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RESEARCH

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# Education-related inequalities in beliefs and behaviors pertaining to COVID-19 non-pharmaceutical interventions

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## Abstract

**Background:** The coronavirus pandemic has exposed existing social inequalities in relation to disease preventive behaviors, risk of exposure, testing and healthcare access, and consequences as a result of illness and containment measures across different population groups. However, due to a lack of data, to date there has been limited evidence of the extent of such within-country inequalities globally.

**Methods:** We examined education-related inequalities in four COVID-19 prevention and testing indicators within 90 countries, using data from the University of Maryland Social Data Science Center Global COVID-19 Trends and Impact Survey, in partnership with Facebook, over the period 1 June 2021 to 31 December 2021. The overall level of education-related inequalities, as well as how they differ across country income groups and how they have changed over time were analyzed using the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII). We also assessed whether these education-related inequalities were associated with government policies and responses.

**Results:** Education-related inequalities in beliefs, mask wearing, social distancing and testing varied across the study countries. Mask wearing and beliefs in the effectiveness of social distancing and mask wearing were overall more common among people with a higher level of education. Even after controlling for other sociodemographic and health-related factors, social distancing practice was higher among the most educated in low/lower middle income countries, but was higher overall among the least educated in high income countries. Overall there were low education-related inequalities in COVID-19 testing, though there was variation across countries.

**Conclusions:** The study highlights important within-country education-related differences in COVID-19 beliefs, preventive behaviors and testing, as well as differing trends across country income groups. This has implications for considering and targeting specific population groups when designing public health interventions and messaging during the COVID-19 pandemic and future health emergencies.

**Keywords:** COVID-19 preventive behavior, COVID-19 testing, Education-related inequality, Within-country inequality, Mask use, Social distancing, Non-pharmaceutical interventions

## Background

Non-pharmaceutical interventions recommended by the World Health Organization – including keeping physical distance of at least 1 meter from others; avoiding crowds and close contact; wearing a properly fitted mask when physical distancing is not possible and in poorly ventilated settings; handwashing; and covering nose and mouth when coughing or sneezing [1, 2] – have played

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a key role in controlling and preventing the spread of COVID-19 [3, 4]. Widespread testing and timely diagnosis are also critical for pandemic control, as symptomatic, asymptomatic and pre-symptomatic individuals spread the virus [5]. WHO has recommended that all individuals meeting the suspected case definition for COVID-19 should be tested, prioritizing individuals at risk of severe disease, inpatients and healthcare workers if resources are constrained and it is not possible to test all individuals meeting the case definition [6].

Lessons from previous pandemics emphasize the importance of widespread adoption of non-pharmaceutical interventions [7], noting regional differences in public perceptions and behaviors [8]. Indeed, the acceptance and uptake of COVID-19 prevention and testing measures have varied across populations and over the course of the pandemic. Countries have adopted different policies and approaches in response to COVID-19, which in turn, have variable implications for public compliance [9] and health equity more broadly [10]. Moreover, adherence to non-pharmaceutical interventions has been shown to fluctuate: while mask wearing (a low-cost, habitual behavior) has shown a rise across countries over the course of the pandemic, distancing behaviors (which entail higher costs) have declined [11].

Characterization of inequalities in COVID-19 prevention and testing measures is critical to better adapt and target public health messaging and interventions, in the context of this pandemic and future public health emergencies. Several multi-country studies have assessed the associations between socioeconomic, demographic and geographical factors and the uptake of COVID-19 non-pharmaceutical interventions, highlighting education as a prominent factor. For example, in a review of 31 single-country studies, Siddiquea et al. (2021) found that participants with 12 years of education or less had lower COVID-19 preventative practices (including hand hygiene, mask wearing, and social distancing) [12]. In a one-month (May–June 2020) online survey of 72,000 individuals from 22 countries, Masoud et al. (2021) found that respondents who were female gender, more highly educated and urban residents had higher COVID-19 knowledge and practice scores [13]. A study across 38 countries, the majority of which (26 out of 38) were high income countries, using data from the online COVID-19 Trends and Impact Survey (UMD-CTIS) found that several sociodemographic factors, including higher education, were significantly associated with higher mask usage in public settings [14].

Within-country patterns of education-related inequality in COVID-19 prevention and testing interventions are variable. While education level has been positively associated with COVID-19 prevention behaviors in several countries, including Iran [15], Saudi Arabia [16] and Syria [17], studies in Brazil [18] and the Democratic Republic of Congo [19] demonstrated higher adherence to social distancing rules among those with lower education attainment. In Bangladesh, education level was the sole predictor for COVID-19 preventative behavioral practices (knowledge and attitudes were not predictive) [20]. With regards to COVID-19 testing, studies in Switzerland [21] and the Netherlands [22] highlighted more COVID-testing among groups with more education and higher socioeconomic position. Studies in the USA [23] and Canada [24] did not find education level to be a significant factor in being tested for COVID-19; rather, relevant factors included having COVID-like symptoms, geography, possession of health insurance and higher income.

