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A Worldwide Ecological Analysis of Climate Change, Mental Health Disorders and Substance Abuse

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Abstract

Background: Climate change has led to an increase in the frequency and severity of natural hazards, which can trigger mental health disorders and can also lead to an increase in substance abuse. The aim of this ecological study is to investigate the association between the exposure to climate change, measured as natural hazards, and mental health prevalence and substance use, at country-level, worldwide.

Methods: All data were extracted from publicly available sources. Crude and adjusted linear regression models were created to explore the association of the proportion of people affected by natural hazards and four different mental health and substance abuse outcomes. Multivariable models included socioeconomic variables.

Results: In the crude regression mode, the total number of people affected by natural hazards period is positively associated with the relative change in anxiety disorders over a five year period. However, when adjusting for confounders the association is lost. Conversely, after adjusting for confounders, the average number of people affected by natural hazards is negatively associated with the relative change in depressive disorder prevalence. No association was found for the number of people affected by natural hazards and the relative change in substance use death rate, as well as the relative change in alcohol consumption.

Conclusion: The average number of people affected by natural hazards was not associated with increased substance use globally and was inconclusive regarding the association with mental health disorders, implying that on a country level, the average impact of natural hazards may not be great enough to detect a change a country's prevalence rates of mental health disorders and substance abuse.

*Key Words***:** climate change, natural hazards, mental health disorders, substance abuse

Contents

Introduction

"Human induced climate change is the largest, most persuasive threat to the natural environment and societies the world has ever experienced" (OHCHR, 2021). As the earth is warming and the climate is changing, natural hazards such as hurricanes, tropical storms, heatwaves, wildfires and floods are not only becoming more frequent, but also more severe (WHO, 2023; IPCC, 2023). This results in several negative effects for humans regarding food and water security, infrastructure, economies, societies and human health (IPCC, 2023). 3.6 billion people already reside in regions that are extremely vulnerable to climate change. Consequently, research predicts that climate change will result in 250 000 fatalities per year between 2030 and 2050, due to physical health impacts such as heat stress, malaria, diarrhoea and undernourishment (WHO, 2023). However, research on climate change's impact on mental health conditions is still more scarce (Wu et al., 2020).

In 2019, one in eight people, 960 million people worldwide, were living with a mental disorder (WHO, 2022). As a result, mental disorders rank among the top 10 global causes of burden of disease (GBD 2019 Mental Disorders Collaborators., 2022). Existing literature suggests that climate change will have a negative impact on mental health conditions globally (Clayton, 2021; IPCC, 2022; Lawrance et al., 2022; Makwana, 2019; Romanello et al., 202; Wahid et al., 2023). Hereby, climate change can cause immediate mental health challenges in response to extreme weather events, but also long term mental health disorders caused by experiencing repeated extreme weather events and their repercussions on infrastructure, economic stability, livelihoods and communities (Clayton, 2021; Haase, 2023; IPCC, 2023; Makwana, 2019; WHO, 2023). After extreme weather events, most people experience stress and insomnia which can lead to mental health disorders such as depression, anxiety and

post-traumatic stress (WHO, 2023: Haase, 2023; European Climate and Health Observatory & Climate ADAPT, 2024). The long-term destabilization of communities affected by extreme weather events can lead to cumulative community stress, a rise in poverty and an increase in domestic violence and displacement. These factors can also lead to an increase in mental health disorders (European Climate and Health Observatory & Climate ADAPT, 2024; U.S Global Change Research Program, 2016). Additionally, people might experience climate anxiety as a result of the distress brought on by current or projected changes in the climate and environment (European Climate and Health Observatory & Climate ADAPT, 2024).

Further evidence suggests that mental disorders triggered by the impacts of climate change can possibly lead to high-risk coping behaviours such as substance abuse. The psychosocial stress triggered by extreme weather events and its destabilising impacts on environmental and social systems may be associated with a change in behavioural patterns to cope with the distress (Haase, 2023; U.S Global Change Research Program, 2016; Cunsolo et al., 2017). Substance abuse and mental illnesses are closely related. According to epidemiological research, 50% of individuals with a substance-use disorder also suffer from at least one mental illness (Vergunst et al., 2022). Furthermore, longitudinal research has demonstrated that psychological stress exposure during pregnancy can heighten the susceptibility of the children to substance use later on in life. Therefore, climate change induced stress can have intergenerational effects on substance use behaviours (Van Duijvenbode & VanDerNagel, 2019). A number of case studies support the association between climate change, mental health disorders and substance abuse (Clayton, 2021; Cruz et al., 2020; Evans, 2019; Middleton et al., 2020; Wu et al., 2020; Chevance et al., 2022). For example, Evans (2019) found that people who had experienced

flooding showed to have increasing rates of depression, as well as substance abuse, compared to people who were not exposed to flooding.

A number of other factors can also affect mental health and substance abuse at a population level: socioeconomic status, access to healthcare, conflict and urbanization (Baptiste-Roberts & Hossain, 2018; McLaughlin et al., 2012; Yu & Williams, 1999; Ne et al., 1993; Buka, 2002; British Psychological Society, 2011; McLellan, 1982; Levy, 2002; Ventriglio et al., 2020; Dekker et al., 2008; Turan & Besirli, 2007). Low economic status is associated with both mental health and substance abuse disorders (Baptiste-Roberts & Hossain, 2018; McLaughlin et al., 2012; Yu & Williams, 1999; Ne et al., 1993; Buka, 2002). Furthermore, having access to affordable healthcare services for the treatment of mental health and substance abuse disorders can lead to a decrease of the prevalence of these disorders (British Psychological Society, 2011; McLellan, 1982). War can also have severe impacts on a person's health. As a result, mental health disorders and substance abuse are positively associated with war and other forms of conflict (Levy, 2002). Lastly, the environmental stressors caused by urbanization have been associated with an increase in mental health and substance abuse disorders (Ventriglio et al., 2020; Dekker et al., 2008; Turan & Besirli, 2007).

The association between climate change induced extreme weather events and substance abuse has not been investigated on a global scale. Additionally, it has not been investigated to what extent mental health disorders mediate this relationship. Therefore, this paper aims to answer the following research question:

"Are the impacts of climate change associated with mental health disorders and substance abuse? If so, to what extent is the association of climate change and substance abuse mediated by mental health?"

Methods

For this analysis, the dataset was created using data from publicly available databases. Worldwide data assessed at country level was extracted for the exposure variable (average number of people affected by natural hazards), the outcome variables (anxiety disorders prevalence, depressive disorders prevalence, death rate of alcohol and drug use disorders, alcohol consumption per capita) and potential confounding variables (GDP per capita, Global Peace Index, Universal Health Coverage Index, share of urban population), as well as interacting variables (World Bank Income Groups, World Bank World Regions). Since only publicly available data were used, no approval from the Ethics Committee was requested.

For this analysis, the time frame from 2015-2019 was chosen, since these years were the most recent with available data for all variables.

Dataset

Natural Hazards

For this analysis, the data on climate change impact is measured as the average number of individuals affected by natural hazards per 100,000 population per country per year. Natural hazards include any climatic, meteorological or geophysical occurrence, such as wildfires, droughts, storms, flooding, earthquakes and volcanic eruptions. The average number of people affected is made up of the sum of those who got injured, became homeless or required assistance. Data was extracted from Our World in Data for five consecutive years (2015-2019) (Ritchie et al., 2024). To account for missing data, the average of available data points was calculated as the prevalence of the period. Data was available for 182 countries. The distribution of this variable was found to be skewed (mean [SD]: 5368.91[11837.02], median [p25-p75]: 642.70 [57.25-3827.70]), which is why the variable was log-transformed (mean [SD]: 5.98 [3.06],

median [p25-p75]: 6.47 [4.06-8.25]) to get more normally distributed values compatible with linear regression models.

Mental Health Disorders

Since climate hazards mainly cause depression, anxiety and post-traumatic stress disorders (WHO, 2023; Haase, 2023, (European Climate and Health Observatory & Climate ADAPT, 2024), two variables with available data on a global scale were used in this study for mental health disorders, anxiety disorders and depressive disorders.

Anxiety Disorders. Anxiety disorders were measured by the anxiety disorders prevalence of a country. The variable was derived for the years 2015 and 2019 from Our World in Data and is age standardized. It is made up of an estimate share of people with anxiety disorders, measured in percentage, no matter if they are diagnosed, based on representative surveys, medical data and statistical modelling. Data was available for 203 countries (Our World in Data, n.d.).

To analyse whether there was a change in mental health disorder prevalence the relative change in percentage was calculated from the year 2015 to 2019 for anxiety disorder prevalence, using the following formula:

$$\text{Formula (a): } \frac{(x_{2019} - x_{2015})}{x_{2015}} * 100$$

As a result, a negative number implies a decrease in the prevalence of anxiety disorders and a positive number an increase in the prevalence of anxiety disorders.

The relative change in anxiety disorders was found to be normally distributed, but had outliers which skewed the distribution (mean [SD]: 0.22 [2.31], median [p25-p75]: 0.11 [-0.3-0.56], min-max: -8.71–16.56), which is why outliers were removed using the Tukey fence method, where data beyond a distance of 1.5 IQR beyond the first and third quartile are removed (Adil &

Irshad, 2015). 12 outliers were successfully removed (mean [SD]: 0.1688 [0.58], median [p25-p75]: 0.12 [-0.25-0.53], min-max: -1.48-1.77).

Depressive Disorders. Depressive disorders were measured by the depressive disorders prevalence of a country. The variable was derived for the years 2015 and 2019 from Our World in Data and is age standardized and made up of an estimate share of people with depressive disorders, measured in percentage, no matter if they are diagnosed, based on representative surveys, medical data and statistical modelling. Data was available for 203 countries (Our World in Data, n.d.). To analyse whether there was a change in mental health disorder prevalence, the relative change in percentage was calculated from the year 2015 to 2019 for depressive disorder prevalence, using Formula (a). As a result, a negative number implies a decrease in the prevalence of depressive disorders and a positive number an increase in the prevalence of depressive disorders.

