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# BMJ Open

**An ecological study of the association between mental illness with human development, income inequalities and unemployment across OECD countries: considering the heterogeneity of mental issues and the interdependence of social effects**

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-035055
Article Type:	Original research
Date Submitted by the Author:	17-Oct-2019
Complete List of Authors:	Barbalat, Guillaume; CNRS & Université Lyon 1 Franck , Nicolas ; CNRS & Université Lyon 1
Keywords:	MENTAL HEALTH, EPIDEMIOLOGY, SOCIAL MEDICINE

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2 **TITLE PAGE**  
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6 **Title:** An ecological study of the association between mental illness with human development,  
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8 income inequalities and unemployment across OECD countries: considering the heterogeneity of  
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10 mental issues and the interdependence of social effects.  
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48 **Abstract word count:** 297.  
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50 **Word count:** 1315 (excluding references, tables and acknowledgements).  
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## **ABSTRACT**

### **OBJECTIVES**

Recent studies have demonstrated worsened mental health in relatively highly developed countries impacted by social inequalities and unemployment. Here, we investigate (1) whether mental health issues are differently or similarly affected by these social factors; and (2) whether their effects on mental health are related or unrelated to each other.

### **SETTING**

Analysis at the country level amongst OECD (Organization for Economic Cooperation and Development) countries (N=36). Data on social indicators was collected from OECD and United Nations Development Programme (UNDP) databases. Data on the prevalence of mental issues was obtained from the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease (GBD) study 2017.

### **PARTICIPANTS**

No involvement of participants.

### **PRIMARY AND SECONDARY OUTCOME MEASURES**

Using linear regression models, we investigated the relative contribution played by human development (as measured by the Human Development Index - HDI), social inequalities (GINI index) and unemployment (unemployment rate) on the prevalence of 10 mental health issues. We then measured the relationship between the socio-economic factors' effects on mental issues using 2x2 Pearson's correlation test and Principal Component Analysis.

### **RESULTS**

First, the overall effect of each socio-economic factor on a combination of mental health disorders was large (r range: 0.51-0.76;  $p < 0.002$ ). However, the influence of social factors on mental health was relative to each mental issue (r range: -0.34 to 0.74). Second, the socio-economic factors' effects on mental health showed strong interdependence ( $r_{\text{HDI-GINI}} = 0.93$ ,  $r_{\text{HDI-unemploy}} = 0.81$ ,  $r_{\text{unemploy-GINI}} = 0.84$ ;  $p < 0.001$ ). Principal component analysis demonstrated that the first principal component of

1  
2 the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained 91.5% of the variance.  
3

#### 4 **CONCLUSION**

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7 These results implore a re-analysis of the socio-economic determinants of mental health where: 1)  
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9 the heterogeneity of mental health issues would be taken into account; and 2) each socio-  
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11 economic indicator's effect would be analysed and interpreted in conjunction with the others.  
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## **STRENGTHS AND LIMITATIONS OF THIS STUDY**

- We investigated whether mental health issues across OECD countries were differently affected by human development, income inequalities and unemployment; and whether these social factors' effects on mental health were related to each other
- Data on the prevalence of mental issues was obtained from the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease (GBD) study 2017, from which an increasing number of high-impact epidemiological studies has already been published
- We found that the strength of the association between mental health with development, inequalities and unemployment was relative to each mental health issue; and that their effects were strongly related to each other
- We conclude that, when investigating the social determinants of mental health, it is crucial to consider the heterogeneity of mental issues and the interdependence of social effects
- One limitation of this study is its observational nature, meaning that we need to be cautious about any over-interpretation of our results as demonstrating causality

## **MAIN TEXT**

### **INTRODUCTION**

Recent studies have suggested that relatively highly developed countries demonstrate worsened mental health when impacted by income inequalities [1–3] and unemployment [4]. Although this has been of great interest to social epidemiologists, two important questions have remained unanswered. First, it is unclear whether mental health issues are differently or similarly affected by these social factors. Given the heterogeneity of mental health problems, one would expect a differential impact of these social factors on various mental health issues. A second uncertainty is whether their effects on mental health are related or unrelated to each other. If they are related, a hypothesis might be that there is an underlying common structure that may account for such effects.

This study aimed at better categorizing the relations between development, inequalities, and unemployment with the prevalence of various mental health issues at the country level. To allow for comparability across populations and minimize the risk of outliers, we restricted our analyses to the 36 countries that belong to the Organization for Economic Cooperation and Development (OECD).

### **METHODS**

#### **Data series**

##### Dependent variable

Prevalences of mental health issues across OECD countries were collected from the Institute of Health Metrics & Evaluation (IHME)'s Global Burden of Disease (GBD) project database [5], where data is estimated from a combination of surveys, medical and epidemiological data, as well as meta-regression models.

Data was extracted for year 2017 for a combination of mental health disorders and the specific following issues: depressive disorders, anxiety disorders, schizophrenia, bipolar disorders,



1  
2 eating disorders, alcohol use disorders, attention-deficit/hyperactivity disorder, autism spectrum  
3 disorders and suicide (**Table 1**). Prevalence data was age standardized, which allowed  
4 comparability across populations when their age profiles were different.  
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### 10 11 Independent variables

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13 Each country's level of human development was measured with the Human Development Index  
14 (HDI; range: 0-1). The HDI summarizes life expectancy, a combination of adult literacy rate and  
15 school enrolment rate, and gross domestic product per capita at purchasing power parity [6].  
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21 For each country, income inequality was measured using the GINI index (range: 0-1), which  
22 intends to represent a nation's income distribution [7]. A GINI coefficient of 0 means that the  
23 country income is perfectly equally distributed. A GINI coefficient of 1 means that all the country's  
24 income is received by just one person.  
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30 Our third socio-economic indicator was unemployment rate, which measures the rate of  
31 unemployment as a percentage of the labour force [8].  
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35 Data for the three predictors was collected from the OECD database except for HDI, which  
36 was retrieved from the United Nations Development Programme database (**Table 1**). Data was  
37 extracted for year 2016, except when unavailable, in which case data was extracted for the closest  
38 year previous to 2016 (year range for data collection: 2014-2016).  
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45 *Table 1 about here*  
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### 50 51 52 53 **Statistical Analysis**

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55 We ran multiple regression linear models where the prevalence of a mental issue across OECD  
56 countries is predicted by the HDI, GINI index, and unemployment rate. Extreme outliers were  
57 defined as data points with Cook's distance > 1 [9]. Using this cut-off, we were not able to identify  
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1  
2 any outliers when running our linear models.  
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4 For each mental health issue, we then converted each of the socio-economic indicators' t  
5 statistic into their corresponding effect size (Pearson's  $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ). We then computed 2x2  
6 Pearson's correlation coefficients between those 3 variables ( $r_{\text{HDI-GINI}}$ ,  $r_{\text{HDI-unemploy}}$ ,  $r_{\text{unemploy-GINI}}$ ) to  
7 estimate their pairwise relationships across all mental health problems. Finally, to investigate the  
8 linear dependency between the 3 indicators' effect sizes, we ran principal component analysis and  
9 obtained explained variance for the first principal component.  
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17 An important caveat when collecting mental health data at the country level is that  
18 prevalence could reflect healthcare spending (which allows for more focus on mental health  
19 disorders) rather than giving a representative perspective on differences between countries. For  
20 our data, Pearson's  $r$  between combined mental health disorders prevalence and healthcare  
21 spending as measured by price per capita at purchasing power parity (obtained from the OECD  
22 database [10]) was of 0.58 ( $p < 0.001$ ). To check that our results were not impacted by overall  
23 healthcare expenditures, we decided to regress out the influence of healthcare spending on the  
24 prevalence of each mental health issue and to re-run our analysis using the residuals as  
25 dependent variables. Finally, to check that our results were not too influenced by outliers, we also  
26 ran our analysis using robust regression methods.  
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39 To run these analyses, we used R 3.6.1.  
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#### 44 **Patient and public involvement**

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47 No patients were involved in this study.  
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## 52 **RESULTS**

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55 Multiple linear regression models performed on the prevalence of a combination of mental health  
56 disorders revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment  
57 ( $r_{\text{unemploy}}$ ) was large ( $r$  range: 0.51-0.76). However they demonstrated great variation when  
58 measured amongst different mental health issues ( $r$  range: -0.34 to 0.74; **Table 2 and**  
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2 **Supplementary Table 1**), the most prominent being no positive effect on suicide and alcohol use  
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4 disorders, and a larger effect on other mental disorders.

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6 Across mental issues, the socio-economic indicators' effect sizes were strongly related to  
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8 each other (Pearson's  $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.81$ ,  $r_{\text{unemploy-GINI}}=0.84$ ). Principal component  
9  
10 analysis demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ )  
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12 explained 91.5% of the variance ( $p=0$ , permutation test with 1000 repetitions).  
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18 *Table 2 about here*  
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26 Finally, note that re-running our analysis after controlling for overall healthcare spending  
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28 across countries and using robust method to control for outliers clearly reproduced this pattern of  
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30 results (**Supplementary Results; Supplementary Tables 2 and 3**).  
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## 33 34 35 **DISCUSSION**

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37 We first demonstrated that, amongst OECD countries, the strength of the relationship between the  
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39 prevalence of mental health issues with development, inequalities and unemployment, whilst  
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41 overall large for a combination of disorders, was in fact relative to each mental health issue.  
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43 Specifically, development, inequalities and unemployment did not negatively impact suicide and  
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45 alcohol use disorders where prevalence could be influenced by other, more fine-grained, socio-  
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47 cultural factors (such as long-term unemployment [11] or work stress [12]). In contrast, other  
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49 disorders tested in this study were clearly associated to these social factors though to various  
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51 degrees. Hypotheses on how each of those mental issues specifically relies to development,  
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53 inequalities and unemployment are beyond the scope of this study and are open to further  
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55 empirical testing.  
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59 A second important finding of our study is that the socio-economic factors' effects on mental  
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1 health are strongly related to each other. This suggests that they share an underlying common  
2 structure. In modern societies, development, inequalities and unemployment can all be viewed as  
3 indicators of key cultural values and norms. That is, a high level of development sets priorities for  
4 people to reach a high threshold of desired outcomes [13]; greater income inequalities can shape  
5 attitudes towards reaching a higher social position compared to others [14]; and not having a job is  
6 typically perceived as being a failure. Overall, these social factors' unifying feature may be their  
7 underlying pressure for success, which in turn could explain their negative impact on mental  
8 health.  
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## 22 **Limitations**

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24 First, because our research questions were directly related to the association of national-level  
25 mental health prevalence and socio-economic indicators, we considered the ecological design the  
26 most appropriate for our study [1]. However, the observational nature of our analysis implies that  
27 other uncontrolled socio-cultural factors might have influenced the prevalence of mental issues in  
28 individual countries. We obviously need to be careful about any over-interpretation of our results as  
29 demonstrating causality while our models can only be predictive.  
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37 Second, it is likely that the effect of development, inequalities, and unemployment is  
38 different across non-OECD countries and especially low and middle income countries. However,  
39 as most of the European and North American populations were included, our results are probably  
40 generalizable to western countries.  
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## 49 **Conclusion**

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51 Despite those limitations, these results implore a re-analysis of the socio-economic determinants of  
52 mental health where: 1) the heterogeneity of mental health issues would be taken into account;  
53 and 2) each socio-economic indicator's effect would be analysed and interpreted in conjunction  
54 with the others.  
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2 **DECLARATION OF INTEREST**  
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4 The authors have no biomedical financial interests or potential conflicts of interest.  
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8 **FUNDING**  
9

10 This research received no specific grant from any funding agency, commercial or not-for-profit  
11 sectors.  
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16 **AUTHOR CONTRIBUTION**  
17

18 All authors were involved in drafting the article or revising it critically for important intellectual  
19 content, and have read and approved the final version of the manuscript. G.B. and N.F. designed  
20 the study. G.B. gathered the data. G.B. and N.F. analysed the data and wrote the paper.  
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28 **DATA AVAILABILITY**  
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30 Data is available upon request to the corresponding author.  
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**TABLES****Table 1. Descriptive statistics for dependent and independent variables.**

Variable	Range	Mean	Standard Deviation
Prevalence of combined mental health disorders <sup>a</sup> (%)	10.87-18.71	14.28	2.13
Prevalence of Autism Spectrum Disorders (%)	0.36-0.94	0.60	0.12
Prevalence of ADHD (%)	0.43-2.53	1.15	0.40
Prevalence of Depressive Disorders (%)	2.25-4.84	3.71	0.65
Prevalence of Schizophrenia (%)	0.20-0.36	0.26	0.05
Prevalence of Anxiety Disorders (%)	2.94-8.50	4.93	1.46
Prevalence of Eating Disorders (%)	0.23-0.94	0.48	0.18
Prevalence of Alcohol Use Disorders (%)	0.46-4.71	1.84	0.99
Prevalence of Suicide (per 100.000)	3.31-27.99	10.89	4.75
Prevalence of Bipolar Disorders (%)	0.57-1.21	0.86	0.15
HDI	0.77-0.95	0.89	0.04
GINI index	0.24-0.46	0.32	0.05
Unemployment rate (%)	2.97-23.54	7.41	4.20

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**Table 2: Effects of human development, income inequalities and unemployment on the prevalence of 10 mental health issues across OECD countries.**

Pearson's r	Combined	ASD	ADHD	DEP	SCZ	ANX	ED	ETOH	SUICIDE	BD
$r_{\text{HDI}}$	0.76	0.74	0.21	0.68	0.72	0.65	0.74	-0.27	-0.07	0.43
$r_{\text{GINI}}$	0.59	0.46	0.30	0.59	0.49	0.40	0.45	-0.10	-0.07	0.14
$r_{\text{unemploy}}$	0.51	0.15	0.27	0.42	0.18	0.29	0.45	-0.18	-0.34	0.30

“Combined”: combination of Autism Spectrum Disorders, Attention-Deficit/Hyperactivity Disorders, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders; “ASD”: Autism Spectrum Disorders; “ADHD”: Attention-Deficit/Hyperactivity Disorders; “DEP”: Depressive Disorders; “SCZ”: Schizophrenia; “ANX”: Anxiety Disorders; “ED”: Eating Disorders; “ETOH”: Alcohol Use Disorders; “SUICIDE”: suicide rates; “BD”: Bipolar Disorders.