While studies to date offer useful insights into socioeconomic inequality in non-pharmaceutical intervention indicators, they pertain to different stages of the pandemic and tend to be limited in geographical scope. There remains a lack of harmonized evidence including many countries across all income groupings regarding socioeconomic inequalities in COVID-19 non-pharmaceutical interventions and their change over time. Rigorous analyses that are global in scale are required to situate, consolidate and extend the current state of knowledge.

The current study addresses this gap in the literature. In this study, we quantify the extent of within-country education-related inequalities in prevention and testing indicators during the COVID-19 pandemic, exploring variations by country income level grouping and assessing change over time. We also assess whether government policies and responses have an association with levels of education-related inequality. Until recently, such an undertaking was limited by the paucity of globally comparable data on COVID-19 prevention and testing measures. Data are now available from the University of Maryland Social Data Science Center Global COVID-19 Trends and Impact Survey (UMD-CTIS), conducted in partnership with Facebook, which has gathered over 200,000 respondents daily since April 2020 – the largest global health survey to date [25].

## Methods

### Data

The UMD-CTIS is an ongoing cross-sectional daily survey that has been implemented since April 23, 2020 in over 200 countries and territories. The survey is delivered via Facebook and is available in 56 languages, which excludes only about 5% of the Facebook user base globally [26]. A representative sample of Facebook users aged 18 years and older is invited every day to respond to questions about COVID-19 symptoms, health risk factors, preventive behaviors, vaccine acceptance, mental health issues, and financial constraints. Individual demographic and socioeconomic characteristics were also collected. The survey instrument has been deployed in multiple waves, with some questions periodically revised to reflect emergent public health needs. The questionnaires are publicly available online [27].

The sampling design and weighting methodology of the UMD-CTIS have been described in detail [28, 29]. Briefly, sampling weights are provided by Facebook to reduce nonresponse and coverage bias. The weight for an individual is scaled to approximate the number of people in the adult population represented by that individual based on age, gender, location, and date. In this study we included survey responses for the seven-month period from the 1 June 2021 to 31 December 2021.

### Study population

Countries were considered for inclusion in the study if they were WHO Member States and Facebook provided weights were available ($n = 109$). Data for the United States of America are not included in the UMD-CTIS, because they were collected via a separate survey and education disaggregation did not align across the two surveys [30]. Nineteen countries were excluded from the analysis due to small sample sizes – when the sample was divided into 12 age/sex subgroups, more than half of the subgroups had fewer than 100 responses, indicating poor data quality and representativeness. Additional sensitivity analysis was conducted to see the effect of including and excluding these counties on the overall results. A total of 90 countries were included in the study: 33 high income countries, 29 upper-middle income countries, 24 lower-middle income countries, and 4 low income countries. This represents 65% of the global adult population (aged 18 and over); 66% of the adult population in high income countries, 40% in upper-middle income countries, 97% in lower-middle income countries, and 29% in low income countries. This study encompasses responses from approximately 14 million people who responded to the outcome questions during the period June to December 2021, with around 2 million responses per month. Note that the attitudes of Facebook users may differ from non-Facebook users and this may vary depending on Facebook penetration within a country; this is at least partly addressed by UMD-CTIS weights, which improve the generalizability of estimates to the general adult population. See the Supplementary Tables for the countries included in the analysis and corresponding sample sizes.

### Outcome variables

Four indicators relating to COVID-19 prevention and testing were used in this study, defined as binary variables. Belief in COVID-19 prevention measures was measured using responses to the questions "How effective is social distancing for preventing the spread of COVID-19?" and "How effective is wearing a face mask for preventing the spread of COVID-19?". The indicator was defined as: 1 if people responded "Very effective" or "Moderately effective" to either question, and 0 otherwise. Responses to these two questions were combined into a single indicator because the two were highly correlated. Mask wearing was measured using responses to the question "In the last 7 days, how often did you wear a mask when in public?". Mask usage was defined as: 1 if the respondent reported wearing a mask "All of the time" or "Most of the time", and 0 otherwise. Social distancing was measured using the responses to the question "In the last 7 days, how often did you intentionally avoid contact with other people?". We defined people avoiding contact with others as: 1 if the respondent answered "All of the time" or "Most of the time", and 0 otherwise. COVID-19 testing was measured using responses of "Yes" to the question "Have you been tested for coronavirus (COVID-19) in the last 14 days?". For all indicators, missing answers (i.e. question seen but not answered) were not included in the denominator.