Substance Abuse

Alcohol and drug use disorders death rate. Substance abuse at country level was measured as the estimated annual number of deaths from alcohol and drug use disorders per 100,000 people. These include only direct deaths from these disorders, meaning they do not include suicide deaths, which can in some cases be connected or attributed to them. The variable is age-standardized and was extracted from Our World in Data (Our World in Data, n.d.). Data points were extracted for the years 2015 and 2019 and the relative change in percentage was calculated, using Formula (a). Therefore, a positive value indicates an increase in alcohol and drug use disorder death rate, while a negative value indicates a decrease for the 5-year time period considered. Data was available for 204 countries.

Alcohol Consumption. Alcohol consumption at country level was assessed with the average alcohol consumption per capita. This entails a projected estimate of pure alcohol consumption per person aged 15 or older. Data was extracted from the World Bank's World Development Indicators for the years 2015 and 2019 (*World Bank Open Data*, n.d.). The relative change in percentage from 2015 to 2019 was calculated using Formula (a). Therefore, a positive value indicates an increase in alcohol consumption, while a negative value indicates a decrease in alcohol consumption. Data was available for 183 countries.

Confounders

Conflict. The 2016 Global Peace Index Report (Institute for Economics & Peace, 2023), which generates a score based on three categories; conflict, harmony, and country militarization—was used to sample data on conflict. This considers both the continuing internal and external conflict, as well as the degree of safety and security in a nation. Higher scores indicate higher levels of conflict; the range is 1.192 in Iceland with the lowest score and 3.806 for Syria with the highest score.

Socioeconomic status. Socioeconomic Status was assessed using Gross Domestic Product (GDP) per capita. Data was extracted from the World Bank's Development Indicators for the year 2015 and was available for 194 countries (*World Bank Open Data*, n.d.). The distribution of GDP per capita was skewed (mean [SD]: 17453 [18181], median [p25-p75]: 11629 [3715-24581]), so it was successfully log transformed (mean [SD]: 9.2 [1.2], median [p25-p75]: 9.4 [8.2-10.1]). GDP per capita was highest in Macao ($116,855.53) and lowest in Burundi ($781.58).

*Urbanization***.** Urbanization is measured by what percentage of the average population resides in urban areas. This variable relies on a country's definition of urban centres. This data

was extracted for the year 2015 from the World Bank Indicators and was available for 182 countries (*World Bank Open Data*, n.d.). Kuwait and Singapore have the highest share of people living in urban areas (100%) and Burundi has the lowest (12.08%).

Healthcare Access. Healthcare access was measured using the Universal Health Coverage (UHC) Service Coverage Index. The UHC is measured on a scale from 0 (worst) to 100 (best) based on the average coverage of essential services including reproductive, maternal, newborn and child health, infectious diseases, non-communicable diseases and service capacity and access. It was extracted from Our World in Data for the year 2015 (Our World in Data, n.d.). The country with the highest Health Coverage Service Index is Canada (90.05) and the country with the lowest is Somalia (21.17).

Interaction Variables

Income Groups. Income Groups classifications are based on the World Bank income groups in 2015, available on Our World in Data (Our World in Data, n.d.). The World Bank's income classifications group countries in four categories: "Low-income", "Lower-middle-income", "Upper-middle-income" and "High-income". It is based on the countries gross national income (GNI) per capita. Data was available for 218 countries.

World Regions. World Regions classifications are based on the world regions according to the World Bank, extracted from Our World in Data (Our World in Data, n.d.). It includes 7 world regions: "East Asia and Pacific", "Europe and Central Asia", "Latin America and Caribbean" "Middle East and North Africa", "North America" "South Asia" "Sub-Saharan Africa". Latin America and Caribbean and North America were merged into one group "Americas", since North America only entailed two countries, which is not sufficient for a linear regression analysis.

Statistical Analysis

The exposure variable (average number of people affected by natural hazards) and the outcome variables (anxiety disorders prevalence, depressive disorders prevalence, death rate of alcohol and drug use disorders, alcohol consumption per capita) were mapped using QGIS 3.8 to examine their geographical distribution.

Further statistical analysis was conducted in R Studio. Firstly, all the variables were examined for normality, looking at mean, median, standard deviation, and interquartile range, as well as a histogram of the variables. Those variables which were skewed (average number of people affected by natural hazards; GDP per capita) were log-transformed or outliers were removed (change in anxiety prevalence). Box and whisker and scatter plots were also created in R-studio.

Crude and adjusted linear regression models were created for each of the outcome variables (anxiety disorders prevalence, depressive disorders prevalence, death rate of alcohol and drug use disorders, alcohol consumption per capita) with the exposure variable (average number of people affected by natural hazards) to examine the association between the impacts of climate change and mental health disorders and substance abuse. All the multivariable regression models were adjusted for all possible confounders (GDP per capita, Global Peace Index, Universal Health Coverage Index, share of urban population).

In order to interpret beta coefficients of log-transformed variables, beta coefficients were divided by a 100. To account for the impacts of Health Coverage, a separate sensitivity analysis was conducted without including health care as a confounder.

Furthermore, all crude and adjusted linear regression models were tested for interaction with the World Bank's income groups and world region, using the likelihood ratio test. When an

interaction was significant ($p < 0.05$), the data was displayed by category of the interaction variable.

Lastly, no mediational analysis was conducted with natural hazards as independent variable and substance abuse as dependent variable and mental health disorders as mediator, since there was no significant association found between the independent and dependent variable.

Results

Distribution of Data

Overall, 218 countries worldwide were considered for the study.

Natural Hazards

The average number of the population affected by natural hazards between 2015−2019 ranges from 0 (Barbados, Belgium, Czechia, Estonia, Kuwait, Latvia, Lithuania, Samoa, Slovakia, Sweden, United States Virgin Islands) to 71,105.82 per 100,000 (Dominica).

The worldwide mean is 4,558.83 per 100,000 over the 5-year period, the median 487.55 per 100,000 and the standard deviation 10,265.15 per 100,000. Figure 1 shows the quantiles of distribution of the average number between the year 2015 to 2019 of population per 100,000/year affected by natural hazards, and Figure 2 shows the distribution of the variable grouped by world regions. In both figures, we can observe that when looking at the overall distribution, the average amount of people affected by natural hazards is the highest in East Asia and Pacific (mean [SD]: 10824 [14323], median [p25-p75]: 3731 [1148-21764]) and South Asia (mean [SD]: 3380 [2751], median [p25-p75]: 3191 [1258-4859]). Followed by this, we have the Americas (mean [SD]: 5904 [13542], median [p25-75]: 1818 [951-4150]) and Sub-Saharan

Africa (mean [SD]: 5975 [10577], median [p25-p75]: 882 [205-4802]). The lowest amount of people affected by natural hazards can be found in the Middle East and North Africa (mean [SD]: 1022 [3176], median [p25-p75]: 100 [13-261]) and Europe and Central Asia (mean [SD]: 175 [477], median [p25-p75]: 11 [1-102]).

Figure 1

World map showing the quantiles of distribution of the average number (year 2015-2019) of population per 100,000/year affected by natural hazards

