STEM Fellowship Inter-University Big Data Challenge 2022

Time Trends and Predictions of Mental Health and Suicide Rates Based on Socioeconomic Indicators From 2000 to 2019

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July 4, 2022

Abstract

Suicide poses a significant health problem worldwide. Most suicides are related to mental health disorders, a critical factor in national economies. Yet national health systems are frequently under-resourced and inefficient, resulting in an imbalance between health expenditures and mental illness burdens. Although suicide rates are highly correlated to mental disorders, there is no direct link between suicide rates and economic status. Thus, the objectives of this report are (1) to investigate the trends and correlations of socioeconomic factors on mental health and suicide rates across different income groups and (2) to project suicide rates and mental disease burdens up to 2030. Using data from the World Bank, Global Burden of Disease 2019, and World Health Organization database from 2000 to 2019, we presented and compared the trends and patterns of economic growth, suicide rates, and mental health for all income groups. Our analysis used DBA k-means clustering to estimate the associations among socioeconomic indicators, mental health illness, and suicide rates. We used the ARIMA model to provide predictions. Our findings reveal the influence of social factors such as unemployment rates on mental health and suicide rates worldwide. Besides, the projections for mental disorders burden during the next decade do not seem to be an encouraging trend except for high-income countries. Our results represent appropriate starting points for governments to adopt more comprehensive interventions and practical strategies to reduce suicide rates and eventually bridge the gap to the 2030 Sustainable Development Goals.

Keywords Socioeconomic indicators, Mental health, Suicide rate

1 Introduction

The role of economic factors on mental health and well-being has been stud-

ied for decades. Several efforts have been made to quantify the impact of the social (income, unemployment) and economic (per capita financial income growth, health expenditure) determinants relative to other influences such as suicide rate and mental health [1]. The evidence suggests that recessions have damaging effects on many health indicators, particularly suicide [2]. Nearly one billion people worldwide suffer from mental health illnesses [3], with 81% of them living in low-income and lower-middle-income countries. Mental Health Atlas [4] showed that in 2020, governments spent slightly over 2% of their health budget on mental health.

Although the available data do not show an increase in suicide rates during the first months of the COVID-19 crisis, the pandemic has severely impacted people's mental health and well-being worldwide. According to the WHO Sustainable Development Goals (SDG) Progress Report in 2022, the global suicide death rate decreased by 29% from 13.0 deaths per 100,000 population in 2000 to 9.2 deaths in 2019. However, there was a massive increase (25%) in the prevalence of anxiety and depression worldwide [5] due to the COVID-19 crisis. As an indicator of the SDGs, the suicide rate should be reduced by one third from non-communicable diseases through prevention and treatment to promote mental health and well-being by 2030 [5].

The effect of socioeconomic factors has been noted in the suicidal behavior [6]. A systematic review of population level studies revealed associations between poverty and suicide rates [7]. According to previous studies, suicide rates are rising in conjunction with unemployment rates [8], [9].

In this study, we aim to answer the following questions: (1) How do socioeconomic factors influence mental health and suicidal behavior? (2) Given the current suicide rates and mental health disorders trends, what are the predicted trends in the next decade? To answer these questions, we first analyzed the influences of socioeconomic factors such as GDP, income, health expenditure, and unemployment on mental health and suicidal behavior on a global scale. Then, we described how suicide rates and the burden of individual mental disorders have changed from 2000 to 2019 in different income groups. Finally, we projected the trends from 2020 to 2030, using historical data from 2000 to 2019.

2 Materials & Methods

2.1 Data source and data extraction

We collected open-source data on annual GDP current, GDP per capita, unemployment rate, suicide rate, mental health disorders, health expenditure (%GDP), and health expenditure per capita for 193 countries of WHO from multiple sources listed in Table 1 [10], [11], [12]. Since collected data did not form a regular time series, we decided to extract and collate all collected data from 165 members of WHO from 2000 to 2019 for further analysis. We then separated our dataset into two final datasets: one grouped by country and the other by income group, based on the threshold of GNI per capita according to WHO [13]. For this study, we used the dataset by income group for clustering purposes, and forecasting, while the detailed dataset grouped by country for analyzing trends and visualizing various attributes of suicide such as mental health disorders, GDP per capita, and unemployment rate, etc.

Table 1: Data source

Source	Data
World Health Organization Database	Health expenditure (%GDP, and per capita)
	Suicide rate by country and income (per 100, 000 population)
Global Burden of Disease 2019 (GBD)	Mental disorders
	DALY - Mental disorders
	Death rates by self harms
	Mental disorders prevalence (percentage)
The World Bank Database	Unemployment (% total work force)
	GDP current and GDP per capita
	Income

2.2 Data preprocessing

When data were missing, we supplemented with additional available country-level data. We imputed the median values for 5-8 countries with unavailable data for the unemployment rate. We dropped any country with too many missing values from the analysis.

We used the `MinMaxScaler` method in the `scikit-learn.processing` library to scale some numeric features (i.e., GDP current, GDP per capita, Income, Health expenditure per capita, and Health expenditure (%GDP)) to a range of value from 0 to 1. We converted other numeric features from percentage or rate into a ratio.

2.3 Time series clustering

We performed Dynamic Time Warping (DTW) Barycenter Averaging (DBA) with three clusters on our standardized dataset to learn a mapping that links our feature of interests to a time series. Algorithm 1 describes the steps of DBA K-means clustering algorithm.

We used the `TimeSeriesKmeans` method with DTW distance metric in the `tslearn.clustering` library and changed the `np.average` with it to compare two time series $x = (x_1, ..., x_n) \in \mathbb{R}^{p*n}$, and $y = (y_1, ..., y_m) \in \mathbb{R}^{p*m}$. Given the cost matrix, $\Delta(x, y) := [\partial(x_i, y_j)]_{i,j}] \in \mathbb{R}^{n*m}$, the inner product $< A, \Delta(x, y) >$ of that matrix with an alignment matrix $A \in \mathcal{A}_{n,m}$ gives the score of A. DTW considers the costs of all possible alignment matrices as follows:

$$DTW(x, y) = \min_{A \in \mathcal{A}_{n,m}} < A, \Delta(x, y) > \quad (1)$$

We then visualized the clusters using the `matplotlib` library. Each line in the plot represents one observation in our dataset.

