa of Suicide mortality rate, male (per 100,000 male population)

To provide contextual insight, Nigeria is compared with the broader African region. The results show that Nigeria largely follows the regional pattern, but with slightly greater stability in its gender gap over time.

While Africa exhibits mild fluctuations, Nigeria's gender disparity remains relatively consistent. This suggests that the factors driving gender differences in Nigeria may be more stable or deeply rooted.

This comparison highlights the importance of examining country-specific patterns within broader regional trends.

3.5 Forecasting of Suicide Rates

Forecasting analysis was conducted to project the future direction of suicide rates in Nigeria beyond the observed study period. This aspect of the study is important because it extends the analysis from historical description to predictive evaluation, thereby providing insight into the possible future burden of suicide mortality if existing patterns persist.

Time series forecasting was implemented using the Autoregressive Integrated Moving Average (ARIMA) modelling framework. The ARIMA approach was adopted because of its suitability for modelling longitudinal data characterized by temporal dependence and evolving trends. According to Obi and Chukwura (2022), ARIMA models are widely used in forecasting because they effectively capture both trend structure and random fluctuations within time-dependent datasets.

3.5.1 Model Identification and Selection

3.5.1.1 Differencing the data

Table 6: Results of unit root test indicating transformation of Nigerian Total Rate to stationarity through differencing

Statistic	Raw data	First Differencing	Second Differencing
Pvalue	0.2638	0.940490488	3.49E-10

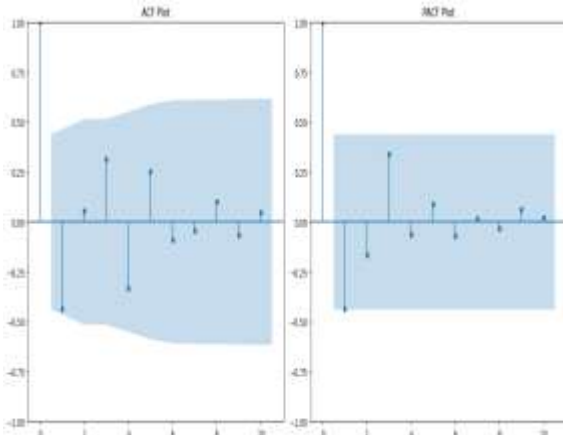


Fig 6: Autocorrelation and Partial Autocorrelation Analysis of the Second-Differenced Time Series of Suicide mortality rate, male (per 100,000 male population)

The results show that the raw data and first differenced series are not statistically significant at the 5% level, indicating non-stationarity. However, the second differenced series yields a highly significant p-value

3.5.2 Estimated ARIMA Model

Table 8: Estimation Results and Diagnostic Summary of the ARIMA(0,2,2) Model for Nigeria Total Rate Time Series of Suicide mortality rate, male (per 100,000 male population)

Dep. Variable:	Total Rate	No. Observations:	22			
Model:	ARIMA(0, 2, 2)	Log Likelihood	0.035			
Date:	Mon, 11 May 2026	AIC	5.930			
Time:	22:27:31	BIC	8.917			
Sample:	0	HQIC	6.513			
	- 22					
Covariance Type: opg						
	coef	std err	z	P> z	[0.025	0.975]
ma.L1	-0.7793	4.505	-0.173	0.863	-9.609	8.051
ma.L2	0.9952	10.991	0.091	0.928	-20.547	22.537
sigma2	0.0458	0.512	0.089	0.929	-0.958	1.049
Ljung-Box (L1) (Q):		0.02	Jarque-Bera (JB):	0.98		
Prob(Q):		0.90	Prob(JB):	0.61		

(3.49×10^{-10}), suggesting that stationarity is achieved only after second-order differencing. Following this, the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) patterns were examined to identify suitable autoregressive and moving average components.