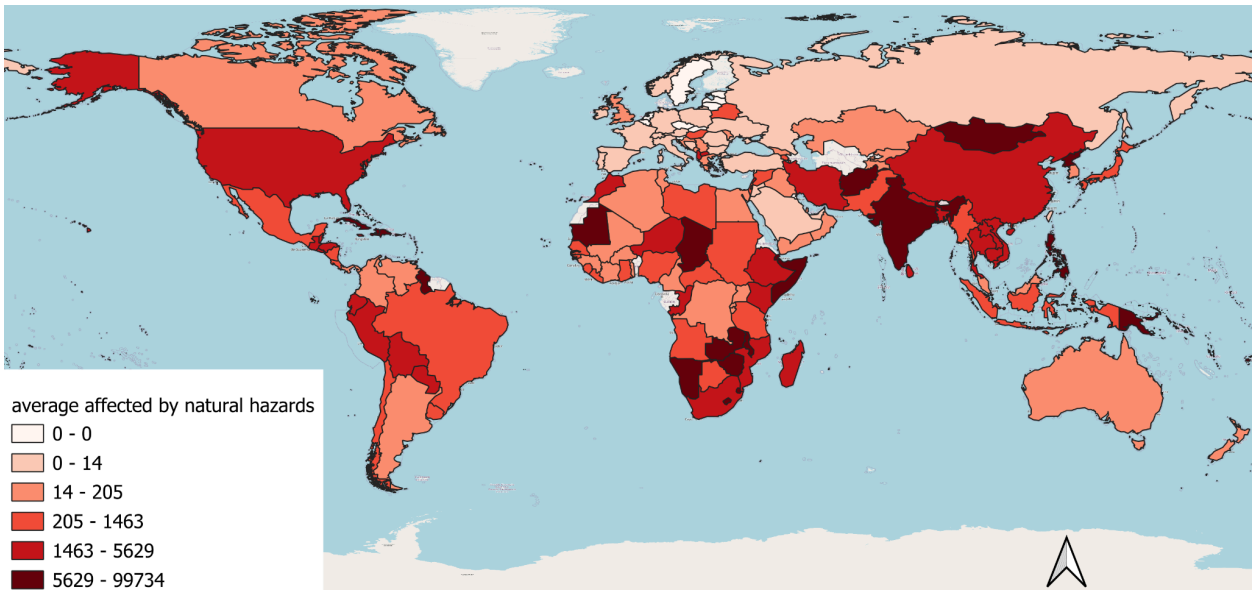
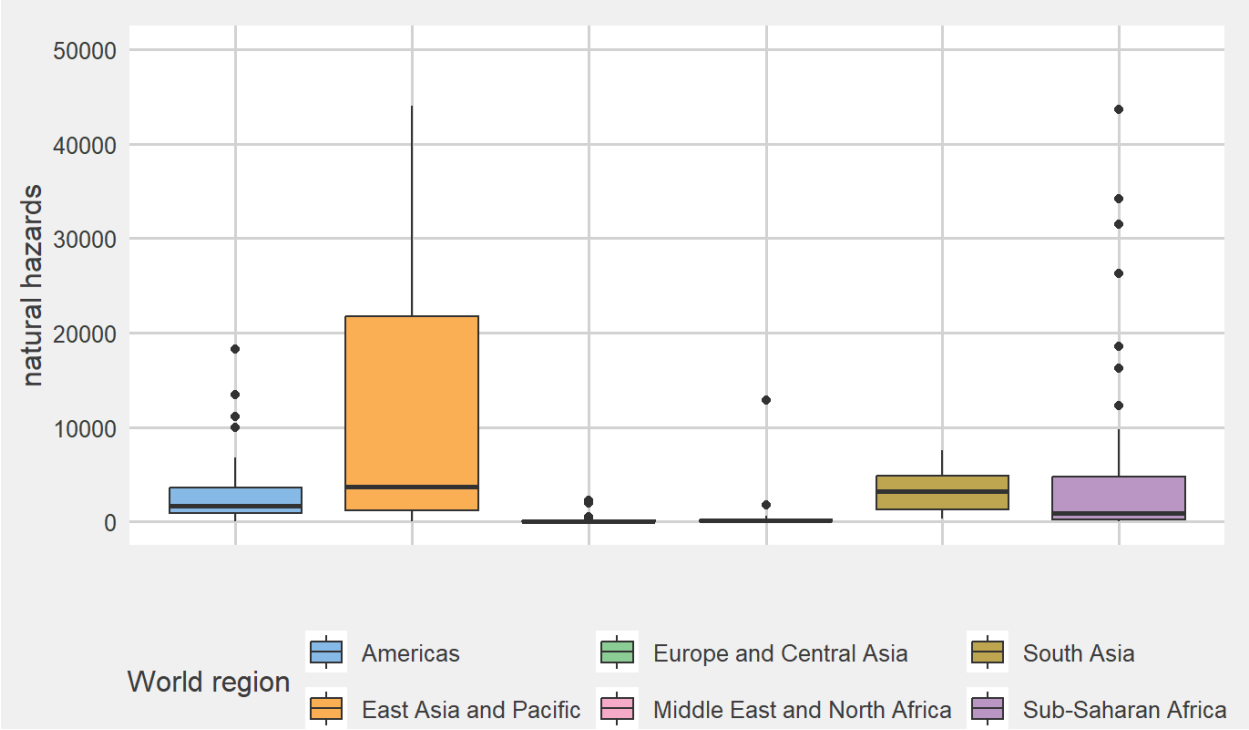


Figure 2

Box and whisker plot of average number of people affected by natural hazards between 2015-2019 grouped by world regions



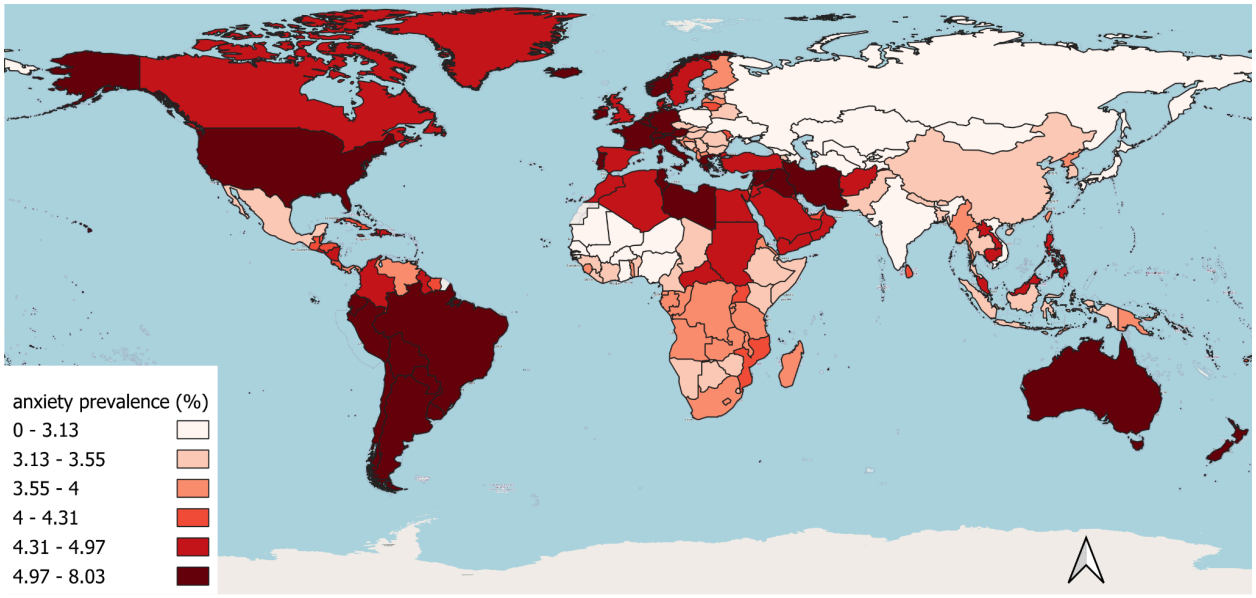
Note. 1 value is not included in the plot.

Anxiety Disorders

The prevalence of anxiety disorders in 2019 ranges from 2.03% in Uzbekistan to 8.03% in Portugal. The global mean is 4.16%, the median is 4.02% and the standard deviation is 1.08%. Figure 3 shows the quantiles of distribution of anxiety disorders prevalence. High rates can be observed in different regions all around the world. However, populations in South America and Central Europe are particularly affected.

Figure 3

World map showing the quantiles of distribution of the prevalence of anxiety disorders (2019)

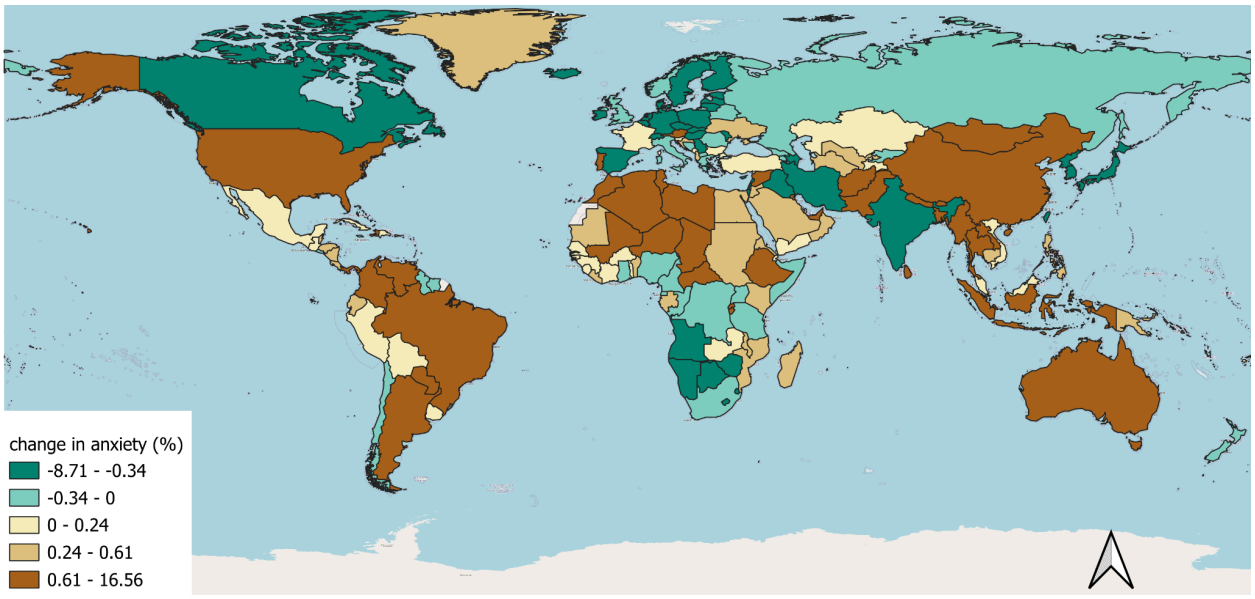


The relative change in anxiety disorder prevalence from the year 2015 to 2019 ranges from -1.48% in Zimbabwe to 1.6% in Kuwait. The global mean, as well as the median, is 0.14% and the standard deviation is 0.56%, so overall there has been a global increase in anxiety disorder prevalence. Figure 4 shows the quantiles of distribution of the relative change in anxiety disorders prevalence. Between 2015 and 2019 anxiety disorders prevalence increased in 118 countries (yellow and brown on the map) and decreased in 72 countries (green on the map).

Comparing Figure 3 and Figure 4, it can be observed that some regions with high anxiety disorder prevalence rates, such as South America and North Africa (Figure 3), also experienced an increase in prevalence rates between 2015 and 2019 (Figure 4). However, regions such as Central Europe experienced a decrease in prevalence rates (Figure 4) but still had high prevalence rates in 2019 (Figure 3). In East and Southeast Asia, an increase in anxiety prevalence between 2015 and 2019 can be observed (Figure 3), but prevalence rates are still relatively low compared to the rest of the world (Figure 4).