### Predictor and control variables

Education level was measured using a categorical variable consisting of seven subgroups (no education, less than primary, primary, secondary, high school, college/university, and post-graduate), which has been included in the survey since 20 May 2021.

Other variables that were used in the analysis as control variables included the individual's sex; age; place of residence (urban or rural); level of housing overcrowding (a continuous variable calculated as the number of people in the household divided by the number of rooms used for sleeping); the presence of at least one diagnosed health risk factor (asthma, lung disease, cancer, diabetes, high blood pressure, kidney disease, weak immune system or obesity); and experience of COVID-like illness (defined as having had fever plus either cough or difficulty breathing within the last 24 hours). Housing overcrowding can be an indicator of economic status (in the absence of indicators of individual's income or household wealth in the survey). Health risk factors and experience of COVID-like symptoms were controlled for because these may be associated with increased practice of social distancing, mask wearing and testing. These control variables were selected because independently they were found to be associated with education and the outcome variables, therefore they might confound the magnitude of education-related inequality in the outcome variables.

### Country-level government responses

Data on relevant government responses were extracted from the Oxford COVID-19 Government Response Tracker (OxCGRT) [31], including policies related to facial coverings and testing, and the extent of public information campaigns. An ordinal scale is used to reflect the extent of government action on specific non-pharmaceutical interventions. Scores for nine policies relating to lockdown and containment (including school and workplace closures, cancelling public events, restrictions on gatherings, closing of public transport, stay at home requirements, and travel bans) have also been aggregated within the OxCGRT into a 'Government Stringency Index'. The average policy or index score was calculated for each country each month.

### Statistical analysis

The level of education-related inequality was assessed using disaggregated data and summary measures of inequality. Disaggregated estimates were calculated for each study country, indicator and education subgroup, for the overall study period (June–December 2021). Disaggregated estimates are only reported at country-level when sample sizes were at least 100 within a given education subgroup over the study period.

Absolute and relative inequality was measured using two summary measures of inequality: the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII). SII and RII were calculated for each study country and indicator, for both the overall study period and for each of the 7 months. SII and RII were also calculated separately for males and females (i.e. double disaggregation by sex and education) for the overall study period to examine whether there were different patterns of inequality between males and females.

SII and RII were calculated at the individual level to take advantage of increased sample size and also enable controlling for other factors. A weighted fractional rank was calculated for all individuals in the dataset from the least educated (rank 0) to the most educated (rank 1), the health indicator of interest was then regressed against this rank, and the predicted values were calculated for the two extremes (rank 0 and rank 1) [32, 33]. The SII is defined as the absolute difference in the indicator prevalence between the most and the least educated (rank 1 – rank 0), taking into account all other individuals in the regression. The RII is defined as the ratio of the estimated indicator prevalence between the most and least educated (rank 1 / rank 0), taking into account all other individuals in the regression. An SII value greater than zero and an RII value greater than 1 indicates that the indicator prevalence is higher among the most educated compared with the least educated, and values further from zero or 1 indicate greater levels of inequality. Conversely, an SII value less than zero and an RII value less than 1 indicates that the indicator prevalence is higher among the least educated. A value of zero for SII or a value of 1 for RII indicates no inequality. SII and RII estimates were assessed to be statistically significant only if the confidence intervals of both estimates did not include zero or 1, respectively.

In addition to reporting crude SII and RII, adjusted SII and RII were also calculated for the overall period (limited sample sizes prevented models from converging for monthly data in many countries). In the first model (*Adjusted*) we controlled for individual sociodemographic characteristics (age, sex, place of residence, and household overcrowding), and in the second model we controlled for these characteristics plus the presence of health risk factors and COVID-like symptoms (*Adjusted2*). A Poisson regression model with a robust variance was used to generate the SII and RII values, and corresponding 95% confidence intervals. We used Poisson regression with the robust variance option to give an unbiased standard error because it provides more accurate estimates compared with a logit model, when the outcome has a high prevalence [34].

Medians were calculated across country-level disaggregated estimates by education and SII and RII estimates, to measure the level of inequality globally and across 2021 World Bank country income groups. The 'low income' and 'lower middle income' groups were combined for this analysis, due to a small number of study countries in the 'low income' group. Global and country income group medians for disaggregated estimates were based only on countries that had sample sizes of at least 100 in each education subgroup; therefore, medians for each indicator are based on different numbers of countries.

Additional analysis investigated the relationship between education-related inequality and government responses relating to social distancing, mask wearing, public health information, and COVID-19 testing. Country-level government response scores were correlated – globally and by income group – against the national average and education-related inequality for the selected indicator using Spearman correlations.

All analyses were weighted to account for the survey sampling design. In addition, post-stratification corrections were made to sampling weights to adjust for age/sex population distribution patterns, as represented by the United Nations Population Division 2019 World Population Projections [35]. All analysis were conducted using STATA 16.1.