## SUPPLEMENTARY MATERIAL

### SUPPLEMENTARY RESULTS

#### Analysis taking into account overall healthcare spending

To ensure that our results were not impacted by overall healthcare expenditures, we decided to regress out the influence of healthcare spending on the prevalence of each mental health issue and to re-run our analysis using the residuals as dependent variables. When performed on a combination of mental health disorders, multiple linear regression models revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment ( $r_{\text{unemploy}}$ ) was medium to large ( $r$  range: 0.47-0.54). However they demonstrated great variation when performed amongst different mental health issues ( $r$  range: -0.34 to 0.52, **Supplementary Table 2**).

Across mental issues, the socio-economic indicators' effect sizes were strongly related to each other ( $r_{\text{HDI-GINI}}=0.89$ ,  $r_{\text{HDI-unemploy}}=0.93$ ,  $r_{\text{unemploy-GINI}}=0.87$ ). Principal component analysis demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained 94% of the variance ( $p=0$ , permutation test with 1000 repetitions).

Therefore, this analysis yield similar results than that reported in the main text.

#### Analysis using robust regression methods

To ensure that our results were not impacted by outliers, we re-ran our analyses using robust regression methods [1]. We used the `lmrob` function from the `robustbase` package in R (version 3.6.1), which computes fast MM-type estimators for linear regression models. We sat the default arguments as suggested in Koller and Stahel (2011) with an initial S-estimate, followed by an M-estimate, a Design Adaptive Scale estimate and a final M-step; and a "linear quadratic quadratic" (lqq for short) psi function [2].

When performed on a combination of mental health disorders, multiple linear regression

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2 models revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment ( $r_{\text{unemploy}}$ )  
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4 was medium to large ( $r$  range: 0.44-0.59). However they demonstrated great variation when  
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6 performed amongst different mental health issues ( $r$  range: -0.43 to 0.55, **Supplementary Table**  
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8 **3**). Across mental issues, the socio-economic indicators' effect sizes were strongly related to each  
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10 other ( $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.87$ ,  $r_{\text{unemploy-GINI}}=0.91$ ). Principal component analysis demonstrated  
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12 that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained 94% of the  
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14 variance ( $p=0$ , permutation test with 1000 repetitions).  
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17 Therefore, results using robust linear regression methods were highly comparable to those  
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19 using non-robust methods.  
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3 **SUPPLEMENTARY TABLES**  
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6 **Supplementary Table 1. Summary statistics of multiple linear regression models run on the**  
7 **prevalence of 10 mental health issues.**  
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Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health issues<sup>a</sup></b>					
HDI	45.9	31.8 to 60.1	6.6	0.76	0.0000002
GINI index	22.1	11.2 to 33.0	4.1	0.59	0.0002
Unemployment	0.2	0.08 to 0.3	3.3	0.51	0.002
<b>Autism Spectrum Disorder</b>					
HDI	2.5	1.7 to 3.3	6.3	0.74	0.0000005
GINI index	0.9	0.3 to 1.5	3.0	0.46	0.006
Unemployment	0.003	-0.004 to 0.01	0.8	0.15	0.4
<b>ADHD</b>					
HDI	2.3	-1.6 to 6.1	1.2	0.21	0.2
GINI index	2.6	-0.4 to 5.6	1.8	0.30	0.09
Unemployment	0.03	-0.007 to 0.06	1.6	0.27	0.1
<b>Depressive Disorders</b>					
HDI	12.3	7.6 to 17.1	5.2	0.68	0.000009
GINI index	7.5	3.9 to 11.2	4.2	0.59	0.0002
Unemployment	0.05	0.01 to 0.09	2.6	0.42	0.01
<b>Schizophrenia</b>					
HDI	1.0	0.6 to 1.3	5.8	0.72	0.000002
GINI index	0.4	0.1 to 0.7	3.1	0.49	0.004
Unemployment	0.001	-0.001 to 0.004	1.0	0.18	0.3
<b>Anxiety Disorders</b>					
HDI	27.4	15.9 to 38.9	4.9	0.65	0.00003
GINI index	10.6	1.7 to 19.4	2.4	0.40	0.02
Unemployment	0.08	-0.02 to 0.2	1.7	0.29	0.1
<b>Eating Disorders</b>					
HDI	3.7	2.5 to 4.9	6.2	0.74	0.0000005
GINI index	1.3	0.4 to 2.2	2.8	0.45	0.008
Unemployment	0.01	0.004 to 0.02	2.8	0.45	0.008
<b>Alcohol Use Disorders</b>					
HDI	-7.6	-17.5 to 2.3	-1.6	-0.27	0.1
GINI index	-2.1	-9.7 to 5.5	-0.6	-0.10	0.6
Unemployment	-0.04	-0.1 to 0.04	-1.0	-0.18	0.3

Supplementary Table 1 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-9.1	-55.6 to 37.4	-0.4	-0.07	0.7
GINI index	-6.8	-42.6 to 28.9	-0.4	-0.07	0.7
Unemployment	-0.4	-0.8 to 0.0005	-2.0	-0.34	0.05
<b>Bipolar Disorders</b>					
HDI	1.8	0.4 to 3.2	2.7	0.43	0.01
GINI index	0.4	-0.6 to 1.5	0.8	0.14	0.4
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**Supplementary Table 2. Summary statistics of multiple linear regression models run on the prevalence of 10 mental health issues after controlling for overall healthcare spending.**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health issues<sup>a</sup></b>					
HDI	20.5	6.6 to 34.4	3.0	0.47	0.005
GINI index	16.9	6.2 to 27.6	3.2	0.49	0.003
Unemployment	0.2	0.1 to 0.3	3.7	0.54	0.0009
<b>Autism Spectrum Disorder</b>					
HDI	1.0	0.1 to 1.8	2.3	0.38	0.03
GINI index	0.6	-0.1 to 1.3	1.5	0.31	0.08
Unemployment	0.004	-0.004 to 0.01	1.0	0.18	0.3
<b>ADHD</b>					
HDI	2.4	-1.4 to 6.3	1.3	0.22	0.2
GINI index	2.6	-0.4 to 5.6	1.8	0.30	0.1
Unemployment	0.03	-0.008 to 0.06	1.6	0.27	0.1
<b>Depressive Disorders</b>					
HDI	6.2	1.4 to 10.9	2.6	0.42	0.01
GINI index	6.3	2.6 to 9.9	3.5	0.52	0.001
Unemployment	0.06	0.02 to 0.1	2.8	0.45	0.008
<b>Schizophrenia</b>					
HDI	0.4	0.04 to 0.8	2.3	0.38	0.03
GINI index	0.3	0.01 to 0.6	2.1	0.35	0.04
Unemployment	0.002	-0.001 to 0.005	1.2	0.21	0.2
<b>Anxiety Disorders</b>					
HDI	9.6	-1.5 to 20.7	1.8	0.30	0.09
GINI index	6.9	-1.6 to 15.4	1.7	0.28	0.1
Unemployment	0.09	-0.001 to 0.2	2.0	0.34	0.05
<b>Eating Disorders</b>					
HDI	1.8	0.5 to 3.1	2.8	0.44	0.009
GINI index	0.9	-0.1 to 1.9	1.8	0.31	0.08
Unemployment	0.02	0.005 to 0.03	2.9	0.42	0.007
<b>Alcohol Use Disorders</b>					
HDI	-2.2	-12.0 to 7.5	-0.5	-0.08	0.6
GINI index	-1.0	-8.5 to 6.5	-0.3	-0.05	0.8
Unemployment	-0.05	-0.1 to 0.04	-1.1	-0.20	0.3

Supplementary Table 2 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-7.8	-54.2 to 38.7	-0.3	-0.06	0.7
GINI index	-6.5	-42.3 to 29.2	-0.4	-0.07	0.7
Unemployment	-0.4	-0.8 to -0.0008	-2.0	-0.34	0.05
<b>Bipolar Disorders</b>					
HDI	1.2	-0.2 to 2.7	1.7	0.29	0.09
GINI index	0.3	-0.8 to 1.4	0.6	0.10	0.6
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**Supplementary Table 3. Summary statistics of multiple linear models run on the prevalence of 10 mental health issues using robust regression methods (after controlling for overall healthcare spending).**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health disorders<sup>a</sup></b>					
HDI	17.5	4.5 to 30.5	2.7	0.44	0.01
GINI index	13.9	3.8 to 24.0	2.8	0.44	0.01
Unemployment	0.2	0.1 to 0.3	4.1	0.59	0.0002
<b>Autism Spectrum Disorders</b>					
HDI	0.9	0.2 to 1.6	2.6	0.42	0.01
GINI index	0.6	0.06 to 1.1	2.3	0.37	0.03
Unemployment	0.004	-0.001 to 0.01	1.5	0.26	0.1
<b>ADHD</b>					
HDI	1.5	-1.6 to 4.6	1.0	0.17	0.3
GINI index	1.5	-0.8 to 3.9	1.3	0.23	0.2
Unemployment	0.03	0.0009 to 0.05	2.1	0.35	0.04
<b>Depressive Disorders</b>					
HDI	6.4	1.6 to 11.2	2.7	0.43	0.01
GINI index	6.7	3.0 to 10.4	3.7	0.55	0.0008
Unemployment	0.06	0.02 to 0.1	2.8	0.45	0.008
<b>Schizophrenia</b>					
HDI	0.3	-0.0003 to 0.7	2.0	0.34	0.05
GINI index	0.2	-0.02 to 0.5	1.9	0.32	0.07
Unemployment	0.002	-0.001 to 0.005	1.3	0.23	0.2
<b>Anxiety Disorders</b>					
HDI	7.4	-2.6 to 17.5	1.5	0.26	0.1
GINI index	4.4	-3.5 to 12.3	1.1	0.20	0.3
Unemployment	0.1	0.02 to 0.2	2.4	0.40	0.02
<b>Eating Disorders</b>					
HDI	1.9	0.8 to 3.0	3.5	0.52	0.001
GINI index	1.2	0.3 to 2.0	2.7	0.43	0.01
Unemployment	0.02	0.006 to 0.02	3.4	0.52	0.002
<b>Alcohol Use Disorders</b>					
HDI	0.9	-6.4 to 8.2	0.3	0.04	0.8
GINI index	-1.2	-6.7 to 4.4	-0.4	-0.07	0.7
Unemployment	-0.05	-0.1 to 0.02	-1.5	-0.26	0.1

Supplementary Table 3 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-3.2	-35.5 to 29.1	-0.2	-0.04	0.8
GINI index	-18.8	-43.8 to 6.3	-1.5	-0.26	0.1
Unemployment	-0.4	-0.6 to -0.09	-2.7	-0.43	0.01
<b>Bipolar Disorders</b>					
HDI	1.4	-0.05 to 2.8	2.0	0.33	0.06
GINI index	0.5	-0.6 to 1.6	0.9	0.16	0.4
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.



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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
<b>Title and abstract</b>	1 ✓	(a) Indicate the study's design with a commonly used term in the title or the abstract
	✓	(b) Provide in the abstract an informative and balanced summary of what was done and what was found
<b>Introduction</b>		
Background/rationale	2 ✓	Explain the scientific background and rationale for the investigation being reported
Objectives	3 ✓	State specific objectives, including any prespecified hypotheses
<b>Methods</b>		
Study design	4 ✓	Present key elements of study design early in the paper
Setting	5 ✓	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 ✓	(a) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7 ✓	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* ✓	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 ✓	Describe any efforts to address potential sources of bias
Study size	10 ✓	Explain how the study size was arrived at
Quantitative variables	11 ✓	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 ✓	(a) Describe all statistical methods, including those used to control for confounding
	✓	(b) Describe any methods used to examine subgroups and interactions
	✓	(c) Explain how missing data were addressed
	✓	(d) If applicable, describe analytical methods taking account of sampling strategy
	✓	(e) Describe any sensitivity analyses
<b>Results</b>		
Participants	13* ✓	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	✓	(b) Give reasons for non-participation at each stage
	✓	(c) Consider use of a flow diagram
Descriptive data	14* ✓	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
	✓	(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15* ✓	Report numbers of outcome events or summary measures
Main results	16 ✓	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
	✓	(b) Report category boundaries when continuous variables were categorized
	✓	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 ✓	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

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<b>Discussion</b>		
Key results	18 ✓	Summarise key results with reference to study objectives
Limitations	19 ✓	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 ✓	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 ✓	Discuss the generalisability (external validity) of the study results
<b>Other information</b>		
Funding	22 ✓	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## An ecological study of the association between mental illness with human development, income inequalities and unemployment across OECD countries

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-035055.R1
Article Type:	Original research
Date Submitted by the Author:	18-Dec-2019
Complete List of Authors:	Barbalat, Guillaume; CNRS & Université Lyon 1 Franck , Nicolas ; CNRS & Université Lyon 1
<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Mental health, Sociology, Global health
Keywords:	MENTAL HEALTH, EPIDEMIOLOGY, SOCIAL MEDICINE

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6 **Title:** An ecological study of the association between mental illness with human development,  
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8 income inequalities and unemployment across OECD countries.  
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46 **Abstract word count:** 297.  
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48 **Word count:** 3190 (excluding references, tables and acknowledgements).  
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## **ABSTRACT**

### **OBJECTIVES**

Recent studies have demonstrated worsened mental health in relatively highly developed countries impacted by social inequalities and unemployment. Here, we investigate (1) whether mental health issues are differently or similarly affected by these social factors; and (2) whether their effects on mental health are related or unrelated to each other.

### **SETTING**

Analysis at the country level amongst OECD (Organization for Economic Cooperation and Development) countries (N=36). Data on social indicators was collected from OECD and United Nations Development Programme (UNDP) databases. Data on the prevalence of mental issues was obtained from the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease (GBD) study 2017.