Figure 4

World map showing the quantiles of distribution of the relative change in anxiety disorders prevalence (year 2015 to 2019)



Furthermore, Figure 5 shows the distribution of the relative change in anxiety disorders prevalence from 2015-2019, grouped by world regions. Looking at the distribution, it can be observed that South Asia has experienced the biggest increase in anxiety disorders prevalence in the five year period (mean [SD]: 0.74 [0.73], median [p25-p75]: 0.77 [0.73-1.12]), followed by the Middle East and North Africa (mean [SD]: 0.39 [0.68], median [p25-p75]: 0.41 [0.17-0.72]). The Americas (mean [SD]: 0.25 [0.38], median [p25-p75]: 0.17 [0.00-0.52], East Asia and Pacific (mean [SD]: 0.25 [0.51], median [p25-p75]: 0.24 [-0.03-0.36]) and Sub-Saharan Africa (mean [SD]: 0.14, median [p25-p75]: 0.16 [-0.15-0.59]) have similar distributions, except for the interquartile range of Sub-Saharan Africa being slightly higher. The biggest decrease in anxiety disorders can be observed in Europe (mean [SD]: -0.21 [0.45], median [p25-p75]: -0.26 [-0.46-0.07]).

Figure 5

Box and whisker plot of the relative change in anxiety disorders prevalence from 2015-2019, grouped by world regions

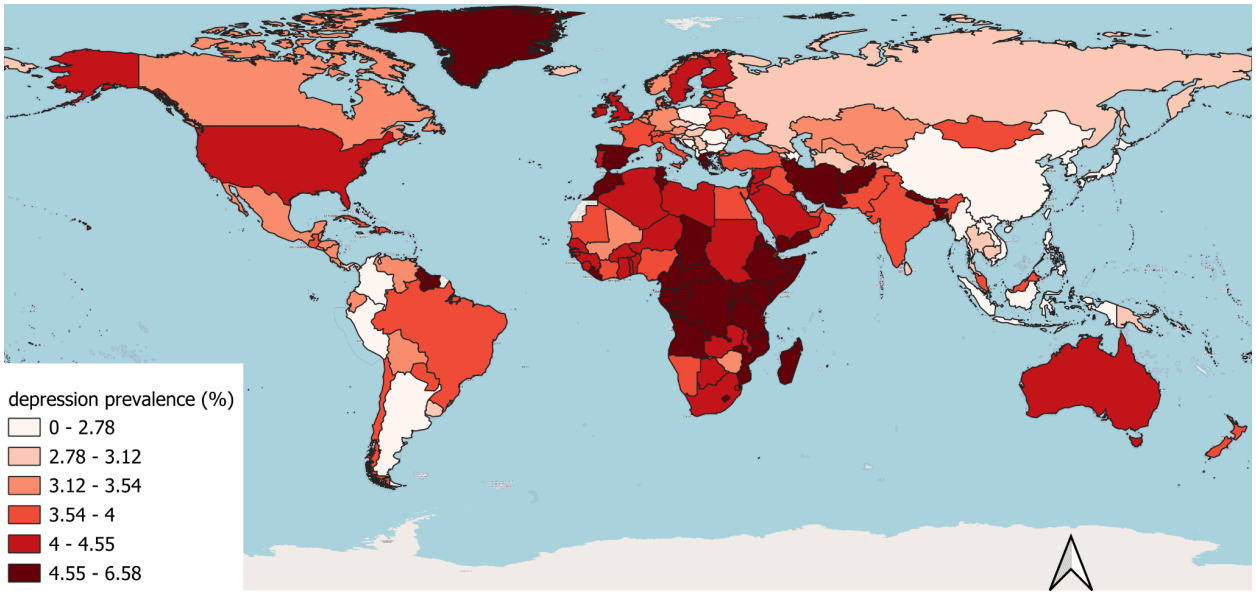
Note. 3 values are not included in the plot.

Depressive Disorders

The prevalence of depressive disorders in 2019 ranges from 1.6% in Brunei Darussalam to 6.58% in Uganda. The global mean is 3.71%, the median is 3.64% and the standard deviation is 0.9%. Figure 6 shows the quantiles of distribution of the prevalence of depressive disorders. High depression rates can particularly be found in Africa (Figure 6).

Figure 6

World map showing the quantiles of distribution of the prevalence of depressive disorders (2019)

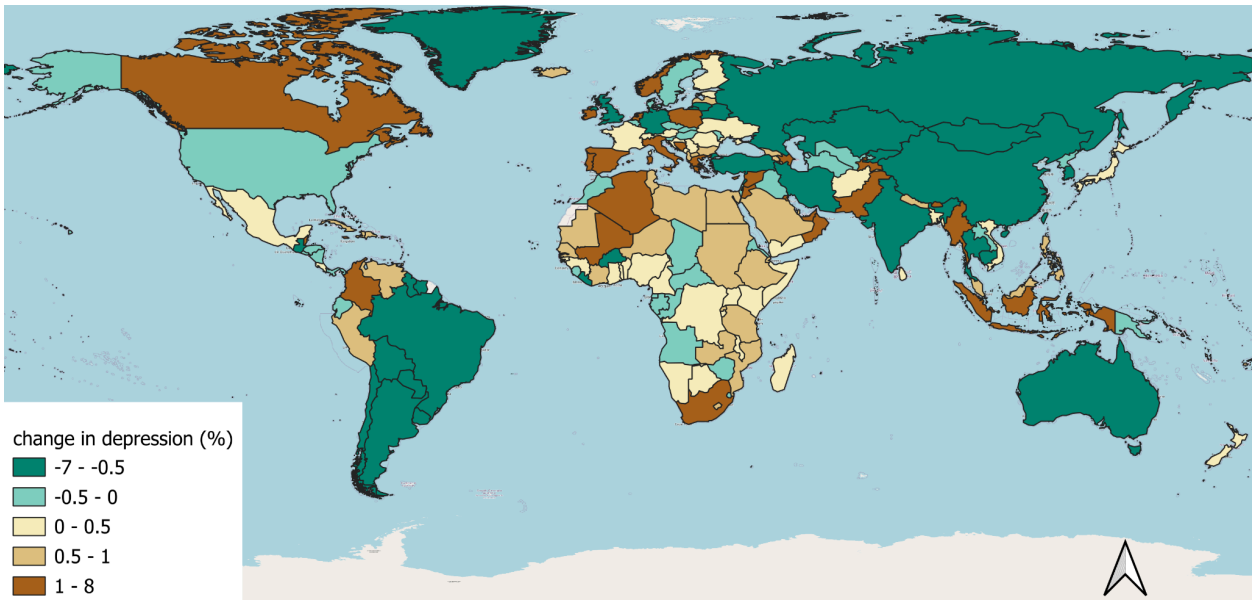


The relative change in depressive disorder prevalence from the year 2015 to 2019 ranges from -5.94% in Liberia to 7.87% in Poland. The global mean is 0.4%, the median is 0.25% and the standard deviation is 1.45%. Overall, there has been a global increase in depressive disorders prevalence. Figure 7 shows the worldwide distribution of the relative change in depressive disorders prevalence in fixed intervals. Between 2015 and 2019 depressive disorders prevalence increased in 126 countries (yellow and brown on the map) and decreased in 64 countries (green on the map).

Comparing Figure 6 and Figure 7, it can be observed that those countries which experienced an increase in depression rates between 2015 and 2019 also tend to have higher prevalence rates compared to the rest of the world, especially when looking at Africa and the Middle East.

Figure 7

World map showing fixed intervals of the relative change in depressive disorders prevalence (year 2015 to 2019)

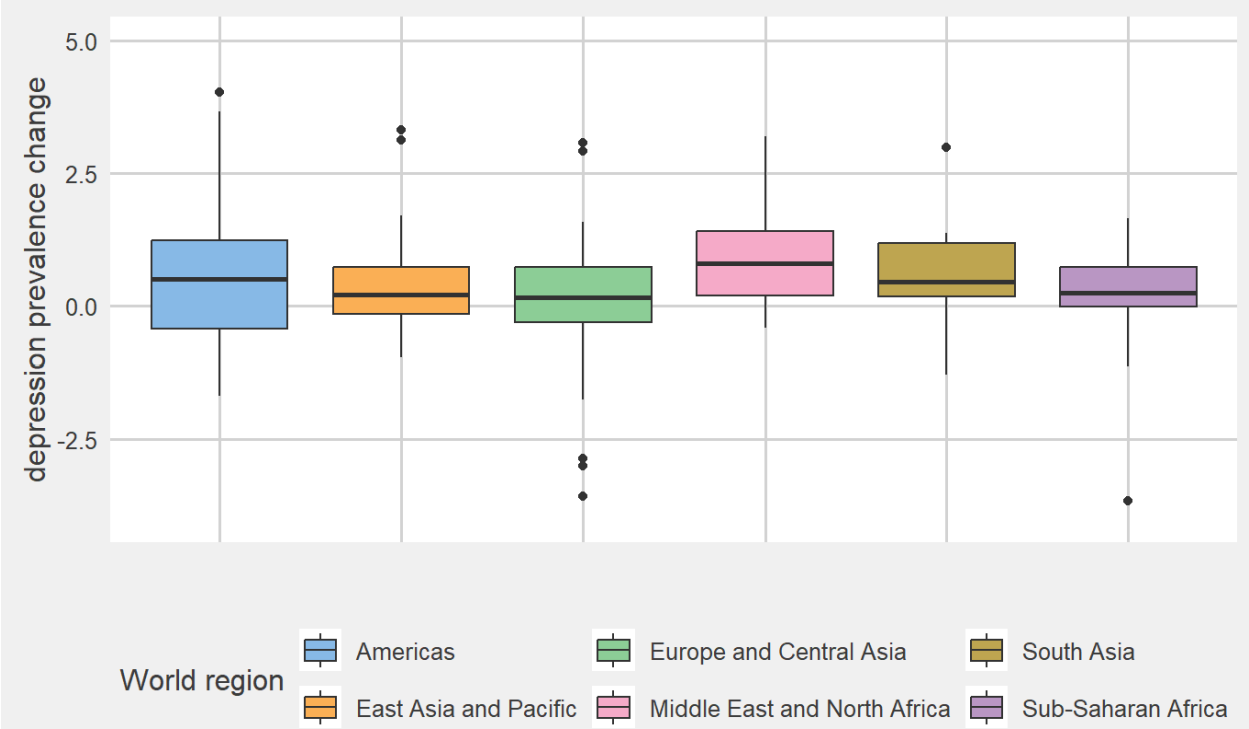


Note. The intervals are based on the quantiles of distribution but were slightly changed, so the interval breaks at 0.