## Results

### National averages

Overall between June and December 2021, 89.9% (95%CI 88.4–91.9%) of people believed in the effectiveness of social distancing and/or mask wearing for preventing the spread of COVID-19 across 90 countries. This proportion was similar across country income groups (Table 1). Mask usage in public was 79.2% overall (95%CI 75.5–87.7%) however there was a wide range across countries, from 9% in Sweden to 99% in Republic of Korea. Overall, 43.9% (95%CI 40.2–48.3%) of people reported avoiding contact with others all or most of the time, with contact avoidance tending to be lowest in high income countries (35.8%, 95%CI 30.2–42.0%). 15.2% (95%CI 13.5–16.4%) of people overall had been tested for COVID-19 in the last 14 days. National testing rates were highest (over 40%) in Austria, Denmark, Germany, Greece, United Arab Emirates, and the United Kingdom.

### Education-related inequality

Disaggregated global and country-income grouping estimates for the four indicators are shown in Table 1 and Fig. 1. Overall patterns in belief in the effectiveness of COVID-19 prevention behaviors and mask usage showed markedly lower prevalence among the no education and less than primary school subgroups compared to the subgroups with primary education or higher. Globally, disaggregated data demonstrated little education-related inequality in avoiding contact with others. COVID-19 testing was slightly higher in the no education and less than primary school subgroups globally and most markedly in the group of low and lower-middle income countries. See Supplementary Table 1 for country-level disaggregated data and Supplementary Table 2 for country-level SII and RII estimates. We did not find that education-related inequalities differed substantially between females and males, therefore only the results for both sexes are reported and discussed in this paper.

### Belief in the effectiveness of COVID-19 prevention behaviors

Globally, the prevalence of beliefs in the effectiveness of social distancing and/or mask wearing was 8.5 percentage points higher (95%CI 7.3–10.6) among the most educated than the least educated overall (4.4 percentage points (95%CI 3.4–6.4), controlling for other factors) (Table 2 and Fig. 2). SII and RII were statistically significant in 71 of 90 countries. Absolute inequalities were particularly high (over 15 percentage points) in Croatia, Czechia, Lebanon, Republic of Moldova, and Slovakia. People with higher levels of education in these countries were 1.2 times more likely to believe in the effectiveness of preventive measures. Education-related inequalities in these beliefs tended to be smaller in countries with higher national averages. In some cases, there was substantial variation in education-related inequalities across countries with similar national averages. For example, national averages in Israel and France were similar (89%), however absolute education-related inequality in France was three times higher than in Israel (SII of 9.9 and 3.4, respectively). Absolute education-related inequalities were higher overall in high income countries (SII = 6.6, 95%CI 4.4–8.4), followed by upper middle income countries (SII = 4.0, 95%CI 2.8–7.2), and low/lower middle income countries (SII = 2.8, 95%CI 2.5–6.2), after controlling for other factors.

### Mask usage

Overall, across all 90 study countries mask wearing was more common among people with higher levels of education. There was a difference of 10.3 percentage points (95%CI 7.3–12.8) between the most and least educated, which reduced to 3.4 percentage points (95%CI 2.3–4.7), controlling for other sociodemographic and health-related factors. Controlling for other factors, there was little education-related inequality in mask wearing in high income countries overall (median SII = 1.2, 95%CI 0.0–2.5); however, in half of high income countries mask wearing was statistically significantly higher among the most educated. In only 2 of 33 high income countries (Denmark and New Zealand) was mask wearing statistically significantly more common among people with less education; however mask wearing in these countries tended to be low overall (13% and 57%, respectively). In upper middle income countries, mask wearing was 5.2 percentage points (95%CI 3.5–7.3) higher among more educated people overall, controlling for other factors. There were gaps of over 15 percentage points in Lebanon and Libya. There was a similar overall gap of 4.2 percentage points (95%CI 2.5–7.3) in low/lower middle income countries, where 16 of 28 countries had higher mask wearing among the most educated.

### Social distancing

Overall, education-related inequality on social distancing was not statistically significant after controlling for sociodemographic, health risk factors and COVID-like symptom variables (median SII = 0.5, 95%CI -1.0–1.7). However, there was substantial variation across country income groupings. In high income countries, social distancing was more common among people with lower levels of education than people with higher levels of education, controlling for other factors. Adjusted SII and RII were statistically significant in 22 of 33 high income countries, and in all but two of these countries,