### **PARTICIPANTS**

No involvement of participants.

### **PRIMARY AND SECONDARY OUTCOME MEASURES**

Using linear regression models, we investigated the relative contribution played by human development (as measured by the Human Development Index - HDI), social inequalities (GINI index) and unemployment (unemployment rate) on the prevalence of 10 mental health issues. We then measured the relationship between the socio-economic factors' effects on mental issues using 2x2 Pearson's correlation test and Principal Component Analysis.

### **RESULTS**

First, the overall effect of each socio-economic factor on a combination of mental health disorders was large (r range: 0.51-0.76;  $p < 0.002$ ). However, the influence of social factors on mental health was relative to each mental issue (r range: -0.34 to 0.74). Second, the socio-economic factors' effects on mental health showed strong interdependence ( $r_{\text{HDI-GINI}} = 0.93$ ,  $r_{\text{HDI-unemploy}} = 0.81$ ,  $r_{\text{unemploy-}}$

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2  $r_{GINI}=0.84$ ;  $p<0.001$ . Principal component analysis demonstrated that the first principal component of  
3  
4 the three variables ( $r_{HDI}$ ,  $r_{GINI}$ ,  $r_{unemploy}$ ) explained 91.5% of the variance.  
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## 6 **CONCLUSION**

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9 These results implore a re-analysis of the socio-economic determinants of mental health where: 1)  
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11 the heterogeneity of mental health issues would be taken into account; and 2) each socio-  
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13 economic indicator's effect would be analysed and interpreted in conjunction with the others.  
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## **STRENGTHS AND LIMITATIONS OF THIS STUDY**

- To allow for comparability across populations and minimize the risk of outliers, our study focused on OECD countries, which are mostly high-income countries.
- Data on the prevalence of 10 mental issues was obtained from the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease (GBD) study 2017, from which an increasing number of high-impact epidemiological studies has already been published.
- Our analysis took into account overall healthcare spending and potential outlier countries.
- The ecological design was necessary because our research questions were directly related to the association of national-level mental health prevalence and socio-economic indicators, however there is no possibility to make inferences about individuals from this dataset.
- The observational nature of our analysis means that other uncontrolled socio-cultural factors might have influenced the prevalence of mental issues in individual countries.

## MAIN TEXT

### INTRODUCTION

A significant proportion of the overall disease burden is related to mental disorders. For instance, depressive disorders and schizophrenia account for as much as 63200 and 15000 absolute Disability-Adjusted Life Year per thousand people, which makes them the second and the eleventh most burdensome disorders, respectively [1]. Suicide is also a serious global public health issue, being amongst the top twenty leading causes of death worldwide, and the second leading cause of death in young people aged 15-29 years [2]. Therefore, how to promote mental health at a wide, public health level is a crucial matter.

Following the bio-psycho-social account of mental disorders, one can say that mental health is currently promoted at 3 basic levels. First, the increasing knowledge of biological determinisms of mental illness has led to great efforts (but not necessarily successes) to destigmatise patients with a mental disorder that is beyond their control [3]. Second, psychological attributes such as confidence, agency, optimism, or resilience are now widely used to promote mental health at a public health level [4]. Third, important insights have revealed that discrimination based on socio-demographic factors such as socio-economic status, race, ethnicity, gender and sexual orientation can have a huge impact on mental health [5].

However, contrary to biological and psychological factors that are now routinely addressed by clinicians, practitioners keep struggling to meet their patients social needs. Recent accounts emphasize the need for a better awareness of the social, economical and political determinants of mental health amongst mental health practitioners [6]. Those accounts call for a better recognition of how structures (such as institutions, systems, or policies) bias social justice against certain types of people and shape symptoms and diseases – especially mental disorders. Recognizing factors that participate to structural discrimination in day-to-day practice would be crucial to advocate for the reduction of inequalities both in clinical interactions and, perhaps even more importantly, to

1  
2 promote better mental health at a public health level [7].  
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4 In the current study, we chose to leave aside dimensions of structural discrimination related  
5 to race, gender, religion and sexual orientation to focus on country-level socio-economic status and  
6 its relationship to mental health disorders prevalence. We investigated 3 measures meant to define  
7 the social and economic status of a nation: human development, income inequalities and  
8 unemployment rate. Human development, which is composed by a measure of health, education  
9 and standard of living, aims at representing the average level of freedoms, opportunities and  
10 financial wealth of a country. Income inequalities gives insight on how wealth is distributed within a  
11 nation. Finally, unemployment rate measures the percentage of people without a professional  
12 occupation.  
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24 Recent studies have suggested that relatively highly developed countries demonstrate  
25 worsened mental health when impacted by income inequalities [8–10] and unemployment [11].  
26 Although this has been of great interest to social epidemiologists, two important questions have  
27 remained unanswered. First, it is unclear whether mental health issues are differently or similarly  
28 affected by these social factors. International classifications such as the DSM or the ICD define  
29 mental disorders as a constellation of potential problems, rather than a single, unifying issue  
30 [12,13]. The question is therefore whether socio-economic indicators influence those various  
31 disorders in a different or similar manner. Given the heterogeneity of mental health problems, one  
32 would expect a differential impact of these social factors on various mental health issues, where for  
33 instance bipolar disorders would have a different relation to socio-economic indicators than  
34 schizophrenia or alcohol use disorders. On the other hand, recent accounts of mental issues have  
35 criticized the view that mental disorders were discriminable. Those accounts are based on clinical,  
36 biochemical, genetics, and cognitive neuroscience studies that have suggested fairly similar  
37 mechanisms underpinning different mental diseases such as schizophrenia, depression, anxiety  
38 disorders, and attention-deficit and hyperactivity disorders (ADHD) [14]. Following this account,  
39 one would expect that social factors would influence different mental disorders in a rather similar  
40 way.  
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2 A second uncertainty is whether those socio-economic factors' effects on mental health are  
3 related or unrelated to each other. On the one hand, there are theoretical reasons to believe that  
4 those socio-economic factors may have a correlated impact on mental problems. A common path  
5 to mental well-being may be that of income, wealth and perhaps success, where development  
6 would relate to *average* wealth, inequalities to wealth *distribution* and unemployment to the main  
7 *source* of wealth for most people. On the other hand however, development, inequalities and  
8 unemployment usually vary in a way that is grossly uncorrelated [15]. Thus, according to this  
9 account, there is no *a priori* empirical reason to suspect that their effects on mental health are  
10 related to each other.  
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21 This study aimed at better categorizing the relations between development, inequalities,  
22 and unemployment with the prevalence of various mental health issues at the country level. To  
23 allow for comparability across populations and minimize the risk of outliers, we restricted our  
24 analyses to the 36 relatively rich countries that belong to the Organization for Economic  
25 Cooperation and Development (OECD). This choice is based on the fact that, in developing  
26 countries, mental disorders could rely on other social factors than the ones we investigated in the  
27 current study, such as human rights and inland security [16]. Likewise, there seems to be key  
28 differences between developing and developed countries in how human development affects  
29 mental health. While the prevalence of mental disorders such as depression decreases when the  
30 level of human development increases, developed countries seem to demonstrate an opposite  
31 pattern: the higher their level of development, the higher their prevalence of mental disorders [17].  
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45 We restricted our analysis to the most common mental health disorders, that is, depressive  
46 disorders, bipolar disorders, schizophrenia, eating disorders, anxiety disorders, ADHD, alcohol use  
47 disorders, and autism spectrum disorders. As an obvious public mental health issue, we also  
48 added suicide prevalence to our analysis. Two caveats are related to the collection of prevalence  
49 data on mental disorders across countries. First, the range of epidemiological studies meant to  
50 report prevalence data are unequally distributed across issues, age groups and countries [18]. To  
51 overcome this challenge, we chose to collect data on the prevalence of mental health disorders  
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1 from the Institute of Health Metrics & Evaluation (IHME)'s Global Burden of Disease (GBD) study  
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3 2017 [19]. To the best of our knowledge, this is currently the only source which produces global  
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5 level estimates across countries where diagnostic categories for mental health and alcohol use  
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7 disorders are adequately represented. Second, prevalence data could reflect, at least in part,  
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9 different healthcare spending across countries rather than giving a representative perspective on  
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11 specific differences between countries. Countries that spend a lot on healthcare would likely show  
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13 inflated prevalence as a result of an increased focus on mental health disorders. To overcome this  
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15 bias, we decided to run a second set of analysis taking into account overall healthcare spending  
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17 and check if results from both analyses are comparable.  
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## 24 **METHODS**

### 25 **Data series**

#### 26 Dependent variable

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29 Prevalences of mental health issues across OECD countries were collected from the Institute of  
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31 Health Metrics & Evaluation (IHME)'s Global Burden of Disease (GBD) project database [19],  
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33 where data is estimated from a combination of surveys, medical and epidemiological data, as well  
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35 as meta-regression models. Data from the GBD study 2017 was released in November 2018, and  
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37 concern years 1990-2017. The GBD study 2017 defines prevalence as the proportion of people in  
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39 a population who are a case of a disease, injury or sequela. All results in GBD refer to point  
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41 prevalence.  
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47 Data was extracted for year 2017 for a combination of mental health disorders and the  
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49 specific following issues: depressive disorders, anxiety disorders, schizophrenia, bipolar disorders,  
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51 eating disorders, alcohol use disorders, ADHD, autism spectrum disorders and suicide (**Table 1**).  
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53 Note that suicide did not include non-fatal self-harm.  
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56 Prevalence data was age standardized, which allowed comparability across populations  
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58 when their age profiles were different. Data was calculated in relation to the entire population.  
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2 Extracted data did not necessitate any further transformation and was ready to be used.  
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### 7 Independent variables

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9 Each country's level of human development was measured with the Human Development Index  
10 (HDI; range: 0-1). The HDI summarizes life expectancy, a combination of adult literacy rate and  
11 school enrolment rate, and gross domestic product per capita at purchasing power parity [20].  
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16 For each country, income inequality was measured using the GINI index (range: 0-1), which  
17 intends to represent a nation's income distribution [21]. A GINI coefficient of 0 means that the  
18 country income is perfectly equally distributed. A GINI coefficient of 1 means that all the country's  
19 income is received by just one person.  
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24 Our third socio-economic indicator was unemployment rate, which measures the rate of  
25 unemployment as a percentage of the labour force [22].  
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29 Data for the three predictors was collected from the OECD database except for HDI, which  
30 was retrieved from the United Nations Development Programme database (**Table 1**). Data was  
31 extracted for year 2016, except when unavailable, in which case data was extracted for the closest  
32 year previous to 2016 (year range for data collection: 2014-2016).  
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38 Source data for all 36 OECD countries can be found as a supplementary file (all\_data.pdf).  
39 There was no missing data. For each indicator (dependent and independent variables), atypical  
40 countries were defined as having a z-score greater than 3 or below -3 (**Table 1**).  
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50 *Table 1 about here*  
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## Statistical Analysis

We ran multiple regression linear models where the prevalence of a mental issue across OECD countries is predicted by the HDI, GINI index, and unemployment rate. Extreme outliers were defined as data points with Cook's distance  $> 1$  [23]. Using this cut-off, we were not able to identify any outliers when running our linear models.

For each mental health issue, we then converted each of the socio-economic indicators' t statistic into their corresponding effect size (Pearson's  $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ). We then computed 2x2 Pearson's correlation coefficients between those 3 variables ( $r_{\text{HDI-GINI}}$ ,  $r_{\text{HDI-unemploy}}$ ,  $r_{\text{unemploy-GINI}}$ ) to estimate their pairwise relationships across all mental health problems. Finally, to investigate the linear dependency between the 3 indicators' effect sizes, we ran principal component analysis and obtained explained variance for the first principal component.

An important caveat when collecting mental health data at the country level is that prevalence could reflect healthcare spending (which allows for more focus on mental health disorders) rather than giving a representative perspective on differences between countries. For our data, Pearson's  $r$  between combined mental health disorders prevalence and healthcare spending as measured by price per capita at purchasing power parity (obtained from the OECD database [24]) was of 0.58 ( $p < 0.001$ ). To check that our results were not impacted by overall healthcare expenditures, we decided to regress out the influence of healthcare spending on the prevalence of each mental health issue and to re-run our analysis using the residuals as dependent variables. Finally, to check that our results were not too influenced by outliers, we also ran our analysis using robust regression methods.

To run these analyses, we used R 3.6.1.

## Patient and public involvement

No patients were involved in this study.

## RESULTS

Multiple linear regression models performed on the prevalence of a combination of mental health disorders revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment ( $r_{\text{unemploy}}$ ) was large ( $r$  range: 0.51-0.76). However they demonstrated great variation when measured amongst different mental health issues ( $r$  range: -0.34 to 0.74; **Table 2 and Supplementary Table 1**), the most prominent being no positive effect on suicide and alcohol use disorders, and a larger effect on other mental disorders. Regarding the latter, development had a strong effect ( $r > 0.65$ ) on the prevalence of each disorder apart from bipolar disorders and ADHD ( $r < 0.43$ ); income inequalities had at least a moderate effect ( $r > 0.40$ ) on the prevalence of each disorder apart from bipolar disorders and ADHD ( $r < 0.30$ ); and unemployment had a moderate effect on depressive and eating disorders ( $r > 0.42$ ), and only a small effect on autism spectrum disorders and schizophrenia ( $r < 0.18$ ) (**Table 2**).

Across mental issues, the socio-economic indicators' effect sizes were strongly related to each other (Pearson's  $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.81$ ,  $r_{\text{unemploy-GINI}}=0.84$ ). Principal component analysis demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained 91.5% of the variance ( $p=0$ , permutation test with 1000 repetitions).

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*Table 2 about here*  
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Finally, note that re-running our analysis after controlling for overall healthcare spending across countries and using robust method to control for outliers clearly reproduced this pattern of results (**Supplementary Results; Supplementary Tables 2 and 3**).