2.4 Statistical Method

Time-series forecasting model is one of the major analysis methods for future prediction based on past observations. We used Auto-Regressive Integrated Moving Average (ARIMA) model to predict the suicide rates and disease burden of mental health and substance use disorders based on the mean values from 2000 to 2019. The model is denoted as ARIMA(p, d, q) where p, d, q refer to the order of autoregression (AR), the degree of difference, and the order of moving average (MA) respectively. In other words, p refers to the number of lags of the stationary time series, q refers to the number of lags of the forecast errors, and d denotes the minimum number of differences needed to make the series stationary. An autoregression AR model of order p can be written as

$$z_t = c + \phi_1 z_{t-1} + \phi_2 z_{t-2} + \ldots + \phi_p z_{t-p} + e_t \quad (2)$$

A moving average MR model of order q uses past forecast errors in a regression

Algorithm 1 DBA clustering algorithm

Input: X: time series dataset, r: number of desired clusters
Output: a set of r clusters
1: Initialize r barycenters by k-means++ heuristic algorithm from X
2: **repeat**
3: Assign each sample to its nearest barycenter by calculating the DTW metric
4: Update barycenters for samples assigned to each cluster
5: **until** convergence

model as

$$z_t = c + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \ldots - \theta_q e_{t-q} \quad (3)$$

Where c is a constant, e_t is a white noise, $\phi = (\phi_1, \phi_2, \ldots \phi_p)$ is the vector of model coefficients.

Algorithm 2 shows the ARIMA model procedure. We selected the best model based on the minimum of Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values. p-value < 0.05 is considered significant. We used `auto_arima()` function from the Python package `pmdarima` to provide the parameters for our ARIMA models to forecast suicide rates and mental disorder disease burdens from 2020 to 2030. We evaluated the performance of our model based on two metrics: Root Mean Square Error (RMSE) 4 and Mean Absolute Error (MAE) 5.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i}^{n}(z_i - \hat{z}_i)^2} \quad (4)$$

$$MAE = \frac{1}{n}\sum_{1}^{n}|z_i - \hat{z}_i| \quad (5)$$

Where z_i is the actual value and $\hat{z}_i$ is the forecast value. Both MAE and RMSE can range from 0 to ∞. The lower values have better predictions.

3 Results

3.1 Global expenditure on health

Figure 1 shows the percentile distributions of global average spending on health during the past two decades. We notice a huge gap in health expenditure across countries. High health expenditure with more than ten percentiles is in North America, South Africa, and Europe. In particular, the United States (15.45%) had reported the highest percentage of health spending. In contrast, some countries in North Africa and South Asia had the lowest proportion of national income on health, such as South Sudan (1.83%) and Equatorial Guinea (2.03%). Table 2 lists the top and bottom five countries.

Figure 2 illustrates the relationship between health spending and the growth of GDP differed by income group. Health expenditure (a share of GDP) climbed in all income groups from 2000 to 2019. Nevertheless, there has been a declining trend in low- and lower-middle-income groups from 2016 to 2019. In 2019, health spending as a share of GDP ranged from 4.88% in the lower-middle-income group to 8.30% in the high-income group, while health spending accounted for 5.56% and 6.30% of GDP on average in low- and upper-middle-income group respectively.

Algorithm 2 ARIMA model

Input: Time series dataset
Output: Predicted results z_t

```
Check stationary
repeat
    Estimate model parameters
    Calculate AIC and BIC values
    Evaluate the model
until Residual graph with no lag
Calculate forecasts
```

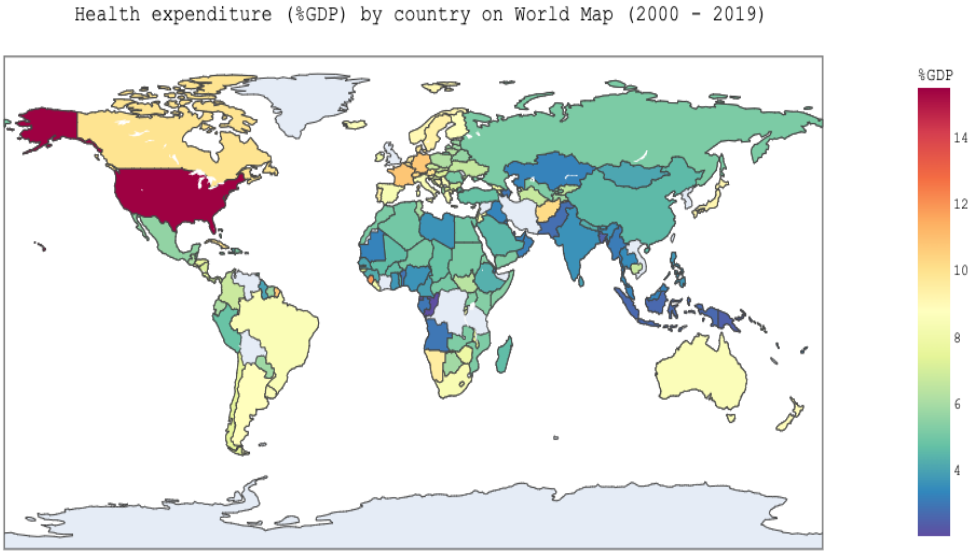

Figure 1: Health expenditure (%GDP) from 2000-2019

3.2 Global Suicide Rate from 2000-2019

Figure 3 highlights the suicide rate across different income groups in the world with two peaks; one small peak with a rising trend from 2004 to 2006 in the upper-middle-income group, and one prominent peak with an increasing trend from 2006 to 2009 in the high- and lower-middle-income groups. Over the next decade, the suicide rate has gradually decreased among all income groups.

3.3 Global prevalence of mental disorders from 2000-2019

Figure 5 (left) shows disparities in the distribution of mental and substance use disorders. Fifty times the proportion of people with mental health problems in high-income countries compared to those in low-income countries (11.95% vs. 0.24%, respectively). Similarly, as we can see in Figure 5 (right), the share of mental disorders on the total disease burden was third times as high for that in high-income countries as that in low-income countries (7.28% vs. 2.27%).

Table 2: The top five (left) and bottom five (right) countries for health expenditure a share of GDP (percentage).

Country	Health expenditure (%GDP)	Country	Health expenditure (%GDP)
United States	15.45	Bangladesh	2.49
Sierra Leone	11.88	Qatar	2.34
Zimbabwe	11.81	Congo	2.03
France	10.77	Equatorial Guniea	2.03
Germany	10.71	South Sudan	1.83