**Table 1** Four COVID-19 prevention and testing indicators disaggregated by education: median national and disaggregated estimates (%) and 95% confidence intervals, globally and by country income group (UMD-CTIS, June–December 2021)

| Indicator | Income group | National average | | Education | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | # countries | National average | # countries | No education | Less than primary school | Primary education | Secondary education | High school education | Higher education | Post-graduate education |
| Believe that social distancing and/or wearing a face mask is very or moderately effective for preventing the spread of COVID-19 | Global | 90 | 89.9 (88.4–91.9) | 47 | 79.6 (76.2–84.6) | 85.9 (82.6–89.1) | 90.5 (87.8–92.2) | 91.0 (87.4–92.6) | 91.2 (87.3–93.0) | 93.2 (91.0–94.6) | 94.3 (91.1–95.7) |
| | High income | 33 | 89.2 (87.4–91.3) | 20 | 76.3 (72.8–79.6) | 82.8 (81.6–87.9) | 88.3 (84.6–90.5) | 87.1 (85.9–91.3) | 86.6 (85.0–93.0) | 90.8 (88.7–93.2) | 90.9 (88.7–94.7) |
| | Upper middle income | 29 | 90.2 (82.7–93.5) | 16 | 87.2 (83.0–91.3) | 90.3 (82.3–91.6) | 92.1 (90.4–93.5) | 92.7 (88.7–93.1) | 92.5 (89.2–93.3) | 94.6 (92.2–95.4) | 95.7 (94.0–96.6) |
| | Low and lower middle income | 28 | 91.4 (83.8–94.0) | 11 | 77.7 (68.4–92.9) | 85.4 (69.8–96.1) | 90.1 (70.6–93.7) | 91.4 (80.2–94.1) | 93.3 (82.7–95.1) | 94.0 (86.5–97.0) | 95.5 (88.5–96.9) |
| Use of mask all or most of the time in public in the past 7 days | Global | 90 | 79.2 (75.5–87.7) | 65 | 75.0 (68.2–79.0) | 76.4 (71.2–81.3) | 81.3 (73.1–85.8) | 83.1 (74.1–86.7) | 83.4 (75.7–88.2) | 84.8 (78.6–91.2) | 87.1 (79.4–91.3) |
| | High income | 33 | 76.7 (63.9–85.0) | 25 | 75.1 (61.7–79.2) | 76.4 (65.3–83.2) | 77.1 (63.3–85.3) | 77.2 (64.1–86.4) | 78.1 (63.1–84.1) | 78.8 (65.1–85.9) | 79.2 (66.7–86.0) |
| | Upper middle income | 29 | 86.1 (74.8–93.8) | 23 | 75.0 (68.2–84.1) | 84.9 (72.1–88.5) | 87.1 (71.6–90.4) | 86.7 (72.7–92.2) | 87.4 (74.8–93.4) | 91.5 (77.2–95.6) | 93.5 (80.4–96.5) |
| | Low and lower middle income | 28 | 82.3 (72.7–91.0) | 17 | 73.9 (62.1–81.7) | 74.4 (61.1–78.6) | 79.5 (64.5–88.3) | 83.1 (64.4–89.2) | 87.8 (68.7–91.5) | 90.9 (74.6–94.3) | 92.6 (76.8–95.4) |
| Avoided contact with other people all or most of the time | Global | 90 | 43.9 (40.2–48.3) | 68 | 44.4 (41.6–47.5) | 48.6 (43.0–51.8) | 46.2 (42.5–51.3) | 44.1 (40.2–49.0) | 44.1 (39.6–51.8) | 45.3 (40.6–55.0) | 46.2 (42.3–56.3) |
| | High income | 33 | 35.8 (30.2–42.0) | 26 | 41.8 (35.8–44.5) | 42.5 (39.3–51.4) | 43.2 (33.6–49.4) | 38.4 (30.4–43.6) | 37.6 (29.4–42.2) | 34.6 (27.2–41.0) | 34.6 (31.7–41.5) |
| | Upper middle income | 29 | 55.1 (39.9–59.9) | 24 | 47.4 (44.3–53.2) | 51.8 (43.3–57.1) | 55.7 (43.0–59.2) | 54.7 (40.2–59.3) | 54.5 (40.3–59.0) | 57.3 (43.1–62.5) | 58.9 (44.5–66.2) |
| | Low and lower middle income | 28 | 52.6 (45.3–58.2) | 18 | 46.1 (39.6–54.9) | 49.9 (39.9–54.2) | 45.3 (39.5–58.9) | 45.1 (41.0–60.0) | 51.9 (44.7–59.8) | 57.5 (49.8–64.8) | 58.1 (52.4–67.6) |
| Tested for COVID-19 in the last 14 days | Global | 90 | 15.2 (13.5–16.4) | 68 | 22.2 (19.0–24.7) | 18.8 (15.9–21.7) | 14.5 (13.3–17.0) | 14.6 (13.0–16.5) | 14.5 (12.5–16.1) | 14.6 (13.0–16.5) | 16.0 (14.9–17.6) |
| | High income | 33 | 16.5 (14.6–20.2) | 26 | 20.9 (16.2–24.9) | 16.9 (15.1–20.7) | 13.6 (10.9–17.1) | 13.8 (11.1–19.0) | 15.5 (11.1–19.0) | 16.5 (12.1–22.2) | 17.6 (15.1–24.0) |
| | Upper middle income | 29 | 14.6 (13.0–16.8) | 24 | 21.0 (18.6–25.1) | 18.9 (14.4–25.6) | 15.5 (12.7–17.8) | 14.7 (12.7–17.5) | 13.9 (12.0–16.2) | 13.6 (12.4–16.6) | 15.7 (13.7–17.6) |
| | Low and lower middle income | 28 | 13.0 (11.5–15.9) | 18 | 26.4 (16.1–35.9) | 21.9 (12.6–34.7) | 17.2 (13.1–24.5) | 16.3 (11.4–20.6) | 13.9 (10.3–17.8) | 12.6 (10.4–17.1) | 14.4 (11.3–19.8) |