## DISCUSSION

This study aimed at clarifying the relationship between mental health and three socio-economic factors: human development, income inequalities and unemployment. We first demonstrated that, amongst OECD countries, the strength of the relationship between the prevalence of mental health issues with development, inequalities and unemployment, was large for a combination of disorders. This confirms the abundant literature showing a positive association between mental issues with inequalities [9] and unemployment [25,26] for a whole range of mental disorders. More generally, the social science literature is unequivocal as per the association between a country's socio-economic status and health across the life span. Indeed, other studies have demonstrated a strong impact of socio-ecological measures of wealth (e.g. salary, pension), income inequalities, education, and employment on overall health outcomes such as life expectancy, healthy life expectancy, and adolescent health [27–31]. Taking this a step further, our study adds one more argument for the implementation of public health policies expected to counter the devastating effect of inequalities and unemployment [10,32,33].

Aside from the effect of inequalities and unemployment on mental health, that of human development is less straightforward. On the one hand, research has shown that development was accompanied with better mental health [34]. Human development clearly promotes health and wellbeing, for instance by reducing mortality due to infectious diseases thanks to vaccination programmes and antibiotics use; but also by encouraging education, innovations, freedom and opportunities. On the other hand, others have demonstrated an opposite relationship between mental health and human development, with mental disorders prevalence paradoxically increasing with the level of human development [17]. The relationship between human development and mental health found in the current study was clearly of that kind, and this relationship was not related to overall healthcare spending. Some have interpreted this deleterious effect of development on mental health as a potential reflection of the mutation of social values towards less social integration and regulation in modern societies [35,36]. In fact, the relationship between human development and mental health disorders prevalence may follow a U-shape curve, with a

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2 negative relationship (less mental disorders when development increases) for developing  
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4 countries, and a positive relationship (more mental disorders when development increases) for  
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6 developed countries. Further studies should continue to investigate this association at a more fine-  
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8 grained level, using for instance multilevel models, to better decipher the effect of human  
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10 development on mental health in developing and developed countries.  
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13 In the current study, we were also interested in whether the association between mental  
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15 health with human development, income inequalities, and unemployment varies across mental  
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17 issues; and whether the three socio-economic factors' effects on mental health are related to each  
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19 other. As a second important result of our study, we demonstrated that the association between  
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21 mental issues and the three socio-economic factors was in fact relative to each mental health  
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23 issue. Non-addictive mental health disorders tested in this study were clearly associated to these  
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25 social factors, though to various degrees. Hypotheses on how each of those mental issues  
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27 specifically relies to development, inequalities and unemployment are beyond the scope of this  
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29 study and are open to further empirical testing. In contrast, development, inequalities and  
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31 unemployment did not negatively impact suicide and alcohol use disorders. This seems to  
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33 contradict within-country studies that have demonstrated that inequalities and unemployment both  
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35 affect suicide and alcohol use disorders prevalence [37–41]. In fact, both issues are also thought to  
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37 be strongly influenced by other socio-cultural factors that vary independently from development,  
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39 inequalities and unemployment. For instance, long-term unemployment [42] or work stress [43]  
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41 have been associated to suicide, while religion [44,45], connectedness and neighbourhood  
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43 conditions [46] are known protective factors against extreme behaviours. Overall, those additional  
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45 factors, untested in this study, may have masked the effect of development, inequalities and  
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47 unemployment on suicide and alcohol use.  
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51 A third important finding of our study is that the socio-economic factors' effects on mental  
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53 health are strongly related to each other. This suggests that they share an underlying common  
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55 pathway. As such, they could pertain to a so-called social structure that would influence and  
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57 restrict the choices and opportunities available to people [47] and tend to bias an overall society  
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1  
2 towards better, or worse, mental health. In modern societies, development, inequalities and  
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4 unemployment can all be viewed as indicators of key cultural values and norms important for social  
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6 inclusion and cohesion. Such values and norms participate to some of the core features of  
7  
8 capitalist systems: accumulation, competition and labour wages. That is, a high level of  
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10 development sets priorities for people to reach a high threshold of desired outcomes in terms of  
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12 education, health or financial wealth [48]. Likewise, greater income inequalities can shape attitudes  
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14 towards reaching a higher social position compared to others [49]. Finally, the value of an  
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16 employment position in this context is both material (it gives a source of income) and socio-cultural  
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18 (not having a job is typically perceived as being a failure in the society). Overall, these social  
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20 factors' unifying feature may be their underlying pressure for success, which in turn could explain  
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22 their negative impact on mental health.  
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## 28 **Limitations**

29  
30 First, because our research questions were directly related to the association of national-level  
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32 mental health prevalence and socio-economic indicators, we considered the ecological design the  
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34 most appropriate for our study [8]. However, the observational nature of our analysis implies that  
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36 other uncontrolled socio-cultural factors might have influenced the prevalence of mental issues in  
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38 individual countries. We obviously need to be careful about any over-interpretation of our results as  
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40 demonstrating causality while our models can only be predictive.  
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44 A second potential limitation of this study is the so-called ecological fallacy, that is, making  
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46 inferences on individual risk from analysis made on aggregate data [50]. Based on this study  
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48 results, one cannot draw conclusions about the specific nature of individuals (e.g. their socio-  
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50 economic status) who suffer from mental health issues. To solve this question, one would need to  
51  
52 design a multilevel study where socio-economic status at the individual level and at the country  
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54 level would be entered as two-level predictors.  
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57 Third, it is likely that the effect of development, inequalities, and unemployment is different  
58  
59 across non-OECD countries and especially low and middle income countries. For instance, and as  
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1 mentioned above, human development would have more of a beneficial effect on mental health in  
2 such developing countries [34]. That said, as most of the European and North American  
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## Conclusion

Despite those limitations, these results implore a re-analysis of the socio-economic determinants of mental health where: 1) the heterogeneity of mental health issues would be taken into account; and 2) each socio-economic indicator's effect would be analysed and interpreted in conjunction with the others.

## DECLARATION OF INTEREST

The authors have no biomedical financial interests or potential conflicts of interest.

## FUNDING

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

## AUTHOR CONTRIBUTION

All authors were involved in drafting the article or revising it critically for important intellectual content, and have read and approved the final version of the manuscript. G.B. and N.F. designed the study. G.B. gathered the data. G.B. and N.F. analysed the data and wrote the paper.

## DATA AVAILABILITY

All data relevant to the study are available as supplementary information.

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**TABLES****Table 1. Descriptive statistics for dependent and independent variables (N=36).**

Variable	Range	Mean	Population-weighted mean	Standard Deviation	Atypical countries <sup>b</sup>
Prevalence of combined mental health disorders <sup>a</sup> (%)	10.87-18.71	14.28	14.76	2.13	None
Prevalence of Autism Spectrum Disorders (%)	0.36-0.94	0.60	0.65	0.12	None
Prevalence of ADHD (%)	0.43-2.53	1.15	1.13	0.40	Australia (2.53%)
Prevalence of Depressive Disorders (%)	2.25-4.84	3.71	3.89	0.65	None
Prevalence of Schizophrenia (%)	0.20-0.36	0.26	0.28	0.05	None
Prevalence of Anxiety Disorders (%)	2.94-8.50	4.93	5.19	1.46	None
Prevalence of Eating Disorders (%)	0.23-0.94	0.48	0.48	0.18	None
Prevalence of Alcohol Use Disorders (%)	0.46-4.71	1.84	1.56	0.99	None
Prevalence of Suicide (per 100.000)	3.31-27.99	10.89	10.66	4.75	Lithuania (27.99 per 100.000)
Prevalence of Bipolar Disorders (%)	0.57-1.21	0.86	0.79	0.15	None
HDI	0.77-0.95	0.89	0.89	0.04	None
GINI index	0.24-0.46	0.32	0.36	0.05	None
Unemployment rate (%)	2.97-23.54	7.41	6.46	4.20	Greece (23.54%)

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

<sup>b</sup> whose z-score is greater than 3 or below -3.

**Table 2: Effects of human development, income inequalities and unemployment on the prevalence of 10 mental health issues across OECD countries (N=36).**

Pearson's r	Combined	ASD	ADHD	DEP	SCZ	ANX	ED	ETOH	SUICIDE	BD
$r_{\text{HDI}}$	0.76	0.74	0.21	0.68	0.72	0.65	0.74	-0.27	-0.07	0.43
$r_{\text{GINI}}$	0.59	0.46	0.30	0.59	0.49	0.40	0.45	-0.10	-0.07	0.14
$r_{\text{unemploy}}$	0.51	0.15	0.27	0.42	0.18	0.29	0.45	-0.18	-0.34	0.30

“Combined”: combination of Autism Spectrum Disorders, Attention-Deficit/Hyperactivity Disorders, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders; “ASD”: Autism Spectrum Disorders; “ADHD”: Attention-Deficit/Hyperactivity Disorders; “DEP”: Depressive Disorders; “SCZ”: Schizophrenia; “ANX”: Anxiety Disorders; “ED”: Eating Disorders; “ETOH”: Alcohol Use Disorders; “SUICIDE”: suicide rates; “BD”: Bipolar Disorders.

## Sheet1

	COUNTRIES	Healthcare_2016 (\$ per capita)	Population_2017	HDI_2016	GINI_2014-2016
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4					
5	AUS	4565.873	24585000	0.938	0.33
6	AUT	5139.924	8820000	0.906	0.284
7	BEL	4666.226	11420000	0.915	0.266
8	CAN	4698.016	36732000	0.922	0.307
9	CZE	2627.698	10641000	0.885	0.253
10	DNK	4774.269	5732000	0.928	0.263
11	FIN	4024.49	5511000	0.918	0.259
12	FRA	4844.017	64843000	0.899	0.291
13	DEU	5550.175	82658000	0.934	0.294
14	GRC	2198.044	10569000	0.868	0.333
15	HUN	1965.018	9730000	0.835	0.288
16	ISL	3916.333	334000	0.933	0.255
17	IRL	4470.748	4753000	0.934	0.297
18	ITA	3264.368	60674000	0.878	0.328
19	JPN	4512.845	127503000	0.907	0.339
20	KOR	2678.23	51096000	0.9	0.355
21	LUX	4785.896	592000	0.904	0.304
22	MEX	1065.875	124777000	0.772	0.458
23	NLD	5018.406	17021000	0.928	0.285
24	NZL	3662.218	4702000	0.915	0.349
25	NOR	5803.702	5296000	0.951	0.262
26	POL	1915.052	37953000	0.86	0.284
27	PRT	2667.691	10289000	0.845	0.331
28	SVK	2187.367	5448000	0.853	0.241
29	ESP	3105.646	46647000	0.889	0.341
30	SWE	5048.876	9905000	0.932	0.282
31	CHE	6942.187	8456000	0.943	0.296
32	TUR	1126.755	81116000	0.787	0.404
33	GBR	3833.251	66727000	0.92	0.351
34	USA	9903.651	325084992	0.922	0.391
35	CHL	1897.797	18470000	0.842	0.454
36	EST	2012.957	1319000	0.868	0.314
37	ISR	2551.4	8244000	0.902	0.346
38	SVN	2682.92	2076000	0.894	0.244
39	LVA	1582.955	1951000	0.844	0.346
40	LTU	2057.825	2845000	0.855	0.378
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## Sheet1

COUNTRIES	Unemploy_2016 (%)	Combined_2017 (%)	ASD_2017 (%)	ADHD_2017 (%)
AUS	5.710301	18.3812834362	0.6362445351	2.5306771454
AUT	6.014071	14.3621360785	0.6247499653	1.0291455466
BEL	7.833329	15.0180942245	0.6270042851	1.0340810836
CAN	6.991667	15.508528659	0.9354863859	1.3818192343
CZE	3.952049	11.3507025196	0.4781512595	1.0365472615
DNK	6.180843	14.2693279617	0.7289829608	1.1611398391
FIN	8.811286	14.8902418052	0.6332739762	1.5210562047
FRA	10.05661	16.361245236	0.5818691317	1.0737833252
DEU	4.122733	15.1776062466	0.6398522986	0.4271855887
GRC	23.54104	15.517001365	0.6220077054	1.0219205509
HUN	5.119285	11.4123956502	0.4688887668	1.0305108838
ISL	2.968629	14.2126279275	0.6059332969	0.9186699168
IRL	8.37511	15.6060996027	0.6694972714	1.1080569888
ITA	11.68803	14.8899699846	0.6242815014	1.187025833
JPN	3.116667	12.3609159143	0.8481478268	0.6891136944
KOR	3.675	11.8085065171	0.6582868691	0.6588837811
LUX	6.285928	14.6309888939	0.6276587589	1.0273360494
MEX	3.885191	10.8697103818	0.4574169643	0.6579181428
NLD	6.00791	16.0445936088	0.6982911568	1.0294338318
NZL	5.1	18.7124207228	0.6258004568	1.9066575163
NOR	4.677024	16.1195478965	0.5875293783	0.780681921
POL	6.161703	10.983524423	0.4735394525	1.0344898081
PRT	11.06846	15.3111569041	0.6047065185	1.020027929
SVK	9.671689	11.0868433214	0.4707288967	1.0318509022
ESP	19.63388	16.1766418629	0.6286840174	1.687412147
SWE	6.991096	15.5630025941	0.6853350476	1.0070551873
CHE	4.918711	14.8574804285	0.6340955061	1.2011420552
TUR	10.83812	14.3051507066	0.3557808045	1.9953047755
GBR	4.809951	14.649797989	0.6752636399	1.0516892814
USA	4.866667	17.3435577511	0.7359423594	1.3057577161
CHL	6.490013	16.0754862806	0.6411863023	1.6610497479
EST	6.753039	12.0396861009	0.4642171942	1.0509778991
ISR	4.808333	12.7166147306	0.5735818845	1.0879258739
SVN	8.006598	11.5639021525	0.4832933639	1.0444496063
LVA	9.641258	11.6333516914	0.4557207875	1.0385200603
LTU	7.860914	12.2014310998	0.4563094582	1.0348294698