3.5.1.2 Best Model Estimation

Table 7: Model Selection Results for ARIMA Using AIC, BIC, and HQIC Criteria

ARIMA Order	AIC	BIC	HQIC
(0, 2, 2)	5.930274	8.917471	6.513406
(2, 2, 1)	7.727756	11.710685	8.505265
(1, 2, 2)	7.855148	11.838077	8.632658
(2, 2, 2)	8.914999	13.893661	9.886886
(0, 2, 1)	10.354024	12.345488	10.74278
(1, 2, 1)	11.249076	14.236272	11.83221

Several candidate ARIMA models were considered during the modelling process, and model adequacy was evaluated using standard selection criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Hannan–Quinn Information Criterion.

The ARIMA (0,2,2) model was ultimately selected as the most appropriate forecasting model because it produced the best overall diagnostic performance and adequately captured the underlying temporal structure of the suicide rate series.

Heteroskedasticity (H):	1.48	Skew:	0.51
Prob(H) (two-sided):	0.62	Kurtosis:	2.65

The estimated model incorporates two moving-average lag components, which account for random shocks and short-term irregularities in the suicide rate series.

The model fit statistics further support the adequacy of the selected model. The Akaike Information Criterion (AIC) value of 5.930 and Bayesian Information Criterion (BIC) value of 8.917 indicate an acceptable balance between model fit and complexity.

3.5.3 Diagnostic Evaluation of the ARIMA Model

After model estimation, diagnostic tests were conducted to assess whether the residuals satisfied the assumptions of white noise behaviour. This stage is important because reliable forecasting requires residuals that are random and free from systematic structure.

The Ljung–Box statistic (Table 4.8) produced a probability value of 0.90, which is substantially greater than the 0.05 significance level. This indicates that the residuals do not exhibit significant autocorrelation and are therefore independently distributed.

Similarly, the Jarque–Bera probability (Table 4.8) value of 0.61 suggests that the residuals are approximately normally distributed. The heteroskedasticity test also produced a non-significant result with a probability value of 0.62, indicating stable variance across the residual series.

Collectively, these diagnostic measures confirm that the ARIMA(0,2,2) model adequately captures the structure of the data and is statistically suitable for forecasting future suicide rate

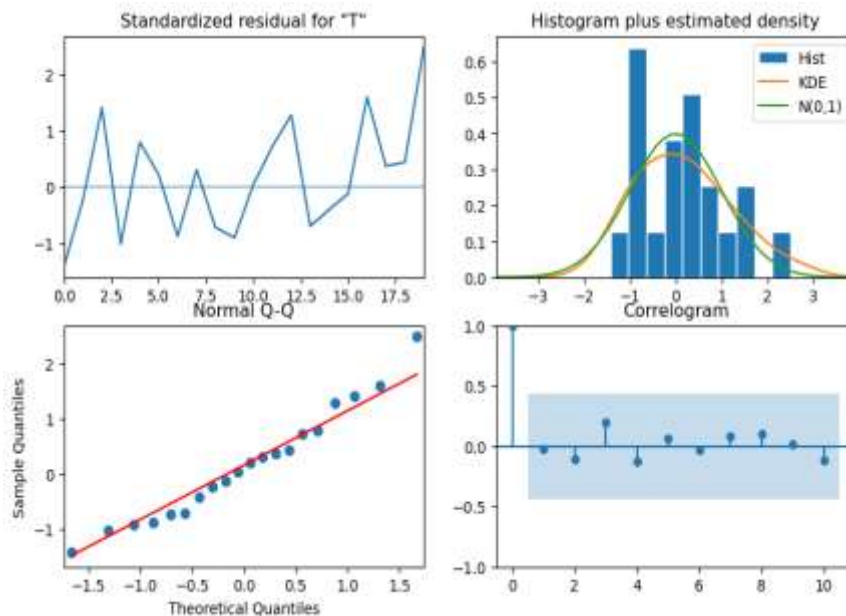


Fig 6: Diagnostic Plots of the ARIMA(0,2,2) Model of Suicide mortality rate, male (per 100,000 male population)

The diagnostic plots generated from the model reveal that the residuals are randomly distributed around zero with no visible trend, clustering, or systematic movement. This randomness suggests that the model has effectively accounted for the temporal structure present in the suicide rate series.