Medians for education disaggregated estimates are based only on those countries with sample sizes of at least 100 in each education subgroup


**Fig. 1** Four COVID-19 prevention and testing indicators disaggregated by education: median disaggregated estimates (%), globally and by country income group (UMD-CTIS, June–December 2021). Notes: Medians for education disaggregated estimates are based only on those countries with sample sizes of at least 100 in each education subgroup

social distancing was higher among the least educated. In Denmark, Israel and Norway, the least educated were at least 1.6 times more likely to be avoiding contact with others than the most educated (median RII < 0.6). A contrasting pattern was evident in low/lower middle income countries, where social distancing was statistically significantly higher among people with higher levels of education (median adjusted SII = 5.4, 95%CI 2.0–10.0). Fifteen of 28 low/lower middle income countries had significantly higher social distancing among groups with higher education; inequalities were particularly large (over 15 percentage points) in Myanmar, Nepal and Sri Lanka. Only Ghana and Kenya reported higher levels of social distancing among the least educated. In upper middle income countries there was no education-related inequality overall; of the 29 countries, social distancing was higher among the most educated in 12 countries, higher among the least educated in 5 countries, and there was no inequality in 12 countries.

### Testing for COVID-19

Overall there were low education-related inequalities in COVID-19 testing across countries. After controlling for other factors, inequalities were highest in high income countries (SII = 2.5, 95%CI 1.0–4.3). Almost two thirds of high income study countries (20 out of 33) had statistically significant SII favoring the most educated, with the United Kingdom reporting the highest education-related inequalities (SII = 14.3). Inequality was low in upper middle income countries (SII = 1.2, 95%CI 0.3–2.3), and in low/lower middle income countries there was no education-related inequality overall after controlling for sociodemographic and health risk factors. There were, however, divergent patterns across these countries. Of 27 low/lower middle income countries, 15 had non-significant inequality. In 7 countries testing was statistically

**Table 2** Education-related inequality in four COVID-19 prevention and testing indicators: median crude and adjusted Slope Index of Inequality (SII) and Relative Index of Inequality (RII), globally and by country income group (UMD-CTIS, June–December 2021)