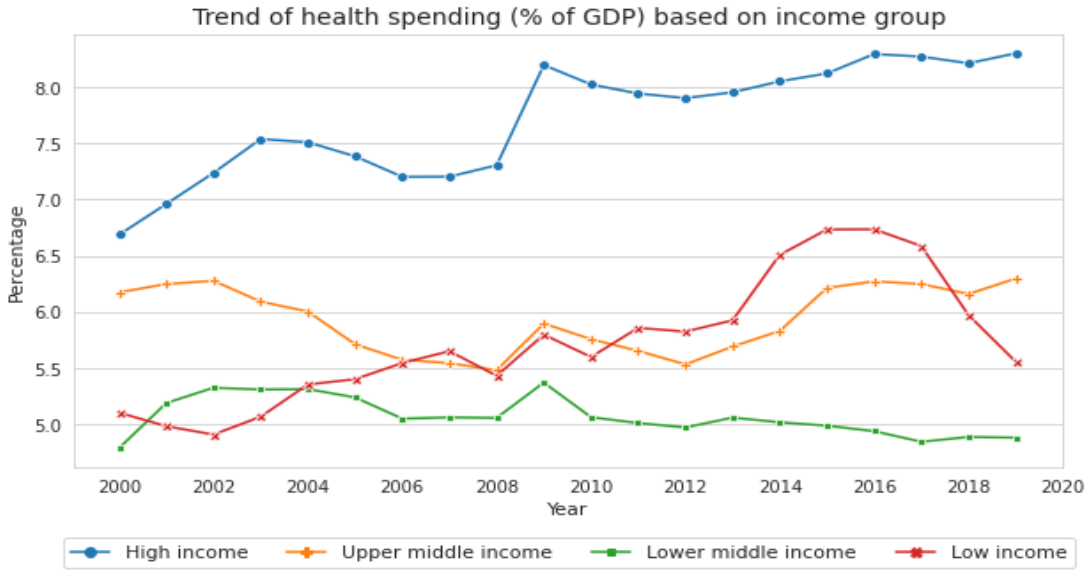

Figure 2: Trend of health expenditure as a share of GDP in different income groups from 2000-2019

Global patterns of mental disorders prevalence were presented in Figure 4. Prevalence of mental disorders varied 1.8 times among the countries. Table 3 (left) lists that Australia (Oceania) (19.07%), New Zealand (Oceania) (18.97%), and Portugal (Southern Europe) (18.71%) were top 3 countries that have the highest percentage of mental disorders prevalence. On the other hand, the lowest percentage of mental disorders prevalence was in Mali (West Africa) (10.44%), Mauritania (Africa) (10.52%), and Poland (Europe) (10.55%).

3.4 DBA K-means Clustering Shows Distinct Clusters between Suicide Rate, Mental Disorder Prevalence, Unemployment Rate, and Health Expenditure across Different Income Groups

Figure 6 illustrates three distinct clusters for high- and lower-middle-income groups. In comparison, there were only two distinct clusters for upper-middle- and low-income groups. Table 4 shows that all income groups included suicide rate, share of deaths from suicide, and mental and substance use disorder deaths as shared features in a cluster. Besides these shared features,

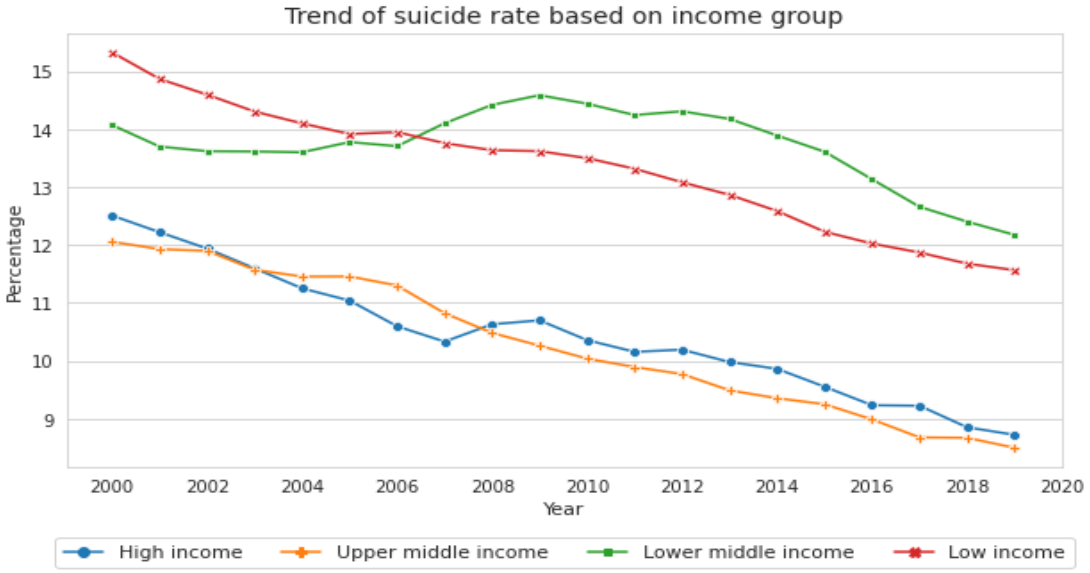

Figure 3: Trend of suicide rate of both sexes with standardized age in different income categories from 2000-2019

Table 3: The top five (left) and bottom five (right) countries for mental disorder prevalence (percentage).

Country	Mental disorder prevalence (%)	Country	Mental disorder prevalence (%)
Australia	19.07	Kazakhstan	10.74
New Zealand	18.97	Azerbaijan	10.61
Portugal	18.71	Poland	10.55
Spain	17.98	Mauritania	10.52
Afghanistan	17.49	Mali	10.44

the suicide rate was also clustered with the unemployment rate and health expenditure (%GDP) in the upper-middle-income group. In contrast, health expenditure per capita was grouped with the suicide rate in lower-middle- and low-income groups.

3.5 Forecasts for Suicide Rates and Mental Disorder Burdens up to Year 2030 by Income Group

The suicide rate was expected to experience a similar trend in all income groups, with a slight rise in 2020 and then falling steadily in the following ten years. Figure 7 shows the forecast trends up to 2030 with its 95% forecasted interval of the suicide rates for four income groups. For the high-income group (top left), the suicide rate was supposed to decrease from 8.72 per 100,000 in 2019 to 6.16 per 100,000 in 2030. There was a deduction from 8.50 to 6.90 per 100,000 from 2019 to 2030 in the upper-income countries (top right). Meanwhile, our model predicted suicide rates to reach 10.53 and 8.29 per 100,000 in 2030 in lower-middle- (bottom left) and low-income countries (bottom right), respectively.

Figure 8 highlights the time trend for mental disorders on the burden of disease in four income groups from 2000 to 2019 and the predictions up to 2030. For the past two decades, the lowest rate of mental disorders were in 2019, i.e., 6.72%, 5.68%, 4.34%, and 3.19% in high- (top left), upper-middle (top