## Sheet1

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COUNTRIES	DEP_2017 (%)	SCZ_2017 (%)	ANX_2017 (%)	ED_2017 (%)	ETOH_2017 (%)
AUS	4.6238809861	0.3633263334	6.5843011771	0.943081004	1.5119351423
AUT	3.2609699942	0.2569578522	5.3412753953	0.6751119616	1.8240650937
BEL	4.1091861548	0.2580726028	5.2126446444	0.6038688957	1.4656385696
CAN	3.9887920735	0.3155881045	5.1782183945	0.4773042772	1.6179370416
CZE	2.6753874663	0.2099890618	3.4436009907	0.242372761	2.0971724563
DNK	3.2918853248	0.254016903	5.3146345499	0.540025325	1.7307231327
FIN	4.7927356063	0.2574443779	3.7520618778	0.5949376269	2.6050609017
FRA	4.2538072628	0.2562379047	6.6267102113	0.5737552866	1.4189578909
DEU	3.9598660918	0.2522693135	6.5404958034	0.5220663374	1.8064746829
GRC	4.1858636992	0.2527008364	5.7902279453	0.5593235698	1.1242569646
HUN	2.7652421786	0.205524223	3.4546566254	0.2376863899	2.1073935961
ISL	3.3616652117	0.2576165352	5.2909878008	0.5580137464	1.2490285925
IRL	4.2509209974	0.3280076665	5.8390924847	0.5599946954	2.1098479051
ITA	3.4642561166	0.2361974523	5.6261210651	0.6267836426	0.4629368554
JPN	3.341564631	0.2955777434	3.5690542849	0.4543786087	0.5828795113
KOR	3.1656839582	0.2639935986	3.7780045481	0.4171034821	2.0200501273
LUX	3.6177186785	0.2636222409	5.3165160352	0.7379165359	1.3532344183
MEX	2.7888065701	0.211765456	3.1863264117	0.3169754492	1.7296042544
NLD	4.0268544034	0.358487188	6.6202421942	0.4678440988	0.7766024847
NZL	3.9712653692	0.3410509489	8.5399314968	0.6732900275	2.1934054542
NOR	3.77191037	0.2114838399	7.5855027602	0.5703626361	1.4190025311
POL	2.2504718928	0.2078099	3.4610750158	0.2294849029	2.044346289
PRT	4.4214605472	0.2493723527	5.3832606315	0.5130788046	1.2629045289
SVK	2.4019985472	0.2084189518	3.4442511078	0.2354746722	2.5004818341
ESP	3.5383592906	0.281538914	5.2802785935	0.7306261886	0.8850033633
SWE	4.4879109942	0.2703918248	5.293836611	0.5746082797	1.5865878354
CHE	3.7080597373	0.2624869018	5.3593931408	0.5739686951	1.3796903016
TUR	3.7186578279	0.2212524162	3.913400441	0.3089411909	0.7780786129
GBR	4.1195239912	0.2629523416	4.6498609311	0.5430536141	1.8970516124
USA	4.8356104088	0.3338899424	6.6350550354	0.5128443294	2.0400868929
CHL	4.057723142	0.2014303969	6.2720843134	0.4161228571	2.4494702182
EST	3.8488542112	0.2039776429	2.9622437654	0.2502707425	4.7136170972
ISR	3.8322207094	0.2591393307	3.0630780729	0.4611753105	0.4983810947
SVN	2.8632776644	0.2118237402	3.449772721	0.2396358281	2.2468269434
LVA	3.4995706624	0.1995096013	2.9449498166	0.2252753737	4.4087812358
LTU	4.1432544207	0.2009824146	2.9372241655	0.2340949007	4.4280010228

## Sheet1

COUNTRIES	SUICIDE_2017 (per 100.000)	BD_2017 (%)
AUS	11.0468849404	1.1420970115
AUT	11.2021569903	0.9397941744
BEL	14.275318769	0.9471588495
CAN	10.9051948299	0.7164133538
CZE	10.7666275634	0.7215695351
DNK	8.8002797464	1.0054935407
FIN	12.9449467354	1.0058262568
FRA	12.400297975	0.9581989776
DEU	9.9174170314	0.7767618863
GRC	3.5062542313	0.9489261067
HUN	14.2817310305	0.7034354507
ISL	9.6083352428	0.9711215949
IRL	8.3741480781	0.8054319625
ITA	4.7595847765	0.9462571309
JPN	15.6479510719	0.6883536082
KOR	20.8056602706	0.569459331
LUX	8.7049926039	0.9346808098
MEX	5.9223876521	0.8189213485
NLD	9.1691061872	0.9473002678
NZL	11.2963423597	1.2060879818
NOR	9.2688064679	0.856901351
POL	13.9481400147	0.7122644933
PRT	7.687679698	0.9258145066
SVK	9.4748496505	0.7124338302
ESP	5.5065007931	0.9769173255
SWE	11.0767355283	1.0579298061
CHE	9.3160623375	0.9539959074
TUR	3.310770446	0.8487702802
GBR	7.3563205517	1.0868375991
USA	12.8357566779	0.6512355015
CHL	10.1389641762	0.7905914166
EST	12.738720091	0.7082405618
ISR	5.7333380073	0.9248024668
SVN	14.3787089293	0.7253433069
LVA	16.9886737387	0.6963494113
LTU	27.9905844218	0.7002779347

## SUPPLEMENTARY MATERIAL

### SUPPLEMENTARY RESULTS

#### Analysis taking into account overall healthcare spending

To ensure that our results were not impacted by overall healthcare expenditures, we decided to regress out the influence of healthcare spending on the prevalence of each mental health issue and to re-run our analysis using the residuals as dependent variables. When performed on a combination of mental health disorders, multiple linear regression models revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment ( $r_{\text{unemploy}}$ ) was medium to large ( $r$  range: 0.47-0.54). However they demonstrated great variation when performed amongst different mental health issues ( $r$  range: -0.34 to 0.52, **Supplementary Table 2**).

Across mental issues, the socio-economic indicators' effect sizes were strongly related to each other ( $r_{\text{HDI-GINI}}=0.89$ ,  $r_{\text{HDI-unemploy}}=0.93$ ,  $r_{\text{unemploy-GINI}}=0.87$ ). Principal component analysis demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained 94% of the variance ( $p=0$ , permutation test with 1000 repetitions).

Therefore, this analysis yield similar results than that reported in the main text.

#### Analysis using robust regression methods

To ensure that our results were not impacted by outliers, we re-ran our analyses using robust regression methods [1]. We used the `lmrob` function from the `robustbase` package in R (version 3.6.1), which computes fast MM-type estimators for linear regression models. We sat the default arguments as suggested in Koller and Stahel (2011) with an initial S-estimate, followed by an M-estimate, a Design Adaptive Scale estimate and a final M-step; and a "linear quadratic quadratic" (lqq for short) psi function [2].

When performed on a combination of mental health disorders, multiple linear regression

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2 models revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment  
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4 ( $r_{\text{unemploy}}$ ) was medium to large (r range: 0.44-0.59). However they demonstrated great variation  
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6 when performed amongst different mental health issues (r range: -0.43 to 0.55, **Supplementary**  
7  
8 **Table 3**). Across mental issues, the socio-economic indicators' effect sizes were strongly related to  
9  
10 each other ( $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.87$ ,  $r_{\text{unemploy-GINI}}=0.91$ ). Principal component analysis  
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12 demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained  
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14 94% of the variance ( $p=0$ , permutation test with 1000 repetitions).  
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17 Therefore, results using robust linear regression methods were highly comparable to those  
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19 using non-robust methods.  
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## SUPPLEMENTARY TABLES

**Supplementary Table 1. Summary statistics of multiple linear regression models run on the prevalence of 10 mental health issues (N=36).**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health issues<sup>a</sup></b>					
HDI	45.9	31.8 to 60.1	6.6	0.76	0.0000002
GINI index	22.1	11.2 to 33.0	4.1	0.59	0.0002
Unemployment	0.2	0.08 to 0.3	3.3	0.51	0.002
<b>Autism Spectrum Disorder</b>					
HDI	2.5	1.7 to 3.3	6.3	0.74	0.0000005
GINI index	0.9	0.3 to 1.5	3.0	0.46	0.006
Unemployment	0.003	-0.004 to 0.01	0.8	0.15	0.4
<b>ADHD</b>					
HDI	2.3	-1.6 to 6.1	1.2	0.21	0.2
GINI index	2.6	-0.4 to 5.6	1.8	0.30	0.09
Unemployment	0.03	-0.007 to 0.06	1.6	0.27	0.1
<b>Depressive Disorders</b>					
HDI	12.3	7.6 to 17.1	5.2	0.68	0.000009
GINI index	7.5	3.9 to 11.2	4.2	0.59	0.0002
Unemployment	0.05	0.01 to 0.09	2.6	0.42	0.01
<b>Schizophrenia</b>					
HDI	1.0	0.6 to 1.3	5.8	0.72	0.000002
GINI index	0.4	0.1 to 0.7	3.1	0.49	0.004
Unemployment	0.001	-0.001 to 0.004	1.0	0.18	0.3
<b>Anxiety Disorders</b>					
HDI	27.4	15.9 to 38.9	4.9	0.65	0.00003
GINI index	10.6	1.7 to 19.4	2.4	0.40	0.02
Unemployment	0.08	-0.02 to 0.2	1.7	0.29	0.1
<b>Eating Disorders</b>					
HDI	3.7	2.5 to 4.9	6.2	0.74	0.0000005
GINI index	1.3	0.4 to 2.2	2.8	0.45	0.008
Unemployment	0.01	0.004 to 0.02	2.8	0.45	0.008
<b>Alcohol Use Disorders</b>					
HDI	-7.6	-17.5 to 2.3	-1.6	-0.27	0.1
GINI index	-2.1	-9.7 to 5.5	-0.6	-0.10	0.6
Unemployment	-0.04	-0.1 to 0.04	-1.0	-0.18	0.3

Supplementary Table 1 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-9.1	-55.6 to 37.4	-0.4	-0.07	0.7
GINI index	-6.8	-42.6 to 28.9	-0.4	-0.07	0.7
Unemployment	-0.4	-0.8 to 0.0005	-2.0	-0.34	0.05
<b>Bipolar Disorders</b>					
HDI	1.8	0.4 to 3.2	2.7	0.43	0.01
GINI index	0.4	-0.6 to 1.5	0.8	0.14	0.4
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**Supplementary Table 2. Summary statistics of multiple linear regression models run on the prevalence of 10 mental health issues after controlling for overall healthcare spending (N=36).**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health issues<sup>a</sup></b>					
HDI	20.5	6.6 to 34.4	3.0	0.47	0.005
GINI index	16.9	6.2 to 27.6	3.2	0.49	0.003
Unemployment	0.2	0.1 to 0.3	3.7	0.54	0.0009
<b>Autism Spectrum Disorder</b>					
HDI	1.0	0.1 to 1.8	2.3	0.38	0.03
GINI index	0.6	-0.1 to 1.3	1.5	0.31	0.08
Unemployment	0.004	-0.004 to 0.01	1.0	0.18	0.3
<b>ADHD</b>					
HDI	2.4	-1.4 to 6.3	1.3	0.22	0.2
GINI index	2.6	-0.4 to 5.6	1.8	0.30	0.1
Unemployment	0.03	-0.008 to 0.06	1.6	0.27	0.1
<b>Depressive Disorders</b>					
HDI	6.2	1.4 to 10.9	2.6	0.42	0.01
GINI index	6.3	2.6 to 9.9	3.5	0.52	0.001
Unemployment	0.06	0.02 to 0.1	2.8	0.45	0.008
<b>Schizophrenia</b>					
HDI	0.4	0.04 to 0.8	2.3	0.38	0.03
GINI index	0.3	0.01 to 0.6	2.1	0.35	0.04
Unemployment	0.002	-0.001 to 0.005	1.2	0.21	0.2
<b>Anxiety Disorders</b>					
HDI	9.6	-1.5 to 20.7	1.8	0.30	0.09
GINI index	6.9	-1.6 to 15.4	1.7	0.28	0.1
Unemployment	0.09	-0.001 to 0.2	2.0	0.34	0.05
<b>Eating Disorders</b>					
HDI	1.8	0.5 to 3.1	2.8	0.44	0.009
GINI index	0.9	-0.1 to 1.9	1.8	0.31	0.08
Unemployment	0.02	0.005 to 0.03	2.9	0.42	0.007
<b>Alcohol Use Disorders</b>					
HDI	-2.2	-12.0 to 7.5	-0.5	-0.08	0.6
GINI index	-1.0	-8.5 to 6.5	-0.3	-0.05	0.8
Unemployment	-0.05	-0.1 to 0.04	-1.1	-0.20	0.3

Supplementary Table 2 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-7.8	-54.2 to 38.7	-0.3	-0.06	0.7
GINI index	-6.5	-42.3 to 29.2	-0.4	-0.07	0.7
Unemployment	-0.4	-0.8 to -0.0008	-2.0	-0.34	0.05
<b>Bipolar Disorders</b>					
HDI	1.2	-0.2 to 2.7	1.7	0.29	0.09
GINI index	0.3	-0.8 to 1.4	0.6	0.10	0.6
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**Supplementary Table 3. Summary statistics of multiple linear models run on the prevalence of 10 mental health issues using robust regression methods (after controlling for overall healthcare spending) (N=36).**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health disorders<sup>a</sup></b>					
HDI	17.5	4.5 to 30.5	2.7	0.44	0.01
GINI index	13.9	3.8 to 24.0	2.8	0.44	0.01
Unemployment	0.2	0.1 to 0.3	4.1	0.59	0.0002
<b>Autism Spectrum Disorders</b>					
HDI	0.9	0.2 to 1.6	2.6	0.42	0.01
GINI index	0.6	0.06 to 1.1	2.3	0.37	0.03
Unemployment	0.004	-0.001 to 0.01	1.5	0.26	0.1
<b>ADHD</b>					
HDI	1.5	-1.6 to 4.6	1.0	0.17	0.3
GINI index	1.5	-0.8 to 3.9	1.3	0.23	0.2
Unemployment	0.03	0.0009 to 0.05	2.1	0.35	0.04
<b>Depressive Disorders</b>					
HDI	6.4	1.6 to 11.2	2.7	0.43	0.01
GINI index	6.7	3.0 to 10.4	3.7	0.55	0.0008
Unemployment	0.06	0.02 to 0.1	2.8	0.45	0.008
<b>Schizophrenia</b>					
HDI	0.3	-0.0003 to 0.7	2.0	0.34	0.05
GINI index	0.2	-0.02 to 0.5	1.9	0.32	0.07
Unemployment	0.002	-0.001 to 0.005	1.3	0.23	0.2
<b>Anxiety Disorders</b>					
HDI	7.4	-2.6 to 17.5	1.5	0.26	0.1
GINI index	4.4	-3.5 to 12.3	1.1	0.20	0.3
Unemployment	0.1	0.02 to 0.2	2.4	0.40	0.02
<b>Eating Disorders</b>					
HDI	1.9	0.8 to 3.0	3.5	0.52	0.001
GINI index	1.2	0.3 to 2.0	2.7	0.43	0.01
Unemployment	0.02	0.006 to 0.02	3.4	0.52	0.002
<b>Alcohol Use Disorders</b>					
HDI	0.9	-6.4 to 8.2	0.3	0.04	0.8
GINI index	-1.2	-6.7 to 4.4	-0.4	-0.07	0.7
Unemployment	-0.05	-0.1 to 0.02	-1.5	-0.26	0.1