| Indicator | Income group | Slope Index of Inequality (SII) | | | Relative Index of Inequality (RII) | | |
|---|---|---|---|---|---|---|---|
| | | Crude (95%CI) | Adjusted (95%CI) | Adjusted2 (95%CI) | Crude (95%CI) | Adjusted (95%CI) | Adjusted2 (95%CI) |
| Believe that social distancing and/or wearing a face mask is very or moderately effective for preventing the spread of COVID-19 | Global | 8.5 (7.3–10.6) | 4.4 (3.4–6.4) | | 1.10 (1.08–1.13) | 1.05 (1.04–1.07) | |
| | High income | 8.4 (6.9–10.9) | 6.6 (4.4–8.4) | | 1.10 (1.08–1.13) | 1.07 (1.05–1.10) | |
| | Upper middle income | 9.0 (5.9–15.1) | 4.0 (2.8–7.2) | | 1.11 (1.06–1.20) | 1.04 (1.03–1.09) | |
| | Low and lower middle income | 8.4 (5.6–12.2) | 2.8 (2.5–6.2) | | 1.09 (1.06–1.15) | 1.03 (1.03–1.08) | |
| Use of mask all or most of the time in public in the past 7 days | Global | 10.3 (7.3–12.8) | 3.8 (2.8–4.7) | 3.4 (2.3–4.7) | 1.14 (1.09–1.19) | 1.05 (1.03–1.06) | 1.04 (1.03–1.06) |
| | High income | 5.3 (3.7–7.9) | 0.6 (−0.4–2.4) | 1.2 (0.0–2.5) | 1.09 (1.06–1.13) | 1.01 (0.99–1.04) | 1.02 (1.00–1.05) |
| | Upper middle income | 12.7 (7.4–19.3) | 5.1 (3.4–6.9) | 5.2 (3.5–7.3) | 1.16 (1.08–1.30) | 1.06 (1.04–1.10) | 1.06 (1.04–1.11) |
| | Low and lower middle income | 15.8 (11.0–20.2) | 4.9 (3.8–6.5) | 4.2 (2.5–7.3) | 1.24 (1.13–1.36) | 1.07 (1.04–1.09) | 1.05 (1.03–1.08) |
| Avoided contact with other people all or most of the time | Global | 9.1 (6.7–11.2) | 0.6 (−1.0–2.2) | 0.5 (−1.0–1.7) | 1.22 (1.16–1.29) | 1.01 (0.98–1.05) | 1.01 (0.98–1.04) |
| | High income | 1.2 (−1.7–4.6) | −2.2 (−4.8–−1.6) | −2.1 (−4.7–−0.5) | 1.05 (0.95–1.11) | 0.92 (0.87–0.97) | 0.93 (0.87–0.99) |
| | Upper middle income | 11.7 (9.6–14.4) | 0.9 (−1.4–4.1) | 0.9 (− 1.1–3.5) | 1.26 (1.19–1.35) | 1.02 (0.98–1.10) | 1.02 (0.98–1.07) |
| | Low and lower middle income | 14.9 (11.6–19.6) | 5.7 (2.4–9.6) | 5.4 (2.0–10.0) | 1.39 (1.32–1.49) | 1.11 (1.05–1.20) | 1.12 (1.05–1.18) |
| Tested for COVID-19 in the last 14 days | Global | −0.7 (−1.9–0.3) | 0.9 (0.4–1.6) | 1.2 (0.4–2.0) | 0.93 (0.87–1.02) | 1.07 (1.03–1.12) | 1.09 (1.02–1.16) |
| | High income | 0.8 (−1.4–2.2) | 2.2 (0.8–4.5) | 2.5 (1.0–4.3) | 1.05 (0.90–1.17) | 1.13 (1.05–1.29) | 1.15 (1.06–1.31) |
| | Upper middle income | −1.2 (−2.3–−0.3) | 1.3 (0.1–2.0) | 1.2 (0.3–2.3) | 0.92 (0.86–0.98) | 1.07 (1.01–1.14) | 1.08 (1.02–1.19) |
| | Low and lower middle income | −2.5 (−3.9–0.5) | 0.3 (− 2.1–1.4) | 0.0 (− 2.2–2.0) | 0.84 (0.74–1.04) | 1.02 (0.86–1.09) | 1.00 (0.87–1.19) |

Notes: The first adjusted model (*Adjusted*) controlled for individual sociodemographic characteristics (age, sex, place of residence, and household overcrowding). The second adjusted model (*Adjusted2*) controlled for these characteristics plus the presence of health risk factors and COVID-like symptoms. *Adjusted2* estimates are not available for the variable "Believe that social distancing and/or wearing a face mask is very or moderately effective for preventing the spread of COVID-19" due to small samples sizes causing low model convergence

significantly higher among the most educated, and in 5 countries it was higher among the least educated. In El Salvador the most educated were over twice as likely to have been tested within the last 14 days than the least educated (RII = 2.3, 95%CI 1.8–2.7).

#### Change in inequality over time

There was little overall change in inequality in beliefs about social distancing and/or mask wearing across all country income groups in the seven-month study period (Fig. 3). However, overall education-related inequality in mask wearing gradually increased over the seven-month period, from a median unadjusted SII of 8.4 in June 2021 to 12.9 in December 2021. This was driven mostly by increases in high income countries (from a median SII of 4.7 to 8.4) and upper middle income countries (from a median SII of 9.3 to 14.4). In low/lower middle income countries, SII remained high over the study period (SII greater than 13).

Unadjusted education-related inequality in social distancing practice reduced by 6.7 percentage points between June and December 2021 in low/lower middle income countries (from a median SII of 18.2 to 11.5) and by 3.5 percentage points in upper middle income countries (median SII of 14.6 to 11.1). By December 2021, the level of education-related inequality was similar in the two groups of countries. In high income countries, education-related inequalities remained low and relatively unchanged.

There was little overall change in inequality in COVID-19 testing. In high income countries there was an increase in education-related inequality in COVID-19 testing in December 2021 favoring the most educated. In low/lower middle income countries education-related inequality in COVID-19 testing was highest in October to December 2021, favoring the least educated.