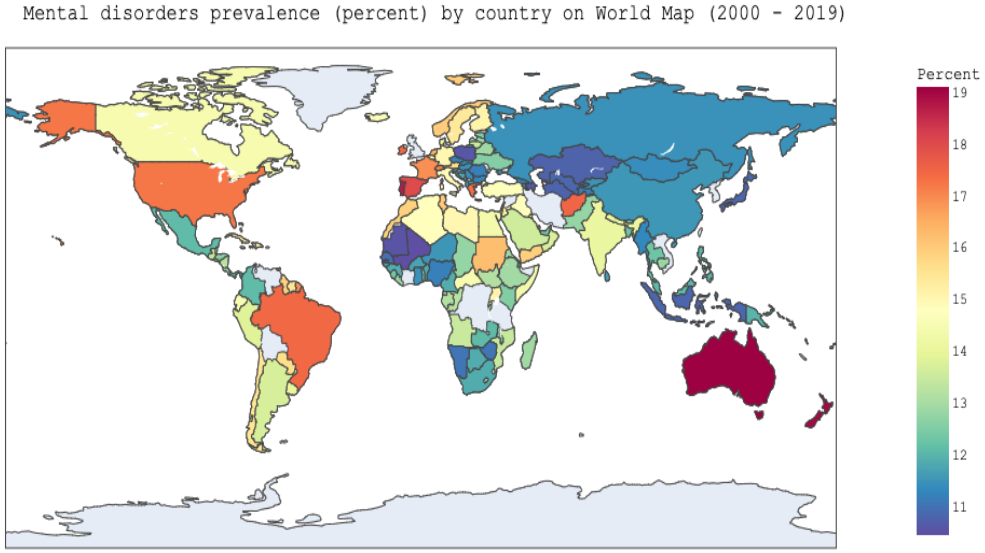

Figure 4: Mental disorder prevalence distribution from 2000-2019

Table 4: DBA K-means clustering distribution in different income groups

High-income	
Series	**Cluster**
gdp_current	Cluster 1
gdp_per_capita	Cluster 1
health expenditure (per capita)	Cluster 1
Income	Cluster 1
Mental disorders prevalence (Percent)	Cluster 2
health expenditure (% GDP)	Cluster 2
unemployment rate (percent)	Cluster 2
Mental disorders burden (Percent)	Cluster 2
Share of deaths from suicide (Percent)	Cluster 3
Mental and substance use disorder deaths (Rate)	Cluster 3
Suicide rate	Cluster 3
Lower-middle-income	
Series	**Cluster**
gdp_per_capita	Cluster 1
health expenditure (% GDP)	Cluster 1
unemployment rate (percent)	Cluster 1
Income	Cluster 1
Mental disorders burden (Percent)	Cluster 1
Mental disorders prevalence (Percent)	Cluster 2
gdp_current	Cluster 2
Share of deaths from suicide (Percent)	Cluster 3
Mental and substance use disorder deaths (Rate)	Cluster 3
health expenditure (per capita)	Cluster 3
Suicide rate	Cluster 3

Upper-middle-income	
Series	**Cluster**
Mental disorders prevalence (Percent)	Cluster 1
gdp_per_capita	Cluster 1
health expenditure (per capita)	Cluster 1
Income	Cluster 1
gdp_current	Cluster 2
Share of deaths from suicide (Percent)	Cluster 3
Mental and substance use disorder deaths (Rate)	Cluster 3
health expenditure (% GDP)	Cluster 3
unemployment rate (percent)	Cluster 3
Mental disorders burden (Percent)	Cluster 3
Suicide rate	Cluster 3
Low-income	
Series	**Cluster**
Share of deaths from suicide (Percent)	Cluster 1
Mental and substance use disorder deaths (Rate)	Cluster 1
gdp_current	Cluster 1
gdp_per_capita	Cluster 1
health expenditure (per capita)	Cluster 1
Income	Cluster 1
Mental disorders burden (Percent)	Cluster 1
Suicide rate	Cluster 1
Mental disorders prevalence (Percent)	Cluster 2
health expenditure (% GDP)	Cluster 3
unemployment rate (percent)	Cluster 3

right), lower-middle- (bottom left) and low-income countries (bottom right), respectively. We observed a rising trend in the contribution of mental disorders to the total disease up to 2020 (6.82%) followed by a significant fall from 2021 (6.74%) onward up to 2030 (5.75%) in the high-income groups (Figure 8, top left). On the contrary, we observed a declining trend up to 2020 with an upward trend over the next decade in other income groups (Figure 8). For instance, the proportional contribution of mental disorders to the total disease burden was predicted to drop slightly to 5.66% in 2020 in upper-middle-income countries,

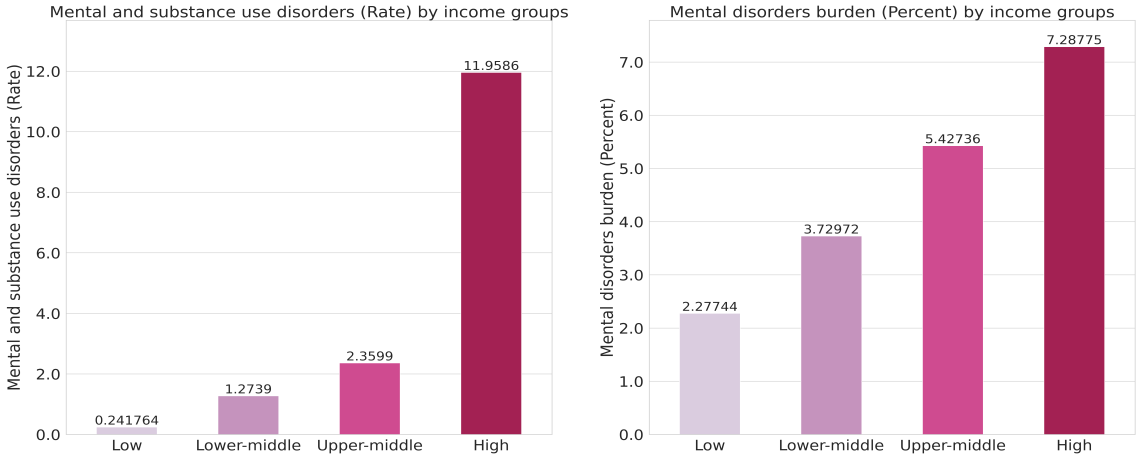

Figure 5: Left: Mental and substance use disorders (rate). Right: Mental disorders burden (percent) by income groups

then climb continually from 5.67% to 6.03% between 2021 and 2030. Similar patterns occur in lower-middle- and low-income groups, with a reduction (4.05% and 2.83%) in 2020, reaching (4.92% and 4.04%) by 2030.

The report used the best fit ARIMA models with the lowest AIC and BIC values shown in Table 5. Table 6 summarizes the accuracy values of the ARIMA model for predictions.

4 Discussion

Suicide continues to be the 10^{th} leading cause of death across eastern Europe, central Europe, high-income Asia Pacific, Australasia, and high-income North America [14]. Several studies indicate that the global change in economic activities has deeply affected people's mental health and may have influenced the suicide rate [15]. Specifically, a rising in suicide rates might occur during periods of recession [16]. In contrast, a decline in suicide rates might occur during periods of economic expansion [15][17]. Although the decrease in suicide rates has been substantial from 2000 to 2019 (Figure 3), we need to consider the complex interplay of factors such as levels of economic development, unemployment, and economic events and the distribution of risk factors like exposure to mental and substance use disorders.

4.1 The Economics of Mental Health

Recent studies indicate that although increases in GDP are associated with increases in suicide rates at low GDP levels, once a given threshold of economic development is reached, further increases in GDP do not correlate with increases in suicide rate [15]. Table 4 suggests a relationship between health expenditure (% GDP) and suicide rates in all income groups, except for the high-income one. Our findings are consistent since GDP per capita is only observed in the same cluster as the suicide rate (Table 4) in the low-income group.