Supplementary Table 3 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-3.2	-35.5 to 29.1	-0.2	-0.04	0.8
GINI index	-18.8	-43.8 to 6.3	-1.5	-0.26	0.1
Unemployment	-0.4	-0.6 to -0.09	-2.7	-0.43	0.01
<b>Bipolar Disorders</b>					
HDI	1.4	-0.05 to 2.8	2.0	0.33	0.06
GINI index	0.5	-0.6 to 1.6	0.9	0.16	0.4
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

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- 1 Maronna RA, Martin RD, Yohai VJ, Salibián-Barrera M. *Robust statistics: theory and methods (with R)*. John Wiley & Sons, 2019.
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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
<b>Title and abstract</b>	1 ✓	(a) Indicate the study's design with a commonly used term in the title or the abstract
	✓	(b) Provide in the abstract an informative and balanced summary of what was done and what was found
<b>Introduction</b>		
Background/rationale	2 ✓	Explain the scientific background and rationale for the investigation being reported
Objectives	3 ✓	State specific objectives, including any prespecified hypotheses
<b>Methods</b>		
Study design	4 ✓	Present key elements of study design early in the paper
Setting	5 ✓	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 ✓	(a) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7 ✓	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* ✓	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 ✓	Describe any efforts to address potential sources of bias
Study size	10 ✓	Explain how the study size was arrived at
Quantitative variables	11 ✓	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 ✓	(a) Describe all statistical methods, including those used to control for confounding
	✓	(b) Describe any methods used to examine subgroups and interactions
	✓	(c) Explain how missing data were addressed
	✓	(d) If applicable, describe analytical methods taking account of sampling strategy
	✓	(e) Describe any sensitivity analyses
<b>Results</b>		
Participants	13* ✓	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	✓	(b) Give reasons for non-participation at each stage
	✓	(c) Consider use of a flow diagram
Descriptive data	14* ✓	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
	✓	(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15* ✓	Report numbers of outcome events or summary measures
Main results	16 ✓	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
	✓	(b) Report category boundaries when continuous variables were categorized
	✓	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 ✓	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

<b>Discussion</b>		
Key results	18 ✓	Summarise key results with reference to study objectives
Limitations	19 ✓	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 ✓	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 ✓	Discuss the generalisability (external validity) of the study results
<b>Other information</b>		
Funding	22 ✓	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## **An ecological study of the association between mental illness with human development, income inequalities and unemployment across OECD countries**

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-035055.R2
Article Type:	Original research
Date Submitted by the Author:	31-Mar-2020
Complete List of Authors:	Barbalat, Guillaume; CNRS & Université Lyon 1 Franck , Nicolas ; CNRS & Université Lyon 1
<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Mental health, Sociology, Global health
Keywords:	MENTAL HEALTH, EPIDEMIOLOGY, SOCIAL MEDICINE

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6 **Title:** An ecological study of the association between mental illness with human development,  
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8 income inequalities and unemployment across OECD countries.  
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46 **Abstract word count:** 297.  
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48 **Word count:** 3190 (excluding references, tables and acknowledgements).  
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## **ABSTRACT**

### **OBJECTIVES**

Recent studies have demonstrated worsened mental health in relatively highly developed countries impacted by social inequalities and unemployment. Here, we investigate (1) whether mental health issues are differently or similarly affected by these social factors; and (2) whether their effects on mental health are related or unrelated to each other.

### **SETTING**

Analysis at the country level amongst OECD (Organization for Economic Cooperation and Development) countries (N=36). Data on social indicators was collected from OECD and United Nations Development Programme (UNDP) databases. Data on the prevalence of mental issues was obtained from the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease (GBD) study 2017.

### **PARTICIPANTS**

No involvement of participants.

### **PRIMARY AND SECONDARY OUTCOME MEASURES**

Using linear regression models, we investigated the relative contribution played by human development (as measured by the Human Development Index - HDI), social inequalities (GINI index) and unemployment (unemployment rate) on the prevalence of 10 mental health issues. We then measured the relationship between the socio-economic factors' effects on mental issues using 2x2 Pearson's correlation test and Principal Component Analysis.

### **RESULTS**

First, the overall effect of each socio-economic factor on a combination of mental health disorders was large (r range: 0.51-0.76;  $p < 0.002$ ). However, the influence of social factors on mental health was relative to each mental issue (r range: -0.34 to 0.74). Second, the socio-economic factors' effects on mental health showed strong interdependence ( $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.81$ ,  $r_{\text{unemploy-}}$

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2  $r_{GINI}=0.84$ ;  $p<0.001$ . Principal component analysis demonstrated that the first principal component of  
3  
4 the three variables ( $r_{HDI}$ ,  $r_{GINI}$ ,  $r_{unemploy}$ ) explained 91.5% of the variance.  
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## 6 **CONCLUSION**

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9 These results implore a re-analysis of the socio-economic determinants of mental health where: 1)  
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11 the heterogeneity of mental health issues would be taken into account; and 2) each socio-  
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13 economic indicator's effect would be analysed and interpreted in conjunction with the others.  
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## **STRENGTHS AND LIMITATIONS OF THIS STUDY**

- To allow for comparability across populations and minimize the risk of outliers, our study focused on OECD countries, which are mostly high-income countries.
- Data on the prevalence of 10 mental issues was obtained from the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease (GBD) study 2017, from which an increasing number of high-impact epidemiological studies has already been published.
- Our analysis took into account overall healthcare spending and potential outlier countries.
- The ecological design was necessary because our research questions were directly related to the association of national-level mental health prevalence and socio-economic indicators, however there is no possibility to make inferences about individuals from this dataset.
- The observational nature of our analysis means that other uncontrolled socio-cultural factors might have influenced the prevalence of mental issues in individual countries.



## **MAIN TEXT**

### **INTRODUCTION**

A significant proportion of the overall disease burden is related to mental disorders. For instance, depressive disorders and schizophrenia account for as much as 63200 and 15000 absolute Disability-Adjusted Life Year per thousand people, which makes them the second and the eleventh most burdensome disorders, respectively [1]. Suicide is also a serious global public health issue, being amongst the top twenty leading causes of death worldwide, and the second leading cause of death in young people aged 15-29 years [2]. Therefore, how to promote mental health at a wide, public health level is a crucial matter.

Following the bio-psycho-social account of mental disorders, one can say that mental health is currently promoted at 3 basic levels. First, the increasing knowledge of biological determinisms of mental illness has led to great efforts (but not necessarily successes) to destigmatise patients with a mental disorder that is beyond their control [3]. Second, psychological attributes such as confidence, agency, optimism, or resilience are now widely used to promote mental health at a public health level [4]. Third, important insights have revealed that discrimination based on socio-demographic factors such as socio-economic status, race, ethnicity, gender and sexual orientation can have a huge impact on mental health [5].

However, contrary to biological and psychological factors that are now routinely addressed by clinicians, practitioners keep struggling to meet their patients social needs. Recent accounts emphasize the need for a better awareness of the social, economical and political determinants of mental health amongst mental health practitioners [6]. Those accounts call for a better recognition of how structures (such as institutions, systems, or policies) bias social justice against certain types of people and shape symptoms and diseases – especially mental disorders. Recognizing factors that participate to structural discrimination in day-to-day practice would be crucial to advocate for the reduction of inequalities both in clinical interactions and, perhaps even more importantly, to

1  
2 promote better mental health at a public health level [7].  
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4 In the current study, we chose to leave aside dimensions of structural discrimination related  
5 to race, gender, religion and sexual orientation to focus on country-level socio-economic status and  
6 its relationship to mental health disorders prevalence. We investigated 3 measures meant to define  
7 the social and economic status of a nation: human development, income inequalities and  
8 unemployment rate. Human development, which is composed by a measure of health, education  
9 and standard of living, aims at representing the average level of freedoms, opportunities and  
10 financial wealth of a country. Income inequalities gives insight on how wealth is distributed within a  
11 nation. Finally, unemployment rate measures the percentage of people without a professional  
12 occupation.  
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24 Recent studies have suggested that relatively highly developed countries demonstrate  
25 worsened mental health when impacted by income inequalities [8–10] and unemployment [11].  
26 Although this has been of great interest to social epidemiologists, two important questions have  
27 remained unanswered. First, it is unclear whether mental health issues are differently or similarly  
28 affected by these social factors. International classifications such as the DSM or the ICD define  
29 mental disorders as a constellation of potential problems, rather than a single, unifying issue  
30 [12,13]. The question is therefore whether socio-economic indicators influence those various  
31 disorders in a different or similar manner. Given the heterogeneity of mental health problems, one  
32 would expect a differential impact of these social factors on various mental health issues, where for  
33 instance bipolar disorders would have a different relation to socio-economic indicators than  
34 schizophrenia or alcohol use disorders. On the other hand, recent accounts of mental issues have  
35 criticized the view that mental disorders were discriminable. Those accounts are based on clinical,  
36 biochemical, genetics, and cognitive neuroscience studies that have suggested fairly similar  
37 mechanisms underpinning different mental diseases such as schizophrenia, depression, anxiety  
38 disorders, and attention-deficit and hyperactivity disorders (ADHD) [14]. Following this account,  
39 one would expect that social factors would influence different mental disorders in a rather similar  
40 way.  
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2 A second uncertainty is whether those socio-economic factors' effects on mental health are  
3 related or unrelated to each other. On the one hand, there are theoretical reasons to believe that  
4 those socio-economic factors may have a correlated impact on mental problems. A common path  
5 to mental well-being may be that of income, wealth and perhaps success, where development  
6 would relate to *average* wealth, inequalities to wealth *distribution* and unemployment to the main  
7 *source* of wealth for most people. On the other hand however, development, inequalities and  
8 unemployment usually vary in a way that is grossly uncorrelated [15]. Thus, according to this  
9 account, there is no *a priori* empirical reason to suspect that their effects on mental health are  
10 related to each other.  
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21 This study aimed at better categorizing the relations between development, inequalities,  
22 and unemployment with the prevalence of various mental health issues at the country level. To  
23 allow for comparability across populations and minimize the risk of outliers, we restricted our  
24 analyses to the 36 relatively rich countries that belong to the Organization for Economic  
25 Cooperation and Development (OECD). This choice is based on the fact that, in developing  
26 countries, mental disorders could rely on other social factors than the ones we investigated in the  
27 current study, such as human rights and inland security [16]. Likewise, there seems to be key  
28 differences between developing and developed countries in how human development affects  
29 mental health. While the prevalence of mental disorders such as depression decreases when the  
30 level of human development increases, developed countries seem to demonstrate an opposite  
31 pattern: the higher their level of development, the higher their prevalence of mental disorders [17].  
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45 We restricted our analysis to the most common mental health disorders, that is, depressive  
46 disorders, bipolar disorders, schizophrenia, eating disorders, anxiety disorders, ADHD, alcohol use  
47 disorders, and autism spectrum disorders. As an obvious public mental health issue, we also  
48 added suicide prevalence to our analysis. Two caveats are related to the collection of prevalence  
49 data on mental disorders across countries. First, the range of epidemiological studies meant to  
50 report prevalence data are unequally distributed across issues, age groups and countries [18]. To  
51 overcome this challenge, we chose to collect data on the prevalence of mental health disorders  
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1 from the Institute of Health Metrics & Evaluation (IHME)'s Global Burden of Disease (GBD) study  
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3 2017 [19]. To the best of our knowledge, this is currently the only source which produces global  
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5 level estimates across countries where diagnostic categories for mental health and alcohol use  
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7 disorders are adequately represented. Second, prevalence data could reflect, at least in part,  
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9 different healthcare spending across countries rather than giving a representative perspective on  
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11 specific differences between countries. Countries that spend a lot on healthcare would likely show  
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13 inflated prevalence as a result of an increased focus on mental health disorders. To overcome this  
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15 bias, we decided to run a second set of analysis taking into account overall healthcare spending  
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17 and check if results from both analyses are comparable.  
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## 24 **METHODS**

### 25 **Data series**

#### 26 Dependent variable

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29 Prevalences of mental health issues across OECD countries were collected from the Institute of  
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31 Health Metrics & Evaluation (IHME)'s Global Burden of Disease (GBD) project database [19],  
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33 where data is estimated from a combination of surveys, medical and epidemiological data, as well  
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35 as meta-regression models. Data from the GBD study 2017 was released in November 2018, and  
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37 concern years 1990-2017. The GBD study 2017 defines prevalence as the proportion of people in  
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39 a population who are a case of a disease, injury or sequela. All results in GBD refer to point  
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41 prevalence.  
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47 Data was extracted for year 2017 for a combination of mental health disorders and the  
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49 specific following issues: depressive disorders, anxiety disorders, schizophrenia, bipolar disorders,  
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51 eating disorders, alcohol use disorders, ADHD, autism spectrum disorders and suicide (**Table 1**).  
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53 Note that suicide did not include non-fatal self-harm.  
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56 Prevalence data was age standardized, which allowed comparability across populations  
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58 when their age profiles were different. Data was calculated in relation to the entire population.  
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2 Extracted data did not necessitate any further transformation and was ready to be used.  
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### 7 Independent variables

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9 Each country's level of human development was measured with the Human Development Index  
10 (HDI; range: 0-1). The HDI summarizes life expectancy, a combination of adult literacy rate and  
11 school enrolment rate, and gross domestic product per capita at purchasing power parity [20].  
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16 For each country, income inequality was measured using the GINI index (range: 0-1), which  
17 intends to represent a nation's income distribution [21]. A GINI coefficient of 0 means that the  
18 country income is perfectly equally distributed. A GINI coefficient of 1 means that all the country's  
19 income is received by just one person.  
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24 Our third socio-economic indicator was unemployment rate, which measures the rate of  
25 unemployment as a percentage of the labour force [22].  
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29 Data for the three predictors was collected from the OECD database except for HDI, which  
30 was retrieved from the United Nations Development Programme database (**Table 1**). Data was  
31 extracted for year 2016, except when unavailable, in which case data was extracted for the closest  
32 year previous to 2016 (year range for data collection: 2014-2016).  
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37 Source data for all 36 OECD countries is available at  
38 <https://data.mendeley.com/datasets/xcycfh96x5/1>. There was no missing data. For each indicator  
39 (dependent and independent variables), atypical countries were defined as having a z-score  
40 greater than 3 or below -3 (**Table 1**).  
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52 *Table 1 about here*  
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## Statistical Analysis

We ran multiple regression linear models where the prevalence of a mental issue across OECD countries is predicted by the HDI, GINI index, and unemployment rate. Extreme outliers were defined as data points with Cook's distance  $> 1$  [23]. Using this cut-off, we were not able to identify any outliers when running our linear models.