The residual time plot further demonstrates that the residual values fluctuate irregularly around the mean

without exhibiting persistent upward or downward movement. Such behaviour is characteristic of white noise processes and indicates that the remaining errors are largely random rather than structurally related.

Collectively, the residual diagnostics confirm that the ARIMA(0,2,2) model satisfies the major assumptions required for reliable forecasting. The absence of significant autocorrelation, the approximate normality

of residuals, and the stability of variance all indicate that the model adequately captures the underlying dynamics of the suicide rate series.

Therefore, the forecasts generated from the model can be considered statistically reliable and suitable for projecting future suicide trends in Nigeria.

3.5.4 Forecast of Suicide Rates for Nigeria (2022–2030)

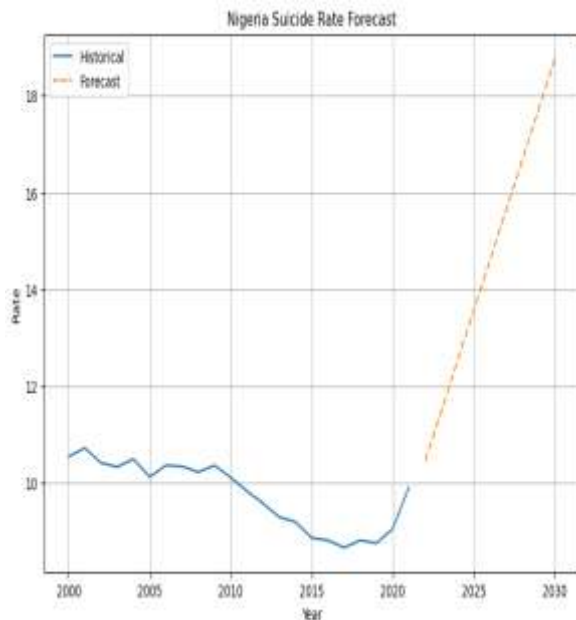


Figure 7: Forecasted Suicide Rates for Nigeria of Suicide mortality rate, male (per 100,000 male population)

The ARIMA (0,2,2) model was used to generate forecasts for Nigeria's suicide rates up to the year 2030. The projections indicate a relatively stable trajectory, with a slight downward tendency.

The absence of sharp increases suggests that suicide rates in Nigeria are unlikely to escalate significantly in the near future. However, the lack of a strong downward trend also implies that substantial reductions may not occur without targeted interventions.

This finding is particularly important in the context of policy planning, as it suggests that current conditions are likely to persist.

3.5.5 Implications of Forecasting Results

The forecasting results provide insight into the likely future direction of suicide rates. While global trends indicate declining rates in several regions, Nigeria appears to be characterized by stability rather than significant improvement.

This supports the rejection of the null hypothesis that time series models do not improve prediction, as the ARIMA model provides meaningful and interpretable projections.

3.6 Summary of Empirical Findings

The analysis reveals several important patterns. Suicide rates vary significantly across regions, with Europe recording the highest levels and the Eastern Mediterranean the lowest. Most regions exhibit declining trends over time, although the rate of decline differs.

Gender disparity is consistently observed, with male suicide rates exceeding female rates across all regions. In many cases, this disparity is increasing, highlighting the need for gender-sensitive interventions.

Nigeria presents a unique profile characterized by moderate suicide rates, relatively low variability, and persistent gender inequality. Forecasting results suggest that these patterns are likely to continue in the near future.

VI. DISCUSSION, CONCLUSION, AND IMPLICATIONS

This study examined suicide rates across selected WHO regions and Nigeria between 2000 and 2021, with emphasis on temporal trends, gender disparities, variability, and forecasting behaviour. The findings demonstrate marked regional differences in suicide dynamics, as well as persistent structural patterns that cut across time and geography.