Table 4 shows that the unemployment rate is associated with mental disorders prevalence in all income groups. Previous studies show that losing a job aggravates many mental health problems. Moreover, people who suffer from severe and common mental disorders are more likely to be unemployed than people with no conditions [18]. Regardless, more fundamental intervention research is necessary to understand better the im-

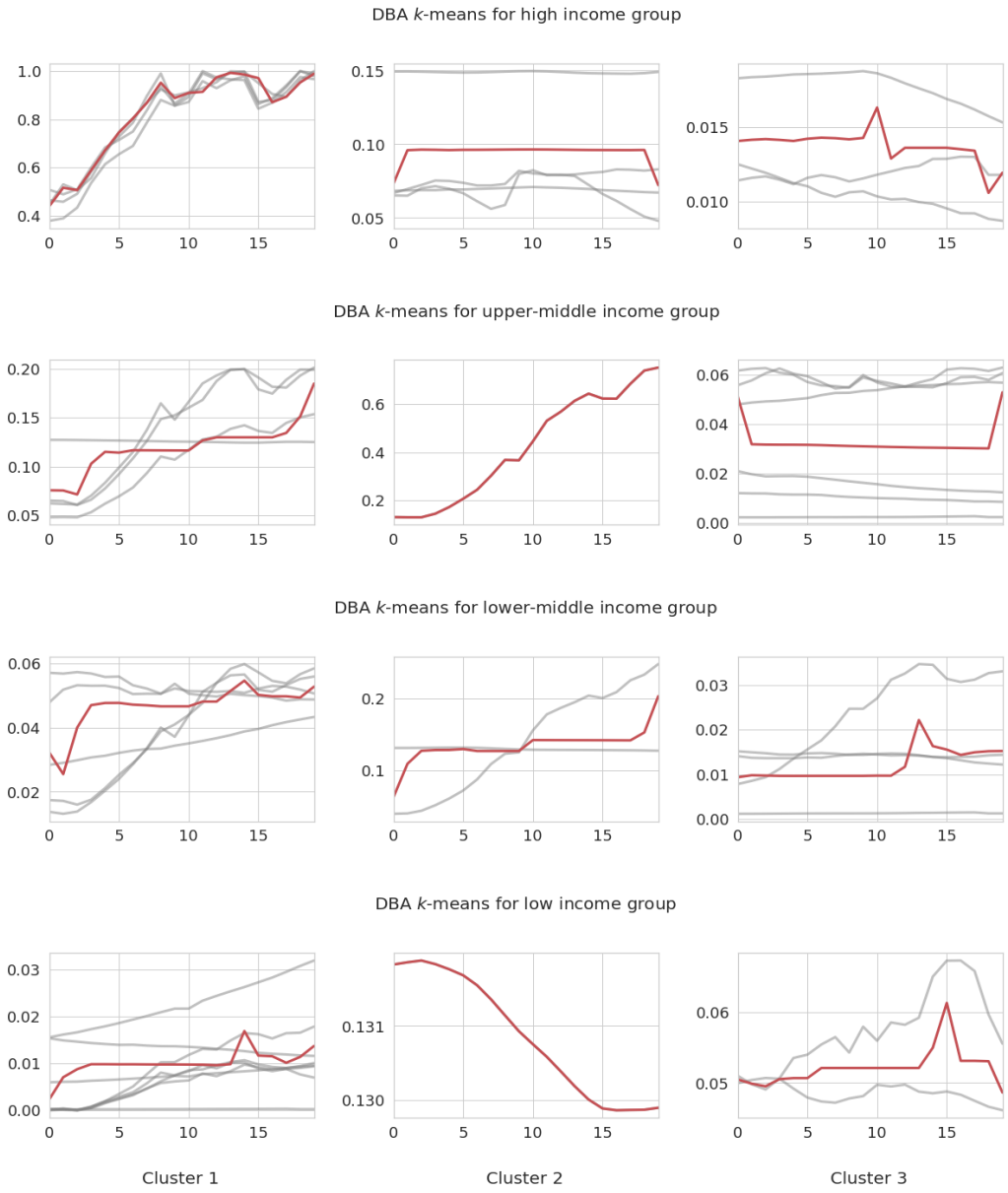

Figure 6: DBA K-means clustering in different income groups

pact of mental disorders and unemployment in other income groups.

Health spending as a percentage of total government expenditures is one of the strongest predictors of suicide rates [19]. As shown in Figure 2, developed countries spent a larger proportion of their health budget on healthcare than developing countries. It is paradoxical that the low-income group invested more national income in health than the lower-middle-income group. This finding suggests that external health aid plays a prominent role in many low-income countries. For example, in 2019, out-of-pocket and external support accounted for roughly three-quarters of health spending in low-income countries [20].

The burden of mental health disorders is sometimes neglected since health impacts are commonly assessed regarding the total number of suicide. Measuring health impact based on suicide rate ignores the influence mental health illness has on an individual's well-being[21]. Nonetheless, a high percentage of suicide deaths is linked to mental health.