For each mental health issue, we then converted each of the socio-economic indicators' t statistic into their corresponding effect size (Pearson's  $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ). We then computed 2x2 Pearson's correlation coefficients between those 3 variables ( $r_{\text{HDI-GINI}}$ ,  $r_{\text{HDI-unemploy}}$ ,  $r_{\text{unemploy-GINI}}$ ) to estimate their pairwise relationships across all mental health problems. Finally, to investigate the linear dependency between the 3 indicators' effect sizes, we ran principal component analysis and obtained explained variance for the first principal component.

An important caveat when collecting mental health data at the country level is that prevalence could reflect healthcare spending (which allows for more focus on mental health disorders) rather than giving a representative perspective on differences between countries. For our data, Pearson's  $r$  between combined mental health disorders prevalence and healthcare spending as measured by price per capita at purchasing power parity (obtained from the OECD database [24]) was of 0.58 ( $p < 0.001$ ). To check that our results were not impacted by overall healthcare expenditures, we decided to regress out the influence of healthcare spending on the prevalence of each mental health issue and to re-run our analysis using the residuals as dependent variables. Finally, to check that our results were not too influenced by outliers, we also ran our analysis using robust regression methods.

To run these analyses, we used R 3.6.1.

## Patient and public involvement

1  
2 No patients were involved in this study.  
3

## 4 **RESULTS**

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7 Multiple linear regression models performed on the prevalence of a combination of mental health  
8 disorders revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment  
9 ( $r_{\text{unemploy}}$ ) was large ( $r$  range: 0.51-0.76). However they demonstrated great variation when  
10 measured amongst different mental health issues ( $r$  range: -0.34 to 0.74; **Table 2 and**  
11 **Supplementary Table 1**), the most prominent being no positive effect on suicide and alcohol use  
12 disorders, and a larger effect on other mental disorders. Regarding the latter, development had a  
13 strong effect ( $r > 0.65$ ) on the prevalence of each disorder apart from bipolar disorders and ADHD  
14 ( $r < 0.43$ ); income inequalities had at least a moderate effect ( $r > 0.40$ ) on the prevalence of each  
15 disorder apart from bipolar disorders and ADHD ( $r < 0.30$ ); and unemployment had a moderate  
16 effect on depressive and eating disorders ( $r > 0.42$ ), and only a small effect on autism spectrum  
17 disorders and schizophrenia ( $r < 0.18$ ) (**Table 2**).  
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31 Across mental issues, the socio-economic indicators' effect sizes were strongly related to  
32 each other (Pearson's  $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.81$ ,  $r_{\text{unemploy-GINI}}=0.84$ ). Principal component  
33 analysis demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ )  
34 explained 91.5% of the variance ( $p=0$ , permutation test with 1000 repetitions).  
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42 *Table 2 about here*  
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50 Finally, note that re-running our analysis after controlling for overall healthcare spending  
51 across countries and using robust method to control for outliers clearly reproduced this pattern of  
52 results (**Supplementary Results; Supplementary Tables 2 and 3**).  
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## DISCUSSION

This study aimed at clarifying the relationship between mental health and three socio-economic factors: human development, income inequalities and unemployment. We first demonstrated that, amongst OECD countries, the strength of the relationship between the prevalence of mental health issues with development, inequalities and unemployment, was large for a combination of disorders. This confirms the abundant literature showing a positive association between mental issues with inequalities [9] and unemployment [25,26] for a whole range of mental disorders. More generally, the social science literature is unequivocal as per the association between a country's socio-economic status and health across the life span. Indeed, other studies have demonstrated a strong impact of socio-ecological measures of wealth (e.g. salary, pension), income inequalities, education, and employment on overall health outcomes such as life expectancy, healthy life expectancy, and adolescent health [27–31]. Taking this a step further, our study adds one more argument for the implementation of public health policies expected to counter the devastating effect of inequalities and unemployment [10,32,33].

Aside from the effect of inequalities and unemployment on mental health, that of human development is less straightforward. On the one hand, research has shown that development was accompanied with better mental health [34]. Human development clearly promotes health and wellbeing, for instance by reducing mortality due to infectious diseases thanks to vaccination programmes and antibiotics use; but also by encouraging education, innovations, freedom and opportunities. On the other hand, others have demonstrated an opposite relationship between mental health and human development, with mental disorders prevalence paradoxically increasing with the level of human development [17]. The relationship between human development and mental health found in the current study was clearly of that kind, and this relationship was not related to overall healthcare spending. Some have interpreted this deleterious effect of development on mental health as a potential reflection of the mutation of social values towards less social integration and regulation in modern societies [35,36]. In fact, the relationship between



1  
2 human development and mental health disorders prevalence may follow a U-shape curve, with a  
3  
4 negative relationship (less mental disorders when development increases) for developing  
5  
6 countries, and a positive relationship (more mental disorders when development increases) for  
7  
8 developed countries. Further studies should continue to investigate this association at a more fine-  
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10 grained level, using for instance multilevel models, to better decipher the effect of human  
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12 development on mental health in developing and developed countries.  
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16 In the current study, we were also interested in whether the association between mental  
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18 health with human development, income inequalities, and unemployment varies across mental  
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20 issues; and whether the three socio-economic factors' effects on mental health are related to each  
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22 other. As a second important result of our study, we demonstrated that the association between  
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24 mental issues and the three socio-economic factors was in fact relative to each mental health  
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26 issue. Non-addictive mental health disorders tested in this study were clearly associated to these  
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28 social factors, though to various degrees. Hypotheses on how each of those mental issues  
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30 specifically relies to development, inequalities and unemployment are beyond the scope of this  
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32 study and are open to further empirical testing. In contrast, development, inequalities and  
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34 unemployment did not negatively impact suicide and alcohol use disorders. This seems to  
35  
36 contradict within-country studies that have demonstrated that inequalities and unemployment both  
37  
38 affect suicide and alcohol use disorders prevalence [37–41]. In fact, both issues are also thought to  
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40 be strongly influenced by other socio-cultural factors that vary independently from development,  
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42 inequalities and unemployment. For instance, long-term unemployment [42] or work stress [43]  
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44 have been associated to suicide, while religion [44,45], connectedness and neighbourhood  
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46 conditions [46] are known protective factors against extreme behaviours. Overall, those additional  
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48 factors, untested in this study, may have masked the effect of development, inequalities and  
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50 unemployment on suicide and alcohol use.  
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54 A third important finding of our study is that the socio-economic factors' effects on mental  
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56 health are strongly related to each other. This suggests that they share an underlying common  
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58 pathway. As such, they could pertain to a so-called social structure that would influence and  
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1  
2 restrict the choices and opportunities available to people [47] and tend to bias an overall society  
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4 towards better, or worse, mental health. In modern societies, development, inequalities and  
5  
6 unemployment can all be viewed as indicators of key cultural values and norms important for social  
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8 inclusion and cohesion. Such values and norms participate to some of the core features of  
9  
10 capitalist systems: accumulation, competition and labour wages. That is, a high level of  
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12 development sets priorities for people to reach a high threshold of desired outcomes in terms of  
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14 education, health or financial wealth [48]. Likewise, greater income inequalities can shape attitudes  
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16 towards reaching a higher social position compared to others [49]. Finally, the value of an  
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18 employment position in this context is both material (it gives a source of income) and socio-cultural  
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20 (not having a job is typically perceived as being a failure in the society). Overall, these social  
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22 factors' unifying feature may be their underlying pressure for success, which in turn could explain  
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24 their negative impact on mental health.  
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### 30 **Limitations**

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33 First, because our research questions were directly related to the association of national-level  
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35 mental health prevalence and socio-economic indicators, we considered the ecological design the  
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37 most appropriate for our study [8]. However, the observational nature of our analysis implies that  
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39 other uncontrolled socio-cultural factors might have influenced the prevalence of mental issues in  
40  
41 individual countries. We obviously need to be careful about any over-interpretation of our results as  
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43 demonstrating causality while our models can only be predictive.  
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46 A second potential limitation of this study is the so-called ecological fallacy, that is, making  
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48 inferences on individual risk from analysis made on aggregate data [50]. Based on this study  
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50 results, one cannot draw conclusions about the specific nature of individuals (e.g. their socio-  
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52 economic status) who suffer from mental health issues. To solve this question, one would need to  
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54 design a multilevel study where socio-economic status at the individual level and at the country  
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56 level would be entered as two-level predictors.  
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59 Third, it is likely that the effect of development, inequalities, and unemployment is different  
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2 across non-OECD countries and especially low and middle income countries. For instance, and as  
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4 mentioned above, human development would have more of a beneficial effect on mental health in  
5  
6 such developing countries [34]. That said, as most of the European and North American  
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8 populations were included in the current study, our results are probably generalizable to western  
9  
10 countries.

## 11 12 13 14 15 16 **Conclusion**

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18 Despite those limitations, these results implore a re-analysis of the socio-economic determinants of  
19  
20 mental health where: 1) the heterogeneity of mental health issues would be taken into account;  
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22 and 2) each socio-economic indicator's effect would be analysed and interpreted in conjunction  
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24 with the others.  
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## 33 **DECLARATION OF INTEREST**

34  
35 The authors have no biomedical financial interests or potential conflicts of interest.  
36  
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## 39 **FUNDING**

40  
41 This research received no specific grant from any funding agency, commercial or not-for-profit  
42  
43 sectors.  
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## 48 **AUTHOR CONTRIBUTION**

49  
50 All authors were involved in drafting the article or revising it critically for important intellectual  
51  
52 content, and have read and approved the final version of the manuscript. G.B. and N.F. designed  
53  
54 the study. G.B. gathered the data. G.B. and N.F. analysed the data and wrote the paper.  
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## 58 **DATA AVAILABILITY**

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Data are available in a public, open access repository  
(<https://data.mendeley.com/datasets/xcycfh96x5/1>).

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**TABLES****Table 1. Descriptive statistics for dependent and independent variables (N=36).**

Variable	Range	Mean	Population-weighted mean	Standard Deviation	Atypical countries <sup>b</sup>
Prevalence of combined mental health disorders <sup>a</sup> (%)	10.87-18.71	14.28	14.76	2.13	None
Prevalence of Autism Spectrum Disorders (%)	0.36-0.94	0.60	0.65	0.12	None
Prevalence of ADHD (%)	0.43-2.53	1.15	1.13	0.40	Australia (2.53%)
Prevalence of Depressive Disorders (%)	2.25-4.84	3.71	3.89	0.65	None
Prevalence of Schizophrenia (%)	0.20-0.36	0.26	0.28	0.05	None
Prevalence of Anxiety Disorders (%)	2.94-8.50	4.93	5.19	1.46	None
Prevalence of Eating Disorders (%)	0.23-0.94	0.48	0.48	0.18	None
Prevalence of Alcohol Use Disorders (%)	0.46-4.71	1.84	1.56	0.99	None
Prevalence of Suicide (per 100.000)	3.31-27.99	10.89	10.66	4.75	Lithuania (27.99 per 100.000)
Prevalence of Bipolar Disorders (%)	0.57-1.21	0.86	0.79	0.15	None
HDI	0.77-0.95	0.89	0.89	0.04	None
GINI index	0.24-0.46	0.32	0.36	0.05	None
Unemployment rate (%)	2.97-23.54	7.41	6.46	4.20	Greece (23.54%)

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

<sup>b</sup> whose z-score is greater than 3 or below -3.

**Table 2: Effects of human development, income inequalities and unemployment on the prevalence of 10 mental health issues across OECD countries (N=36).**

Pearson's r	Combined	ASD	ADHD	DEP	SCZ	ANX	ED	ETOH	SUICIDE	BD
$r_{\text{HDI}}$	0.76	0.74	0.21	0.68	0.72	0.65	0.74	-0.27	-0.07	0.43
$r_{\text{GINI}}$	0.59	0.46	0.30	0.59	0.49	0.40	0.45	-0.10	-0.07	0.14
$r_{\text{unemploy}}$	0.51	0.15	0.27	0.42	0.18	0.29	0.45	-0.18	-0.34	0.30

“Combined”: combination of Autism Spectrum Disorders, Attention-Deficit/Hyperactivity Disorders, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders; “ASD”: Autism Spectrum Disorders; “ADHD”: Attention-Deficit/Hyperactivity Disorders; “DEP”: Depressive Disorders; “SCZ”: Schizophrenia; “ANX”: Anxiety Disorders; “ED”: Eating Disorders; “ETOH”: Alcohol Use Disorders; “SUICIDE”: suicide rates; “BD”: Bipolar Disorders.