Figure 8 display the distribution of the relative change in depressive disorders prevalence from 2015-2019, grouped by world regions. The mean and median in all world regions is positive and the distribution does not differ much per region. Aside from the Middle East and North Africa (mean [SD]: 0.59 [1.67], median [p25-p75]: 0.71 [-0.05-1.36]) and the Americas (mean [SD]: 0.65 [1.40], median [p25-p75]: 0.51 [-0.44-1.24]), which have the highest medians, the medians of the regions range between 0.18 and 0.45 (East Asia and Pacific (mean [SD]: 0.41 [0.92], median [p25-p75]: 0.21 [-0.16-0.73]); Europe and Central Asia (mean [SD]: 0.35 [1.90], median [p-25-p75]: 0.18 [-0.30- 0.74]); South Asia (mean [SD]: 0.69 [1.31], median [p25-p75]: 0.45 [0.17-1.18]); Sub-Saharan Africa (mean [SD]: 0.14 [1.19], median [p25-p75]: 0.23 [-0.04-0.73])).

Figure 8

Box and whisker plot of the relative change in depressive disorders prevalence from 2015-2019 grouped by world regions



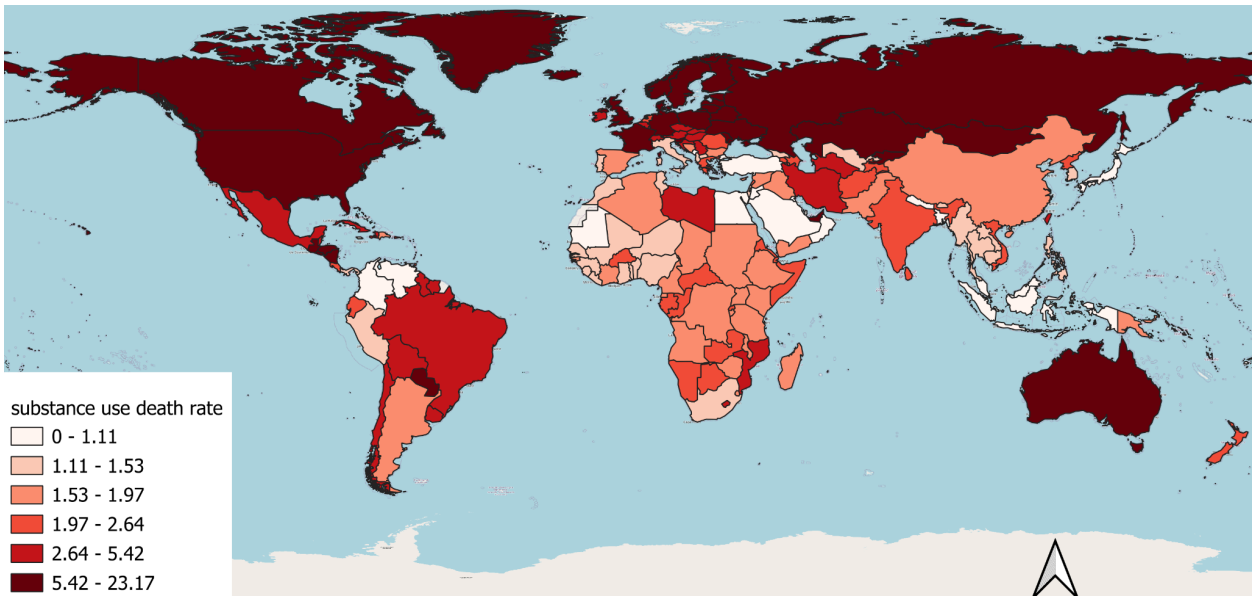
Note. 4 values are not included in the plot.

Substance Abuse

The annual number of deaths from alcohol and drug use disorders per 100,000 people in 2019 ranges from 0.28 in Egypt to 23.17 in Belarus. The global mean is 3.57, the median is 2.01 and the standard deviation is 4.1. Figure 9 shows the worldwide distribution of the annual number of deaths from alcohol and drug use disorders per 100,000 people. High numbers of alcohol and drug use disorder death rates can especially be observed in Northern Europe, North America and Australia (Figure 9).

Figure 9

World map showing the quantiles of distribution of the number of deaths from alcohol and drug use disorders per 100,000 people (2019)

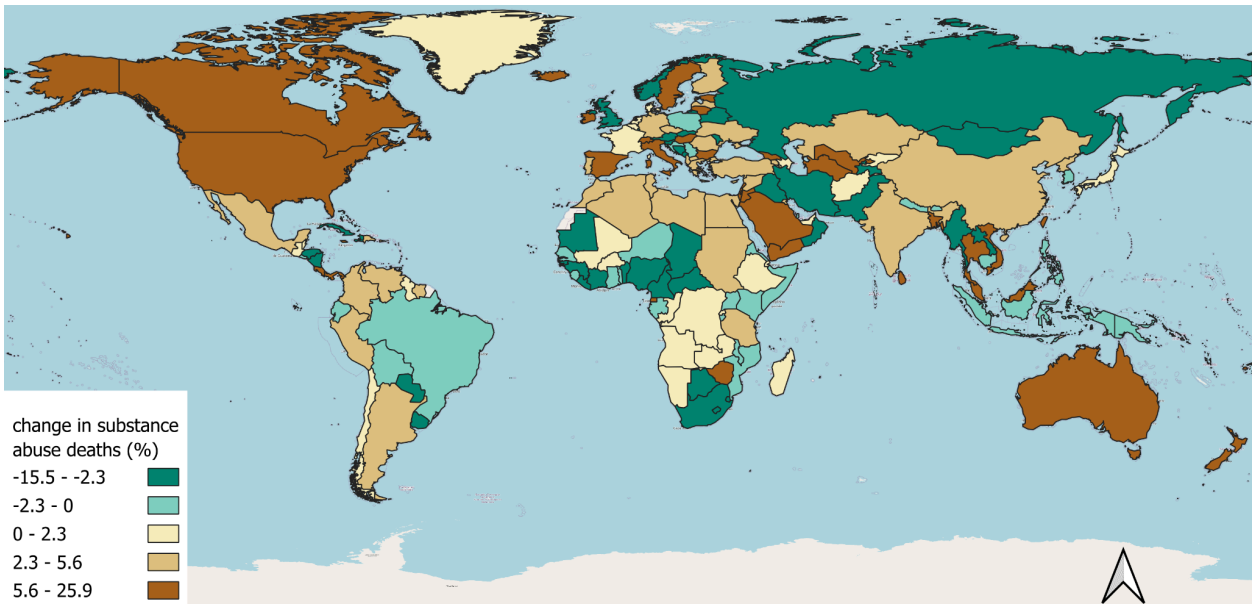


The relative change in alcohol and drug use disorders death rate between 2015 and 2019 ranges from -15.53% in South Africa to 19.61% in Cape Verde. On a global scale, the mean is 1.83%, the median 0.91% and the standard deviation is 5.46%, so there has been a global increase in alcohol and drug use disorder death rate. Figure 10 shows the quantiles of distribution of the relative change in alcohol and drug use disorders death rate between the years 2015 and 2019. In the five-year period, the death rate of alcohol and drug use disorder increased in 106 countries (yellow and brown on the map) and decreased in 83 countries (green on the map).

When comparing Figure 9 and 10, it can be seen that North America, which had a high number of deaths from alcohol and drug use disorders per 100,000 people in 2019, also experienced a high increase in the relative change in alcohol and drug use disorders death rate between 2015 and 2019. However, it is difficult to infer trends for other world regions.

Figure 10

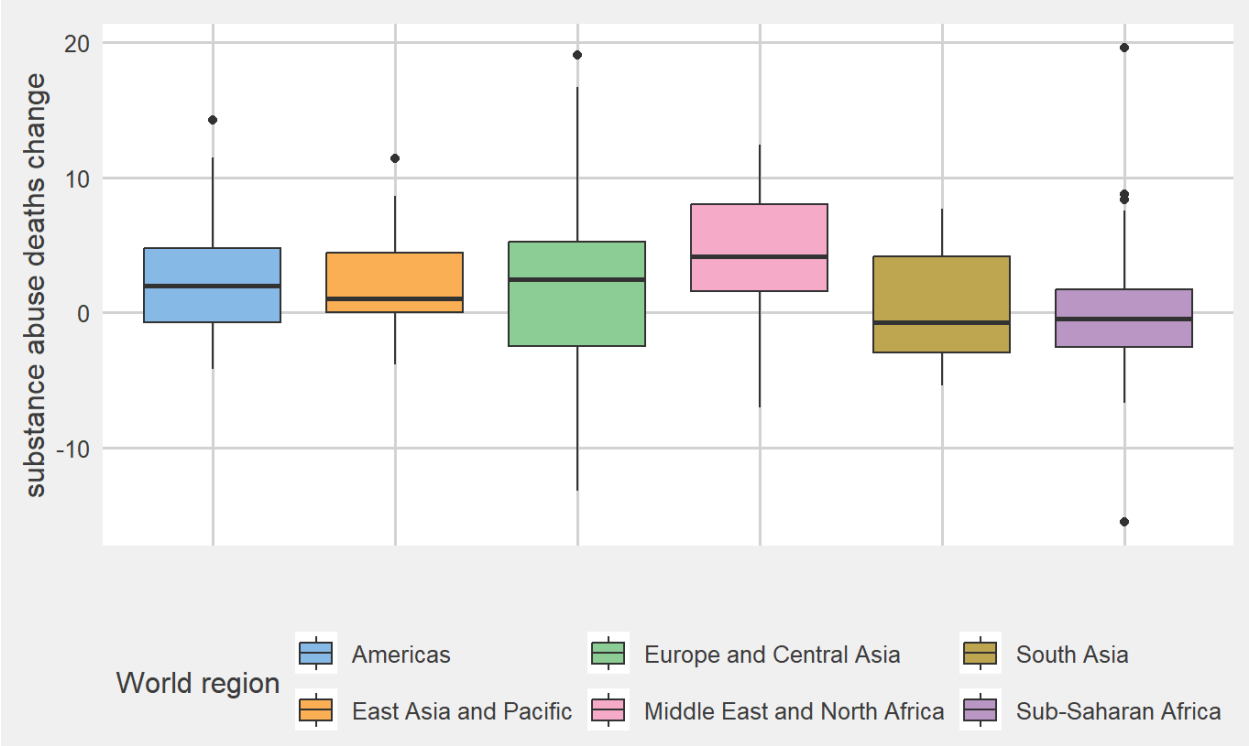
World map showing the quantiles of distribution of the relative change in alcohol and drug use disorders death rate (year 2015 to 2019)