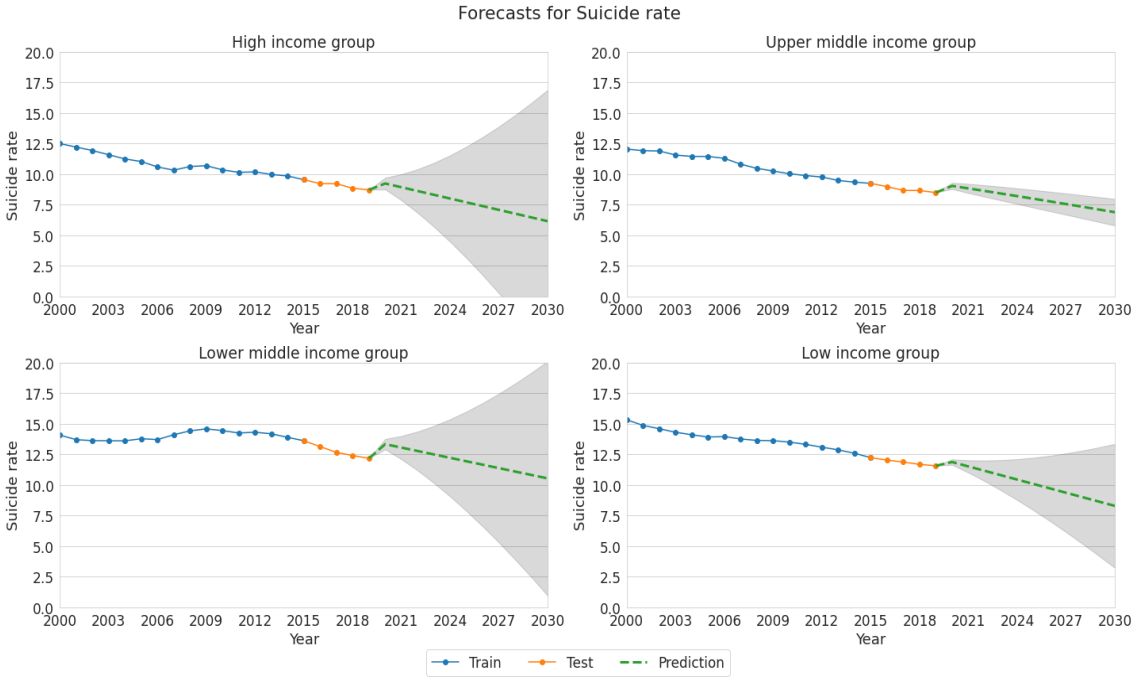

Figure 7: Trend for suicide rate from 2000 to 2019 and forecast up to 2030 by income groups. Solid line denote suicide rates from 2000 to 2019 estimated by Global Burden of Disease 2019. The fitted data is separated with the training data (blue dots) and test data (orange dots). Green dashed lines denote suicide rates by income group from 2019 to 2030 predicted by ARIMA model based on the mean rates in the last 20 years. Grey areas denote 95% confidence intervals of the predicted suicide rates.

4.2 Mental Disorder Burdens and Suicide Rate Predictions

Suicide rates have decreased substantially from 2000 to 2019 worldwide (Figure 3). This declining trend can be attributed to several factors, including global economic and social developments, improved health services, and treatments for mental health illnesses [22]. To compare with previous studies, we provided worldwide trends of suicide rate and mental disorders burden in four income groups in the next decade. Based on our predictions, all income groups may not achieve a one-third reduction goal by 2030 regarding suicide rates, although they may experience a declining trend overall. Excluding high-income groups, the burden of mental health illness on the total disease will grow increasingly over time in the other three income groups. This result is similar to the previous study [23]. This imbalanced distribution requires immediate action from governments of upper-middle-, lower-middle- and low-income countries to allocate more resources to their mental health expenditures. Otherwise, mental health illnesses will put more burden on their nations than any other disease in the next decade.

4.3 Limitations

In this study, we only used WHO subregions as the primary units of analysis due to the lack of qualitative and quantitative data from WHO and GBD. Previous studies show that the effects on the aggregate level might be spurious and may not correspond to directionally consistent results at the regional and individual levels[24]. In addition, reliable data

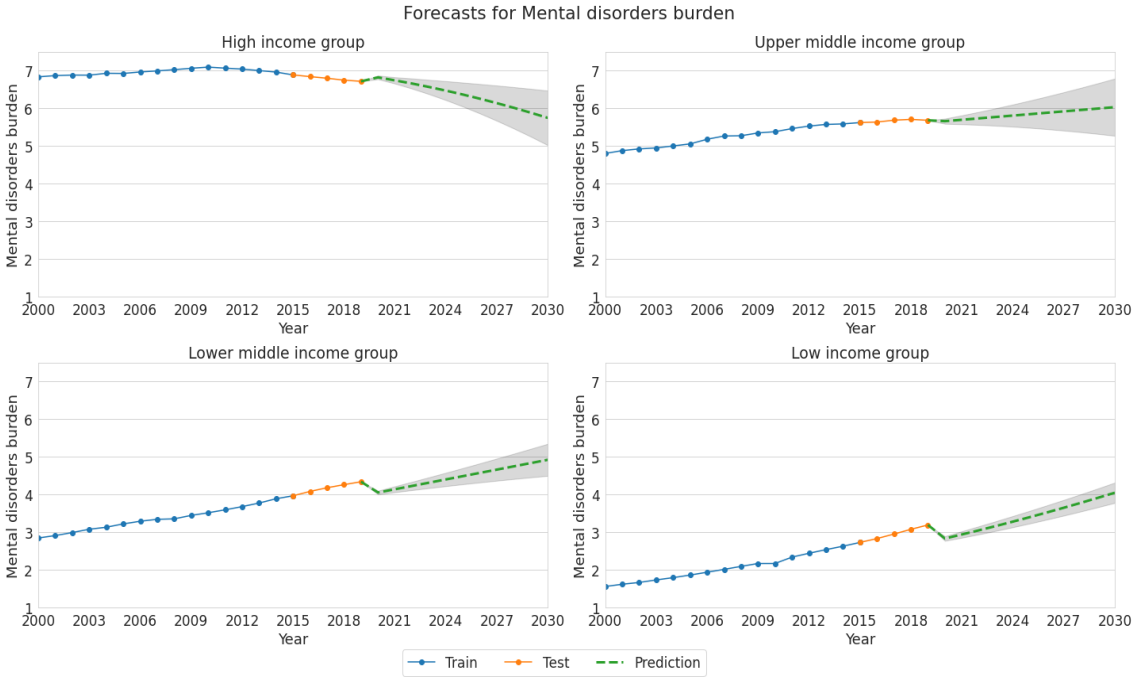

Figure 8: Mental health disorders as a share of total disease burden from 2000 to 2019 and predictions up to 2030 by income groups. Solid line denote mental disorders on the total disease burden from 2000 to 2019 estimated by Global Burden of Disease 2019. The fitted data is separated with the training data (blue dots) and test data (orange dots). Green dashed lines denote mental disorders on the total disease burden by income group from 2019 to 2030 projected by ARIMA model based on the mean rates in the past 20 years. Grey areas denote 95% confidence intervals of the projected mental disorders as a share of total disease burden.

on government health spending, specifically mental health, are scarce. Moreover, our data do not reflect the situations during the COVID-19 pandemic, which has led to an increase in people developing mental health and substance use disorders [25]. Thus, the lack of data and information can hinder interventions and policy making.

Furthermore, we could not consider other socioeconomic factors, such as health expenditure, unemployment rate, etc., due to the limitation of ARIMA models. Therefore, the predictions were based purely on past observations on the suicide rates and mental disorders burden. Finally, potential registration bias caused by differences in the requirements to registry deaths by suicide between countries over time should be taken into account [26].

Conclusions

Health expenditure and GDP are correlated to suicide rates worldwide. Nevertheless, the direction and magnitude of the correlation differ between developing and developed countries. Previous studies suggest that suicide rates are more responsive to economic factors, such as real GDP per capita, than to social factors alone [27]. However, our study shows that social factors such as unemployment rates play a significant role in upper-middle-income countries. Our finding suggests that the influences of social factors on suicide rates are complex and theoretical knowledge in this area is limited but much needed for developing effective

Table 5: AIC and BIC values for Best-fit ARIMA Models for Predictions.