## SUPPLEMENTARY MATERIAL

### SUPPLEMENTARY RESULTS

#### Analysis taking into account overall healthcare spending

To ensure that our results were not impacted by overall healthcare expenditures, we decided to regress out the influence of healthcare spending on the prevalence of each mental health issue and to re-run our analysis using the residuals as dependent variables. When performed on a combination of mental health disorders, multiple linear regression models revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment ( $r_{\text{unemploy}}$ ) was medium to large ( $r$  range: 0.47-0.54). However they demonstrated great variation when performed amongst different mental health issues ( $r$  range: -0.34 to 0.52, **Supplementary Table 2**).

Across mental issues, the socio-economic indicators' effect sizes were strongly related to each other ( $r_{\text{HDI-GINI}}=0.89$ ,  $r_{\text{HDI-unemploy}}=0.93$ ,  $r_{\text{unemploy-GINI}}=0.87$ ). Principal component analysis demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained 94% of the variance ( $p=0$ , permutation test with 1000 repetitions).

Therefore, this analysis yield similar results than that reported in the main text.

#### Analysis using robust regression methods

To ensure that our results were not impacted by outliers, we re-ran our analyses using robust regression methods [1]. We used the `lmrob` function from the `robustbase` package in R (version 3.6.1), which computes fast MM-type estimators for linear regression models. We sat the default arguments as suggested in Koller and Stahel (2011) with an initial S-estimate, followed by an M-estimate, a Design Adaptive Scale estimate and a final M-step; and a “linear quadratic quadratic” (lqq for short) psi function [2].

When performed on a combination of mental health disorders, multiple linear regression

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2 models revealed that the effect of development ( $r_{\text{HDI}}$ ), inequalities ( $r_{\text{GINI}}$ ) and unemployment  
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4 ( $r_{\text{unemploy}}$ ) was medium to large ( $r$  range: 0.44-0.59). However they demonstrated great variation  
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6 when performed amongst different mental health issues ( $r$  range: -0.43 to 0.55, **Supplementary**  
7  
8 **Table 3**). Across mental issues, the socio-economic indicators' effect sizes were strongly related to  
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10 each other ( $r_{\text{HDI-GINI}}=0.93$ ,  $r_{\text{HDI-unemploy}}=0.87$ ,  $r_{\text{unemploy-GINI}}=0.91$ ). Principal component analysis  
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12 demonstrated that the first principal component of the three variables ( $r_{\text{HDI}}$ ,  $r_{\text{GINI}}$ ,  $r_{\text{unemploy}}$ ) explained  
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14 94% of the variance ( $p=0$ , permutation test with 1000 repetitions).  
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17 Therefore, results using robust linear regression methods were highly comparable to those  
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19 using non-robust methods.  
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3 **SUPPLEMENTARY TABLES**  
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6 **Supplementary Table 1. Summary statistics of multiple linear regression models run on the**  
7 **prevalence of 10 mental health issues (N=36).**  
8

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health issues<sup>a</sup></b>					
HDI	45.9	31.8 to 60.1	6.6	0.76	0.0000002
GINI index	22.1	11.2 to 33.0	4.1	0.59	0.0002
Unemployment	0.2	0.08 to 0.3	3.3	0.51	0.002
<b>Autism Spectrum Disorder</b>					
HDI	2.5	1.7 to 3.3	6.3	0.74	0.0000005
GINI index	0.9	0.3 to 1.5	3.0	0.46	0.006
Unemployment	0.003	-0.004 to 0.01	0.8	0.15	0.4
<b>ADHD</b>					
HDI	2.3	-1.6 to 6.1	1.2	0.21	0.2
GINI index	2.6	-0.4 to 5.6	1.8	0.30	0.09
Unemployment	0.03	-0.007 to 0.06	1.6	0.27	0.1
<b>Depressive Disorders</b>					
HDI	12.3	7.6 to 17.1	5.2	0.68	0.000009
GINI index	7.5	3.9 to 11.2	4.2	0.59	0.0002
Unemployment	0.05	0.01 to 0.09	2.6	0.42	0.01
<b>Schizophrenia</b>					
HDI	1.0	0.6 to 1.3	5.8	0.72	0.000002
GINI index	0.4	0.1 to 0.7	3.1	0.49	0.004
Unemployment	0.001	-0.001 to 0.004	1.0	0.18	0.3
<b>Anxiety Disorders</b>					
HDI	27.4	15.9 to 38.9	4.9	0.65	0.00003
GINI index	10.6	1.7 to 19.4	2.4	0.40	0.02
Unemployment	0.08	-0.02 to 0.2	1.7	0.29	0.1
<b>Eating Disorders</b>					
HDI	3.7	2.5 to 4.9	6.2	0.74	0.0000005
GINI index	1.3	0.4 to 2.2	2.8	0.45	0.008
Unemployment	0.01	0.004 to 0.02	2.8	0.45	0.008
<b>Alcohol Use Disorders</b>					
HDI	-7.6	-17.5 to 2.3	-1.6	-0.27	0.1
GINI index	-2.1	-9.7 to 5.5	-0.6	-0.10	0.6
Unemployment	-0.04	-0.1 to 0.04	-1.0	-0.18	0.3

Supplementary Table 1 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-9.1	-55.6 to 37.4	-0.4	-0.07	0.7
GINI index	-6.8	-42.6 to 28.9	-0.4	-0.07	0.7
Unemployment	-0.4	-0.8 to 0.0005	-2.0	-0.34	0.05
<b>Bipolar Disorders</b>					
HDI	1.8	0.4 to 3.2	2.7	0.43	0.01
GINI index	0.4	-0.6 to 1.5	0.8	0.14	0.4
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**Supplementary Table 2. Summary statistics of multiple linear regression models run on the prevalence of 10 mental health issues after controlling for overall healthcare spending (N=36).**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health issues<sup>a</sup></b>					
HDI	20.5	6.6 to 34.4	3.0	0.47	0.005
GINI index	16.9	6.2 to 27.6	3.2	0.49	0.003
Unemployment	0.2	0.1 to 0.3	3.7	0.54	0.0009
<b>Autism Spectrum Disorder</b>					
HDI	1.0	0.1 to 1.8	2.3	0.38	0.03
GINI index	0.6	-0.1 to 1.3	1.5	0.31	0.08
Unemployment	0.004	-0.004 to 0.01	1.0	0.18	0.3
<b>ADHD</b>					
HDI	2.4	-1.4 to 6.3	1.3	0.22	0.2
GINI index	2.6	-0.4 to 5.6	1.8	0.30	0.1
Unemployment	0.03	-0.008 to 0.06	1.6	0.27	0.1
<b>Depressive Disorders</b>					
HDI	6.2	1.4 to 10.9	2.6	0.42	0.01
GINI index	6.3	2.6 to 9.9	3.5	0.52	0.001
Unemployment	0.06	0.02 to 0.1	2.8	0.45	0.008
<b>Schizophrenia</b>					
HDI	0.4	0.04 to 0.8	2.3	0.38	0.03
GINI index	0.3	0.01 to 0.6	2.1	0.35	0.04
Unemployment	0.002	-0.001 to 0.005	1.2	0.21	0.2
<b>Anxiety Disorders</b>					
HDI	9.6	-1.5 to 20.7	1.8	0.30	0.09
GINI index	6.9	-1.6 to 15.4	1.7	0.28	0.1
Unemployment	0.09	-0.001 to 0.2	2.0	0.34	0.05
<b>Eating Disorders</b>					
HDI	1.8	0.5 to 3.1	2.8	0.44	0.009
GINI index	0.9	-0.1 to 1.9	1.8	0.31	0.08
Unemployment	0.02	0.005 to 0.03	2.9	0.42	0.007
<b>Alcohol Use Disorders</b>					
HDI	-2.2	-12.0 to 7.5	-0.5	-0.08	0.6
GINI index	-1.0	-8.5 to 6.5	-0.3	-0.05	0.8
Unemployment	-0.05	-0.1 to 0.04	-1.1	-0.20	0.3

Supplementary Table 2 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-7.8	-54.2 to 38.7	-0.3	-0.06	0.7
GINI index	-6.5	-42.3 to 29.2	-0.4	-0.07	0.7
Unemployment	-0.4	-0.8 to -0.0008	-2.0	-0.34	0.05
<b>Bipolar Disorders</b>					
HDI	1.2	-0.2 to 2.7	1.7	0.29	0.09
GINI index	0.3	-0.8 to 1.4	0.6	0.10	0.6
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.



**Supplementary Table 3. Summary statistics of multiple linear models run on the prevalence of 10 mental health issues using robust regression methods (after controlling for overall healthcare spending) (N=36).**

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Combined mental health disorders<sup>a</sup></b>					
HDI	17.5	4.5 to 30.5	2.7	0.44	0.01
GINI index	13.9	3.8 to 24.0	2.8	0.44	0.01
Unemployment	0.2	0.1 to 0.3	4.1	0.59	0.0002
<b>Autism Spectrum Disorders</b>					
HDI	0.9	0.2 to 1.6	2.6	0.42	0.01
GINI index	0.6	0.06 to 1.1	2.3	0.37	0.03
Unemployment	0.004	-0.001 to 0.01	1.5	0.26	0.1
<b>ADHD</b>					
HDI	1.5	-1.6 to 4.6	1.0	0.17	0.3
GINI index	1.5	-0.8 to 3.9	1.3	0.23	0.2
Unemployment	0.03	0.0009 to 0.05	2.1	0.35	0.04
<b>Depressive Disorders</b>					
HDI	6.4	1.6 to 11.2	2.7	0.43	0.01
GINI index	6.7	3.0 to 10.4	3.7	0.55	0.0008
Unemployment	0.06	0.02 to 0.1	2.8	0.45	0.008
<b>Schizophrenia</b>					
HDI	0.3	-0.0003 to 0.7	2.0	0.34	0.05
GINI index	0.2	-0.02 to 0.5	1.9	0.32	0.07
Unemployment	0.002	-0.001 to 0.005	1.3	0.23	0.2
<b>Anxiety Disorders</b>					
HDI	7.4	-2.6 to 17.5	1.5	0.26	0.1
GINI index	4.4	-3.5 to 12.3	1.1	0.20	0.3
Unemployment	0.1	0.02 to 0.2	2.4	0.40	0.02
<b>Eating Disorders</b>					
HDI	1.9	0.8 to 3.0	3.5	0.52	0.001
GINI index	1.2	0.3 to 2.0	2.7	0.43	0.01
Unemployment	0.02	0.006 to 0.02	3.4	0.52	0.002
<b>Alcohol Use Disorders</b>					
HDI	0.9	-6.4 to 8.2	0.3	0.04	0.8
GINI index	-1.2	-6.7 to 4.4	-0.4	-0.07	0.7
Unemployment	-0.05	-0.1 to 0.02	-1.5	-0.26	0.1

Supplementary Table 3 continued

Predictor	Estimator coefficient	95% Confidence interval	T value	Effect size (Pearson's r)	P value
<b>Suicide</b>					
HDI	-3.2	-35.5 to 29.1	-0.2	-0.04	0.8
GINI index	-18.8	-43.8 to 6.3	-1.5	-0.26	0.1
Unemployment	-0.4	-0.6 to -0.09	-2.7	-0.43	0.01
<b>Bipolar Disorders</b>					
HDI	1.4	-0.05 to 2.8	2.0	0.33	0.06
GINI index	0.5	-0.6 to 1.6	0.9	0.16	0.4
Unemployment	0.01	-0.001 to 0.02	1.8	0.30	0.08

<sup>a</sup> this includes Autism Spectrum Disorders, ADHD, Conduct Disorders, Idiopathic developmental intellectual disability, Depressive disorders, Schizophrenia, Anxiety disorders, Eating disorder and Bipolar disorders.

**REFERENCES**

- 1 Maronna RA, Martin RD, Yohai VJ, Salibián-Barrera M. *Robust statistics: theory and methods (with R)*. John Wiley & Sons, 2019.
- 2 Koller M, Stahel WA. Sharpening wald-type inference in robust regression for small samples. *Comput Stat Data Anal* 2011; **55**: 2504–2515.

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
<b>Title and abstract</b>	1 ✓	(a) Indicate the study's design with a commonly used term in the title or the abstract
	✓	(b) Provide in the abstract an informative and balanced summary of what was done and what was found
<b>Introduction</b>		
Background/rationale	2 ✓	Explain the scientific background and rationale for the investigation being reported
Objectives	3 ✓	State specific objectives, including any prespecified hypotheses
<b>Methods</b>		
Study design	4 ✓	Present key elements of study design early in the paper
Setting	5 ✓	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 ✓	(a) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7 ✓	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* ✓	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 ✓	Describe any efforts to address potential sources of bias
Study size	10 ✓	Explain how the study size was arrived at
Quantitative variables	11 ✓	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 ✓	(a) Describe all statistical methods, including those used to control for confounding
	✓	(b) Describe any methods used to examine subgroups and interactions
	✓	(c) Explain how missing data were addressed
	✓	(d) If applicable, describe analytical methods taking account of sampling strategy
	✓	(e) Describe any sensitivity analyses
<b>Results</b>		
Participants	13* ✓	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	✓	(b) Give reasons for non-participation at each stage
	✓	(c) Consider use of a flow diagram
Descriptive data	14* ✓	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
	✓	(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15* ✓	Report numbers of outcome events or summary measures
Main results	16 ✓	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
	✓	(b) Report category boundaries when continuous variables were categorized
	✓	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 ✓	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

<b>Discussion</b>		
Key results	18 ✓	Summarise key results with reference to study objectives
Limitations	19 ✓	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 ✓	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 ✓	Discuss the generalisability (external validity) of the study results
<b>Other information</b>		
Funding	22 ✓	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).