The analysis revealed that suicide trends vary significantly across regions. Europe recorded the highest suicide rates at the beginning of the study period but experienced a steady long-term decline. This pattern is consistent with global evidence suggesting that improved mental health awareness, stronger healthcare systems, and targeted suicide prevention strategies have contributed to reductions in mortality in several high-income regions (World Health Organization, 2014; Rotejanaprasert et al., 2024). South-East Asia also exhibited a general downward trend, although early years were characterized by noticeable fluctuations.

In contrast, the Eastern Mediterranean region maintained relatively low and stable suicide rates throughout the study period. However, existing literature suggests that these estimates may be

influenced by underreporting due to sociocultural stigma and legal constraints surrounding suicide reporting in some countries (Malakouti et al., 2014). Nigeria, on the other hand, displayed a relatively stable suicide pattern with minimal fluctuations and no clear downward trajectory. This stability suggests the persistence of underlying structural risk factors such as limited mental health infrastructure, socioeconomic stressors, and weak surveillance systems.

A key finding of the study is the consistent gender disparity in suicide rates across all regions. Males recorded significantly higher suicide rates than females throughout the period of analysis. In Europe, this gap was particularly pronounced, while Nigeria also exhibited a widening male-to-female suicide ratio, which increased over time. By 2021, the disparity had become more pronounced, indicating growing male vulnerability. This pattern aligns with global evidence that males are disproportionately affected by completed suicide due to a combination of behavioral, cultural, and socioeconomic factors, including lower help-seeking behavior, substance use, and societal expectations surrounding masculinity (World Health Organization, 2014; Sha et al., 2024).

The analysis of variability further revealed important differences in the stability of suicide trends across regions. Europe exhibited relatively high volatility despite an overall downward trend, suggesting that improvements were not linear but influenced by periodic social and economic changes. South-East Asia also displayed fluctuations in earlier years before stabilizing. Nigeria, however, showed low variability, indicating a persistent and relatively unchanged suicide pattern over time. Rather than reflecting improvement, this stability likely indicates entrenched structural conditions that have not significantly changed over the study period.

Forecasting analysis using the ARIMA(0,2,2) model provided additional insight into the future trajectory of suicide rates in Nigeria. Diagnostic tests confirmed the adequacy of the model, with residuals exhibiting randomness and no significant autocorrelation. Forecast results suggest that suicide rates are likely to remain relatively stable up to 2030, with only a mild downward trend. This implies that without deliberate policy intervention, substantial reductions in suicide mortality are unlikely in the near future. The findings underscore the importance of integrating predictive

modelling into public health planning, particularly for mental health surveillance and prevention strategies.

Overall, the findings highlight that suicide is a complex and multidimensional public health issue shaped by temporal, regional, and demographic factors. While some regions have made measurable progress in reducing suicide rates, others—particularly low- and middle-income contexts—continue to experience stagnation. Gender inequality remains a dominant and consistent feature of suicide mortality worldwide, with males disproportionately affected across all settings.

The study contributes to existing literature by extending traditional descriptive approaches through the integration of time series forecasting, variability analysis, and gender-based inequality measures. This provides a more comprehensive understanding of suicide dynamics and offers predictive insight into future trends, particularly for Nigeria.

From a policy perspective, the findings emphasize the urgent need for strengthened mental health systems, improved suicide surveillance, and targeted interventions addressing male vulnerability. Public health strategies should also focus on reducing stigma associated with mental illness and encouraging early help-seeking behavior. Furthermore, the incorporation of predictive analytics into national health planning is essential for anticipating future risks and allocating resources effectively.

In conclusion, suicide trends between 2000 and 2021 reveal both progress and persistent challenges. While global declines are evident in some regions, others continue to experience stagnation and inequality in outcomes. Without sustained and targeted intervention, particularly in resource-limited settings, suicide is likely to remain a stable but significant public health burden.

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