Income Group	Suicide Rate			Mental Disorder Burden		
	Model	AIC	BIC	Model	AIC	BIC
High-income	ARIMA(0,2,0)	2.224	2.863	ARIMA(1,2,0)	-186.412	-184.495
Upper-middle-income	ARIMA(0,2,1)	-9.445	-7.528	ARIMA(0,2,1)	-178.481	-177.203
Lower-middle-income	ARIMA(0,2,0)	-0.941	-0.302	ARIMA(0,2,1)	-187.927	-186.646
Low-income	ARIMA(0,2,0)	-18.853	-18.214	ARIMA(1,2,1)	-175.875	-173.318

Table 6: RMSE and MAE for Best-fit ARIMA Models for Predictions.

Income Group	Suicide Rate		Mental Disorder Burden	
	RMSE	MAE	RMSE	MAE
High-income	0.2731	0.2326	0.0926	0.0793
Upper-middle-income	0.0965	0.0838	0.0480	0.0373
Lower-middle-income	0.3260	0.3172	0.0326	0.0322
Low-income	0.5055	0.4521	0.0204	0.0172

interventions.

In contrast, the role of unemployment and indebtedness in linking economic recession with suicide rates would support increased government spending on social protection (e.g., unemployment benefits, healthcare, and debt relief programs) [28]. In addition, our findings on the close relationship between mental health illness, mental disorders, and suicide rates over the total disease burden could be helpful for policymakers to establish more systematic approaches to reduce the growing mental health burden. Besides, governments can invest more in mental health to counterbalance the increased financial stress which tends to occur in unemployed and heavily indebted populations during recessions [28]. Regardless, it is essential to guarantee the quality and quantity of data collected, especially in the lower-middle- and low-income countries, to address better the socioeconomic factors across countries in different income groups.

Acknowledgements

We would like to thank the STEM Fellowship for this opportunity and their ongoing support in the data science community.

References

[1] Yannish Naik, Peter Baker, Ian Walker, Taavi Tillmannn, Kristin Bash, Darryl Quantz, Frances Hillier-Brown, and Clare Bambra. The macro-economic determinants of health and health inequalities-umbrella review protocol. *Systematic Reviews*, 6(222):1–8, 2017.

[2] Stuckler D, Basu S, and McKee M. Budget crises, health, and social welfare programmes. *BMJ*, 340(c3311), 2010.

[3] World Mental Health Day: an opportunity to kick-start a massive scale-up in investment in mental

health, 08 2020. Accessed: 2022-06-04.

[4] *Mental health atlas 2020*. World Health Organization, 2021.

[5] United Nations. SDG Progress Report (2022) – Advanced Unedited Version., 2022. Accessed: 2022-06-05.

[6] Lester D and Yang BJ. Microsocioeconomics versus macrosocioeconomics as a model for examining suicide. *Psychol Rep*, 69:735–8, 1991.

[7] Rehkopf D and Buka S. The association between suicide and the socio-economic characteristics of geographical areas: a systematic review. *Psychol Med*, 36(145:7), 2006.

[8] Stuckler D, Basu S, Suhrcke M, Coutts A, and McKee M. The public health effect of economic crises and alternative policy responses in europe: an empirical analysis. *Lancet*, 374(315-3), 2009.

[9] Milner A, McClure R, and De Leo D. Socio-economic determinants of suicide: an ecological analysis of 35 countries. *Social Psychiatry Psychiatric Epidemiol*, 47(19-7), 2012.

[10] World bank databank, 2022. Accessed: 2022-06-06.

[11] World health organization, 2022. Accessed: 2022-06-06.

[12] Global burden of disease study 2019 (gbd 2019) data resources, 2022. Accessed: 2022-06-06.

[13] The world by income and region, 2022. Accessed: 2022-06-06.

[14] Mohsen Naghavi. Global, regional, and national burden of suicide mortality 1990 to 2016: systematic analysis for the global burden of disease study 2016. *BMJ Journals*, 364(194):1–11, 2019.

[15] Blasco-Fontecilla H, Perez-Rodriguez MM, and et al Garcia-Nieto R. Worldwide impact of economic cycles on suicide trends over 3 decades: differences according to level of development. a mixed effect model study. *BMJ Journals*, 2(e000785):1–7, 2012.

[16] Tapia Granados JA. Increasing mortality during the expansions of the us economy, 1990-1996. *Int J Epidemiol*, 34:1194–202, 2005.

[17] Ying YH and Chang K A. A study of suicide and socioeconomic factors. *Suicide Life Threat Behav*, 39:214–26, 2009.

[18] Evelien P.M Brouwers. Social stigma is an underestimated contribution factor to unemployment in people with mental illness or mental health issues: position paper and future directions. *BMC Pyschology*, 8(36):1–7, 2020.

[19] Marco Innamorati, Antonino Tamburello, David Lester, Mario Amore, Paolo Girardi, Roberto Tatarelli, and Maurizio Pompili. Inequalities in suicide rates in the european union's elderly: trends and impact of macro-socioeconomic factors between 1980 and 2006. *The Canadian Journal of Psychiatry*, 55(4):229–238, 2010.

[20] World Health Organization et al. Global expenditure on health: public spending on the rise? 2021.

[21] Martin Prince, Vikram Patel, Shekhar Saxena, Mario Maj, Joanna Maselko, Michael R Phillips, and Atif Rahman. No health without mental health. *The Lancet*, 370(9590):859–877, 2007.

[22] Guilherme Borges, Matthew K Nock, Josep M Haro Abad, Irving Hwang, Nancy A Sampson, Jordi Alonso, Laura Helena Andrade, Matthias C Angermeyer, Annette Beautrais, Evelyn Bromet, et al. Twelve-month prevalence of and risk factors for suicide attempts in the world health organization world mental health surveys. *The Journal of clinical psychiatry*, 71(12):21777, 2010.

[23] Daniel V Vigo, Devora Kestel, Krishna Pendakur, Graham Thornicroft, and Rifat Atun. Disease burden and government spending on mental, neurological, and substance use disorders, and self-harm: cross-sectional, ecological study of health system response in the americas. *The Lancet Public Health*, 4(2):e89–e96, 2019.

[24] Voracek M. Suicide rates, national intelligence estimates, and differential k theory. *Percept Mot Skills .*, 109(733-6), 2009.

[25] Alison Brunier and Carla Drysdale. Covid-19 pandemic triggers 25% increase in prevalence of anxiety and depression worldwide, 2022. Accessed: 2022-06-05.

[26] Moniruzzaman S and Andersson R. Economic development as a determinant of injury mortality-a longitudinal approach. *Soc Sci Med*, 66(1699-708), 2008.

[27] Chen J, Choi YJ, and Sawada Y. How is suicide different in japan? *Japan: CIRJE Discussion Papers*, 2008.

[28] Oysesanya M, Lopez-Morinigo J, and Dutta R. Systematic review of suicide in economic recession. *World journal of psychiary*, 5(2):243–254, 2015.