In Figure 11, the distribution of the relative change in alcohol and drug use disorders death rate from the year 2015 to 2019 grouped by world regions, can be observed. The Middle East and North Africa experienced the biggest increase in death rates from substance abuse disorders (mean [SD]: 4.07 [4.97], median [p25-p75]: 4.17 [1.54-8.04], followed by Europe and Central Asia (mean [SD]: 2.63 [7.21], median [p25-p75]: 2.42 [-2.51-5.20]. However, Europe and Central Asia also has the biggest interquartile range (8.08). Furthermore, the Americas (mean [SD]: 2.32 [4.20], median [p25-p75]: 1.98 [-0.76-4.73]) and East Asia and Pacific (mean [SD]: 2.07 [3.90], median [p25-p75]: 1.05 [0.00-4.43]) have a similar distribution. Lastly the only two regions with a negative median are South Asia (mean [SD]: 0.56 [5.22], median [p25-p75]: -0.76 [-2.97-4.17]) and Sub-Saharan Africa (mean [SD]: -0.19 [5.02], median [p25-p75]: -0.48 [-2.59-1.68].

Figure 11

Box and whisker plot of the relative change in alcohol and drug use disorders death rate (year 2015 to 2019) grouped by world regions



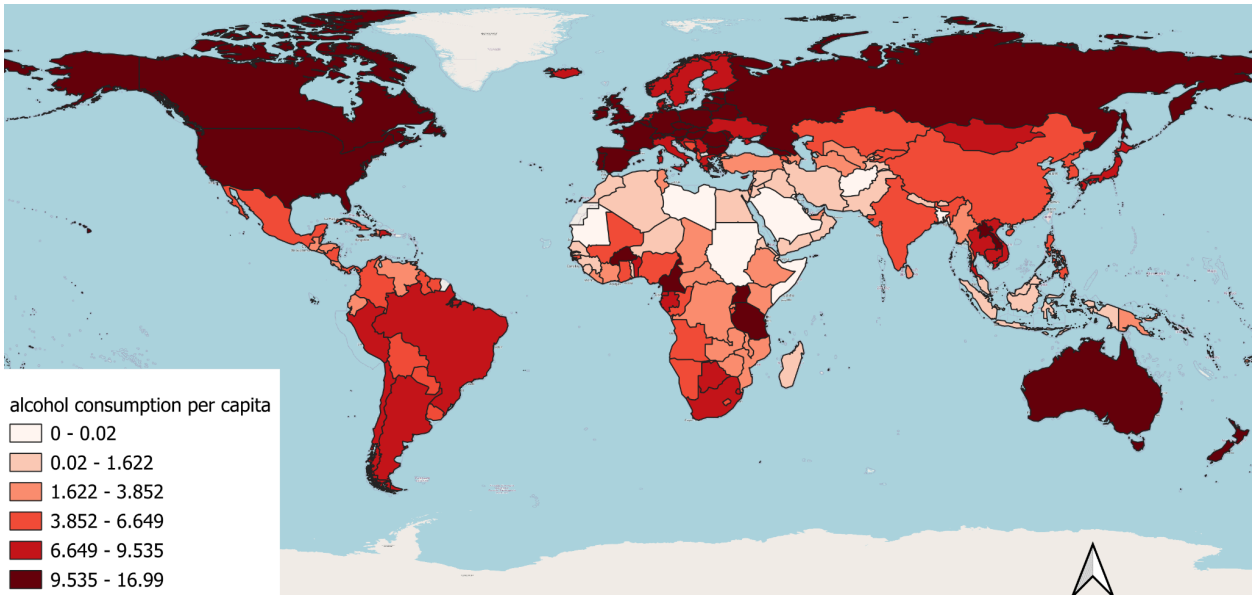
Note. 4 values are not included.

Alcohol Consumption

Alcohol consumption per capita in litres in 2019 ranges from 0 litres in Kuwait, Somalia, Saudi Arabia and Mauritania to 16.99 litres in Romania. The global mean is 5.39 litres, the median is 4.92 litres and the standard deviation is 3.99 litres. Figure 12 the quantiles of distribution of alcohol consumption. High alcohol consumption rates can especially be observed in Europe, North America and Oceania (Figure 12).

Figure 12

World map showing the quantiles of distribution of alcohol consumption per capita (2019)



The relative change in alcohol consumption between 2015 and 2019 ranges from -97.27% in Sudan to 85.13% in Afghanistan. On a global scale the mean is -0.77%, the median is 0% and the standard deviation 16.92%. In the five-year period, alcohol consumption decreased globally. Figure 13 shows the quantiles of distribution of the relative change in alcohol consumption from the year 2015 to 2019. During these five years, alcohol consumption increased in 82 countries (yellow and brown on the map) and decreased in 87 countries (green on the map).

Comparing Figure 12 and 13, it is difficult to identify trends between the relative change in alcohol consumption per capita between 2015 and 2019 and the alcohol consumption per capita in 2019.

Figure 13

World map showing the quantiles of distribution of the relative change in alcohol consumption per capita (year 2015 to 2019)

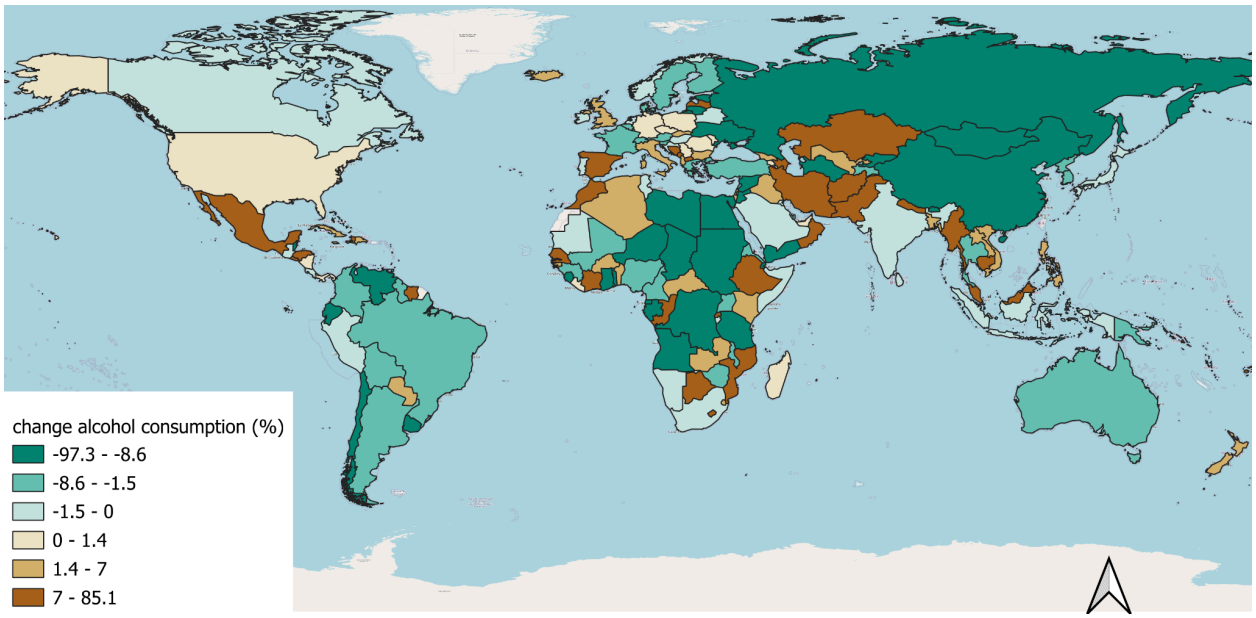
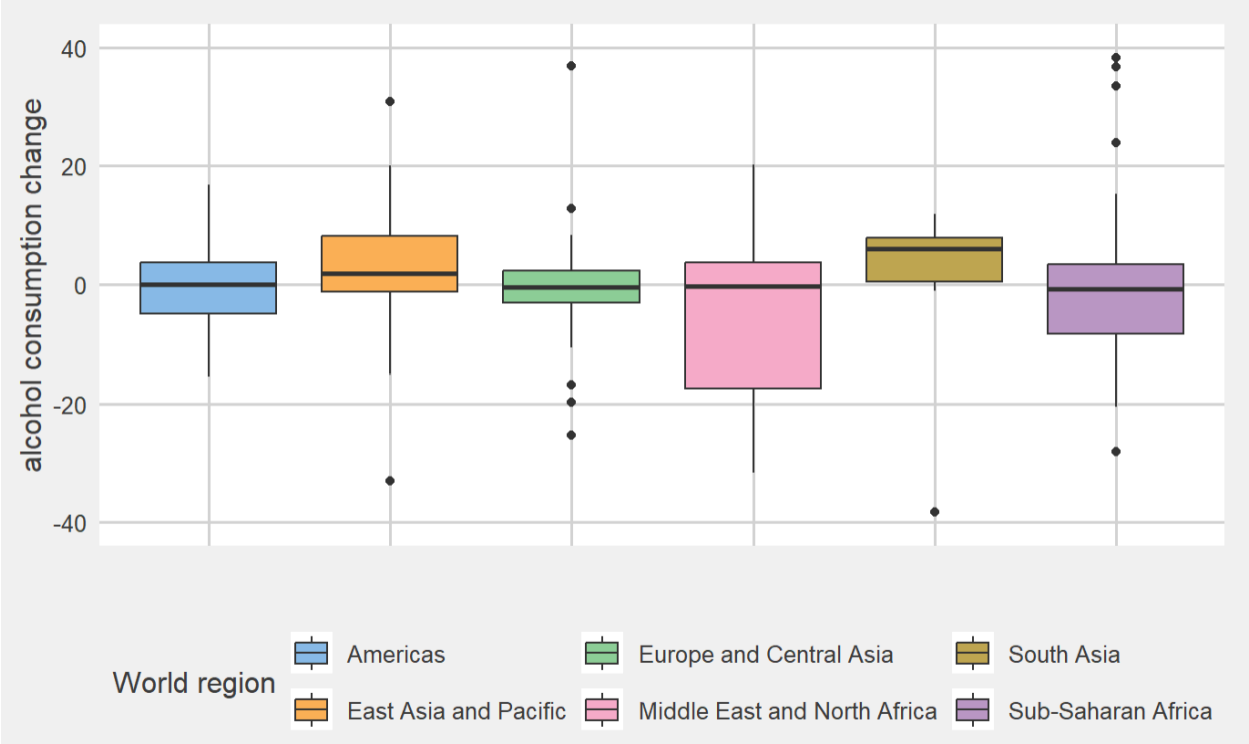


Figure 14 displays the distribution of the relative change in alcohol consumption between 2015 and 2019 grouped by world regions. South Asia experienced the highest increase in alcohol consumption (mean [SD]:11.15 [36.82], median [p25-p75]: 6.83 [2.07-10.13] and the Middle East and North Africa has the biggest interquartile range of 21.14 (mean [SD]: -6.25, median [p25-p75]:-0.34 [-17.41-3.73]). For the Americas (mean[SD]: -1.11 [12.23], median [p25-p75]: -0.06 [-5.89-3.69]), East Asia and the Pacific (mean [SD]: 4.92 [15.45], median [p25-p75]: 1.94 [-0.95-9.95]), Europe and Central Asia (mean [SD]: -0.68 [9.17], median [p25-p75]: -0.47 [-3.13-2.30]: and Sub Saharan Africa (mean [SD]: -3.33 [21.10], median [p25-p75]: -1.31 [-10.60-3.26]) the distributions do not differ significantly and their interquartile ranges are in between -10 and 10.

Figure 14

Box and whisker plot of the relative change in alcohol consumption (year 2015 to 2019) grouped by world regions



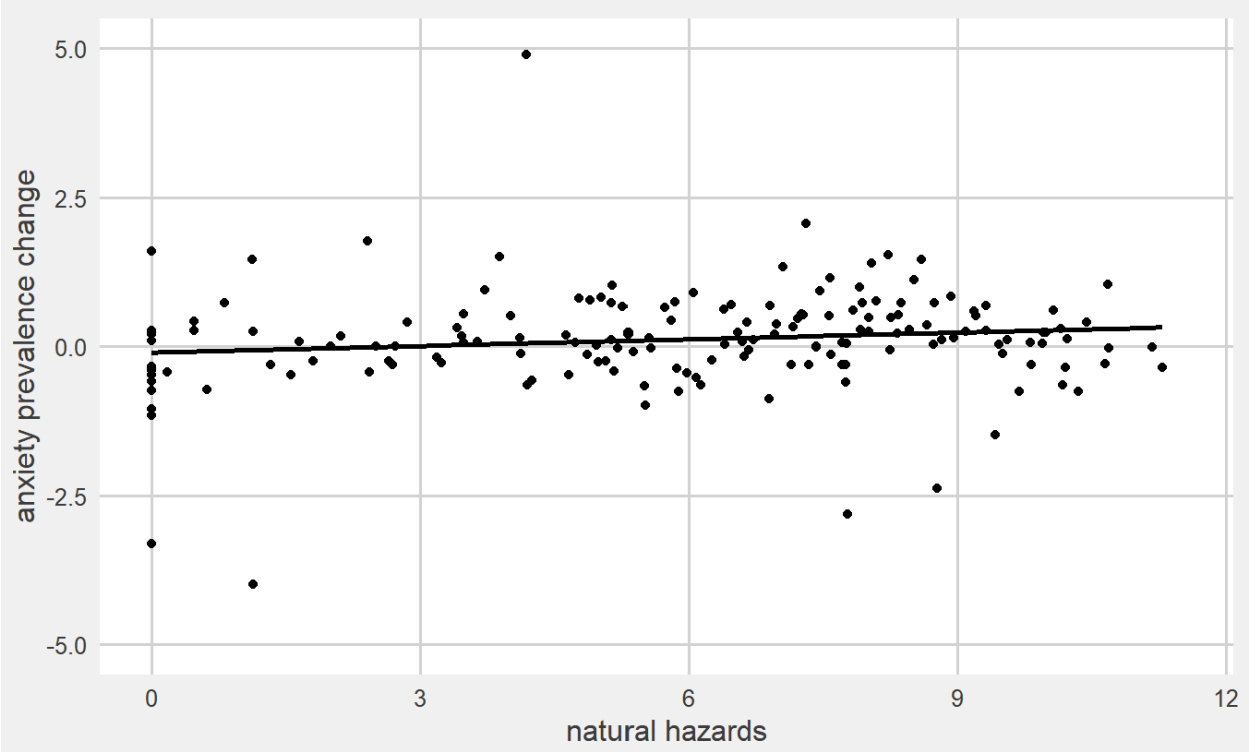
Note. 5 values are excluded from the plot

Regression Analysis

The results for the crude and adjusted linear regression model are displayed in Table 2. In the crude model, the average number of people affected by natural hazards per 100,000 is positively associated with a relative change in anxiety disorders over a five-year period (β 0.0003; 95% CI -0.00 – 0.0006; p = 0.052). The association is borderline significant since p = 0.052. For every 100 new people per 100.000/year affected by natural hazards, the change in anxiety disorders prevalence increases by 0.03 percentage points. The linear regression model is displayed in Figure 15.

Figure 15

Scatter plot graph with regression line of the association between the total number of people affected by natural hazards (log transformed) over 5 years and the relative change in anxiety disorders prevalence (2015-2019)



Note. 6 values are excluded from the plot

In the crude model there was no significant association found between the change in depressive disorder and the average amount of people affected by natural hazards. However, in the adjusted model the average number of people affected by natural hazards period is negatively associated with the relative change in depressive disorder prevalence over a 5-year period (β -0.0014; 95% CI -0.0026 – -0.0001; p = 0.035). For every 100 new people per 100.000/year affected by natural hazards, the change in depressive disorders prevalence decreases by 0.14 percentage points.

For the other two outcome variables, the change in substance use deaths and the change in alcohol consumption, there was no significant association found with the exposure variable, natural hazards, in both the crude and adjusted model.

Besides that, associations between the outcome variables and confounders were found in the crude model. The relative change in anxiety disorder prevalence is significantly associated with GDP per capita, Global Peace Index, Universal Health Coverage and Urbanisation. The relative change in depressive disorder prevalence is significantly associated with GDP per capita and the relative change in substance use disorders death rate is associated with GDP per capita, Universal Health Coverage and Urbanisation, while the relative change in alcohol consumption is only associated with urbanisation. Conversely, these associations are lost in the adjusted regression model (Table 1).

All models were tested for interaction with both income groups and world regions, but no significant interaction was found. Furthermore, a sensitivity analysis was performed without the healthcare variable. However, the associations were maintained in the sensitivity analysis, so the results of the sensitivity analysis are not displayed.

Table 1

Crude and adjusted linear regression beta coefficient and relative 95% confidence interval (CI) assessing the association between the average number of people affected by natural hazards per 100,00 over 5 years and the four different mental health and substance use outcomes

	Crude β coefficient	**Adjusted β coefficient**	**Crude β coefficient**	**Adjusted β coefficient**
	Relative change in anxiety disorder prevalence		**Relative change in depressive disorder prevalence**	
	N	**N = 114**	**N**	**N = 125**

Natural hazards*	**159**	**0.0003 (-0.00 – 0.0006)**	0.0001 (-0.0003 – 0.0006)	**172**	-0.0006 (-0.0015 – 0.0002)	**-0.0014 (-0.0026 – -0.0001)**
GDP per capita*	**173**	**-0.0015 (-0.0022 – -0.0008)**	0.0004 (-0.0021 – 0.0028)	**186**	**0.0022 0.0002 – 0.0043**	0.0048 (-0.0020 – 0.0115)
Global Peace Index	**148**	**0.22 (0.04 – 0.40)**	0.18 (-0.09 – 0.45)	**161**	-0.32 (-0.83 – 0.18)	0.06 (-0.69 – 0.82)
Universal Health Coverage	**180**	**-0.01 (-0.01 – -0.00)**	-0.00 (-0.02 – 0.01)	**193**	0.01 (-0.00 – 0.02)	-0.01 (-0.05 – 0.03)
Urban population	**163**	**-0.01 (-0.01 – -0.00)**	-0.00 (-0.01 – 0.00)	**174**	0.00 (-0.01 – 0.01)	-0.02 (-0.04 – 0.00)
	Relative change in substance use disorders death rate			**Relative change in alcohol consumption**		
	N		**N =125**	**N**		**N = 125**
Natural hazards*	**172**	-0.0025 (-0.0053 – 0.0004)	-0.0001 (-0.0043 – 0.0042)	**160**	0.0062 (-0.0028 – 0.0152)	0.0017 (-0.0103 – 0.0138)
GDP per capita*	**186**	**0.0127 (0.0057 – 0.0198)**	0.0118 (-0.0111 – 0.0347)	**176**	-0.0074 (-0.0287 – 0.0139)	-0.0208 (-0.0852 – 0.0437)
Global Peace Index	**161**	-0.67 (-2.46 – 1.11)	1.14 (-1.41 – 3.68)	**158**	-2.53 (-7.91 – 2.85)	-0.37 (-7.55 – 6.80)

Universal Health Coverage	**194**	**0.09 (0.04 – 0.14)**	0.07 (-0.06 – 0.20)	**183**	0.01 (-0.14 – 0.15)	0.26 (-0.11 – 0.62)
Urban population	**175**	**0.06 (0.02 – 0.09)**	-0.00 (-0.08 – 0.07)	**164**	**-0.13 (-0.23 – -0.02)**	-0.16 (-0.37 – 0.06)

**Note.* Log transformed variables were calculated back

Discussion

Mental Health Disorders

This is the first study exploring the ecological association between the exposure to natural hazards and mental health disorders and substance abuse behaviours on a global scale. Overall, the findings of this study do not point at an association between the exposure to natural hazards and substance abuse behaviours and are inconclusive regarding the association with mental health disorders.