Appendix

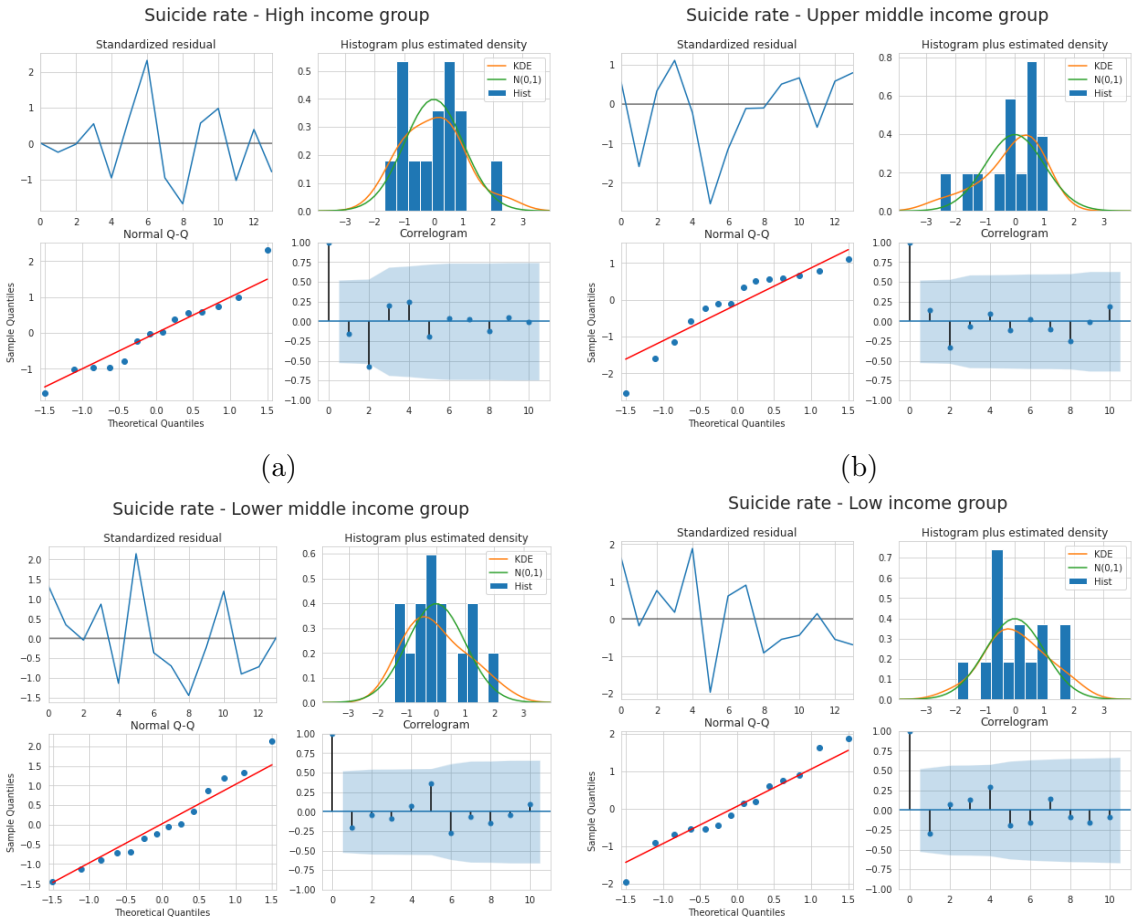

Figure 9: Diagnostic statistics for suicide rate

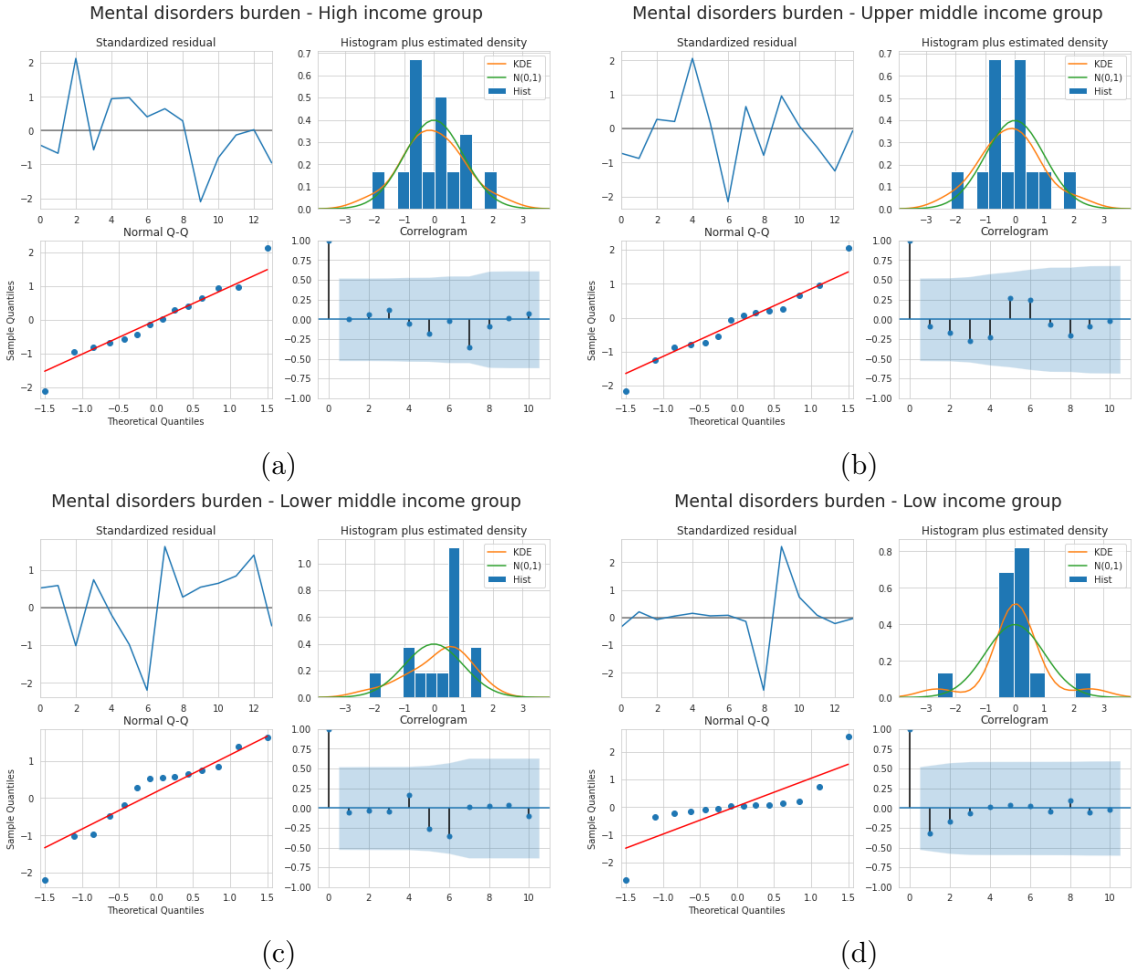

Figure 10: Diagnostic statistics for Mental disorders burden