The crude regression model suggests that per every 100 more people per 100.000/year affected by natural hazards, the change in anxiety disorders prevalence increases by 0.03 percentage points. This suggests that several public health risks coexist and might work in unison at the population level, even in the absence of direct causality. The association of the change in anxiety disorder prevalence and GDP per capita, the Global Peace Index, Universal Health Coverage, and urbanisation in the crude model suggests that there may be other factors impacting this relationship. Nonetheless, it cannot be identified which factors are the most prominent in influencing the change in anxiety disorder prevalence.

It is also important to note that the number of countries included in the regression model significantly decreases from the crude to the adjusted model (N=159 vs N=114), potentially impacting the results as well.

Aside from the confounders used in this analysis, there are a number of complex individual and socioecological factors that could not be assessed on country level, but could explain the coexistence of natural hazards and the increase in the change of anxiety disorder prevalence.

Firstly, the intensity and type of traumatic events during natural hazards that a person has experienced throughout their life can determine the mental health response they have after the event of a natural hazard (Cerna-Turoff et al., 2024). A number of studies investigating the mental health impact on children after natural disasters, found that only children who had previously experienced trauma or specific negative events during and after the natural hazard showed a significant increase in anxiety and depressive symptoms. These negative experiences included events such as being trapped during the disaster, suffering injury, fear, or bereavement during the disaster, witnessing injury or death, or having inadequate social support (Tang et al., 2014). Additionally, a person's world views and actions can further influence the impact natural hazards have on mental health. On the one hand, behaviours such as humour, positive reframing, and acceptance can act as protective measures for mental health outcomes. On the other hand, stoicism and maladaptive coping mechanisms, such as venting and diversion, can worsen mental health conditions (Bei et al., 2013). Likewise, those who turn to religion as a coping mechanism to derive significance and constructive lessons from adversity, tend to have better mental health outcomes when dealing with phycological stress (Ano & Vasconcelles, 2005).

Lastly, people's mental health conditions and recovery after traumatic experiences are influenced by their social support networks; their families, communities and societies overall. Following natural hazards, the development of symptoms of poor mental health is influenced by social and familial support as well as the broader geopolitical setting (Wickrama & Kaspar, 2007). A study by Wind et al. (2011) studied the relationship between social capital and disaster mental health outcomes and found that those who had social support after the experience of natural hazards, had better mental health outcomes.

Although this study adjusted for all meaningful confounding variables that could be measured at country level, these individual and social factors could not be accounted for and might therefore have impacted the results.

Furthermore, there was no association found between natural hazards and the change in depressive disorder prevalence in the crude model. However, the adjustment of confounders reveals a significant relationship that was not apparent in the crude model. Per every 100 more people per 100.000/year affected by natural hazards, the change in depressive disorders prevalence decreases by 0.14 percentage points. These findings contradict what previous literature has found (Lawrance et al., 2022; Romanello et al., 2021; IPCC, 2022; Wahid et al., 2023; Clayton, 2021; WHO, 2023: Haase, 2023; European Climate and Health Observatory & Climate ADAPT, 2024), as well as the finding in this study of the positive coexistence of average amount of people affected by natural hazards and the change in anxiety disorder prevalence. It is important to note that previous studies have studied populations that were directly affected by natural hazards and did not measure the increase of depressive disorders on the scale of an entire country's population. This implies that on a country level, the average impact of natural hazards may not be great enough to drastically change a country's prevalence rates of mental health

disorders. Besides that, the contradiction in findings with anxiety disorders could be explained with the onset period of depression. While anxiety can arise more quickly, especially in reaction to particular stressors, depression is generally more likely to develop gradually over an extended period of time (Wiseman et al., 2015). As a result, the five year period used in this study might not be sufficient to capture the full extent of the possible impact of natural hazards on depression disorders.

Substance Abuse

For both, the relative change in substance use disorders death rate and the relative change in alcohol consumption, there were no significant associations found with the average number of people affected by natural hazards in the crude, as well as the adjusted model. These findings are not aligned with what previous literature has found (Haase, 2023; U.S Global Change Research Program, 2016; Cunsolo et al., 2017; Van Duijvenbode & VanDerNagel, 2019; Clayton, 2021; Cruz et al., 2020; Evans, 2019; Middleton et al., 2020; Wu et al., 2020; Chevance et al., 2022). Similarly to what was said before concerning depressive disorders, it is important to highlight that previous studies have studied populations that were directly affected by natural hazards and did not measure the change of these factors at a country's population level. Again, this implies that on a country level, the average impact of natural hazards may not be great enough to drastically change a country's substance abuse rates.

Aside from that, the consumption of alcohol and other substances is highly dependent on social and cultural norms. In some cultures, drinking is a common cultural and social practices, while it is frowned upon in others (Castro et al., 2014). Likewise, different policies and regulations can have an impact on the alcohol consumption and drug use of a country. These policies include the drinking age of a country, restrictions regarding the sale and purchase of

substances, taxation policies, as well as potential prosecution for the use or sale of substances (Brand et al., 2007; Walsh et al., 1989). In Kuwait, for example, the alcohol consumption per capita has been zero litres from the earliest (2000) to the latest point of measurement (2019) (*World Bank Open Data*, n.d.), since it is illegal to possess, consume, produce or carry alcohol or any other substance in the country (WHO, 2018).

In this study, the impact of cultural factors and policies was minimised by calculating the relative change of the substance use disorders death rate and the alcohol consumption per capita, however these factors can still not be fully accounted for.

Limitations

This global country-level ecological study aims to capture the global distribution of variables and their associations. Because of this, the study's main weakness is ecological fallacy, which implies that relationships observed at population level might not necessarily apply to the individual level (Sui, 2009). This implies that any association found at population level would have to be verified on an individual scale.

Furthermore, this study aimed at investigating the impacts of climate change. However, the variable used to measure the impact of climate change, natural hazards, does not only include climate related disasters, but also geophysical events. Nonetheless, since over 90 percent of natural hazards are weather related (UNEP, n.d.), this limitation is minimised. Besides that, this variable includes the total number of people who have been injured, required assistance or become homeless due to natural hazards, but does not account for economic losses, damage to infrastructure or the destabilization of communities, which can also impact mental health in the long term (WHO, 2023; IPCC, 2023; Clayton, 2021; Haase, 2023). Moreover, the impacts of

climate change are not only restricted to the impacts of climate related hazards, but also include emotional responses, such as climate anxiety and other eco-emotions to the current or projected changes in the climate and environment (European Climate and Health Observatory & Climate ADAPT, 2024).

Additionally, the study would have benefitted from the use of mental health incidence rates, rather than calculating the change in prevalence, to estimate how many new cases emerged in the given time period. However, it is important to note that the use of prevalence rates in this study was due to data availability.

Similarly, this study investigated the time frame from 2015-2019 due to data availability, but as extreme weather events are becoming more frequent each year (IPCC, 2023), the analysis would have benefitted from the use of a more recent time frame.

Lastly, another limitation due to data availability was that post-traumatic stress disorders (PTSD) could not be investigated in this study, even though it has been identified as one of the main mental health disorders triggered by natural hazards, along with anxiety and depressive disorders, in previous literature (WHO, 2023: Haase, 2023; European Climate and Health Observatory & Climate ADAPT, 2024; U.S Global Change Research Program, 2016).

Conclusion and Implications

The average number of people affected by natural hazards was not associated with an increased substance use globally and was inconclusive regarding the association with mental health disorders, when analysed at country level and adjusting for possible confounders. However, countries with a higher proportion of the population affected by disasters also experienced a higher change in the prevalence of anxiety disorders and after adjusting for

confounders there is a negative association between the proportion of people affected by natural hazards and the change in depressive disorder prevalence. Overall, these findings are not aligned with what previous literature has found, implying that on a country level, the average impact of natural hazards may not be great enough to drastically change a country's prevalence rates of substance abuse and mental health disorders. As a result, future research should give priority to sub-national analysis, rather than country level analysis, in order to identify particular locations or populations that are disproportionately impacted by natural hazards and assess their subsequent mental health and substance abuse impacts. Hereby, future research should also investigate the role of confounding factors that could not be included in this study, such as psychological coping mechanisms and community support, as well as cultural influences regarding substance use.

Besides that, more research is needed to investigate the indirect impacts of natural hazards and assess the impact of repercussions on infrastructure and economic stability on mental health disorders and substance use. Additionally, the impacts of climate change are not only restricted to the impacts of climate related hazards, but also include emotional responses, such as climate anxiety and other eco-emotions, to the current or projected changes in the climate and environment (European Climate and Health Observatory & Climate ADAPT, 2024), which went beyond the scope of this study but should be addressed in future research to investigate the full impact climate change has on mental health.

Lastly, several limitations of this study were due to data availability, highlighting the importance of global data collection on planetary health related issues. More data on these issues would help to establish a greater degree of accuracy in future studies and would enable a better assessment of the full impacts of climate change on human health.

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