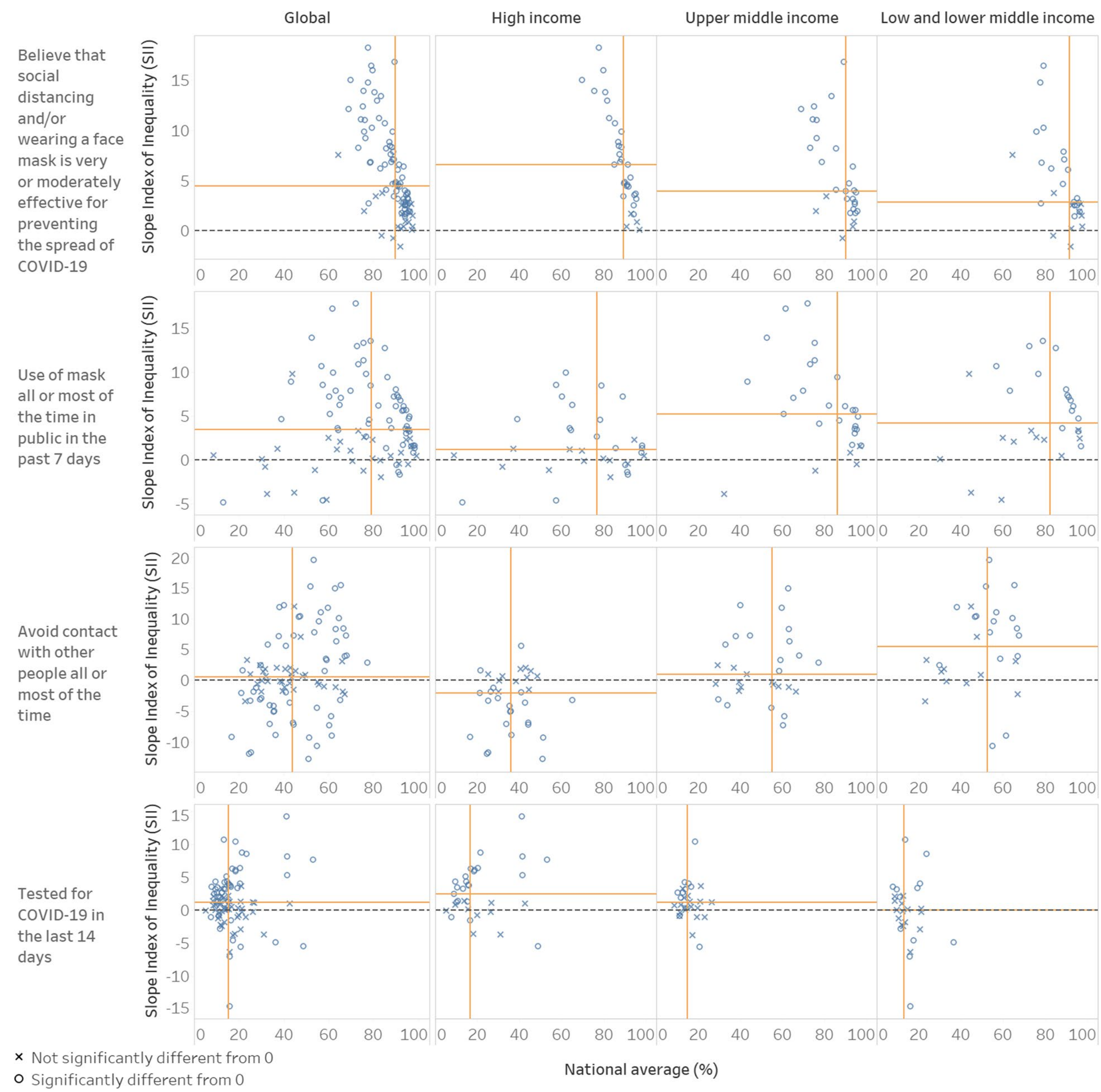


**Fig. 2** Education-related inequality in four COVID-19 prevention and testing indicators: median adjusted Slope Index of Inequality (SII) compared to national averages (%), globally and by country income group (UMD-CTIS, June–December 2021). Notes: Blue symbols represent countries. Orange lines show the medians across countries. Black dashed line shows no inequality (zero). Adjusted SII controlling for individual sociodemographic characteristics (age, sex, place of residence, and household overcrowding) plus the presence of health risk factors and COVID-like symptoms (*Adjusted2*), apart from the variable "Believe that social distancing and/or wearing a face mask is very or moderately effective for preventing the spread of COVID-19" for which estimates for *Adjusted* are shown

**Controlling for the effect of government responses**

Overall, the extent of public information campaigns about COVID-19 was not associated with the percentage of people believing in the efficacy of social distancing and mask wearing in COVID-19 prevention, nor with education-related inequality in this indicator (Table 3).

Overall, practice of mask wearing in public was associated with government policy on facial coverings, with more mask wearing when policies were stricter. However, education-related inequality in mask wearing was not associated with government policy overall. Only in upper middle income countries was there a statistically

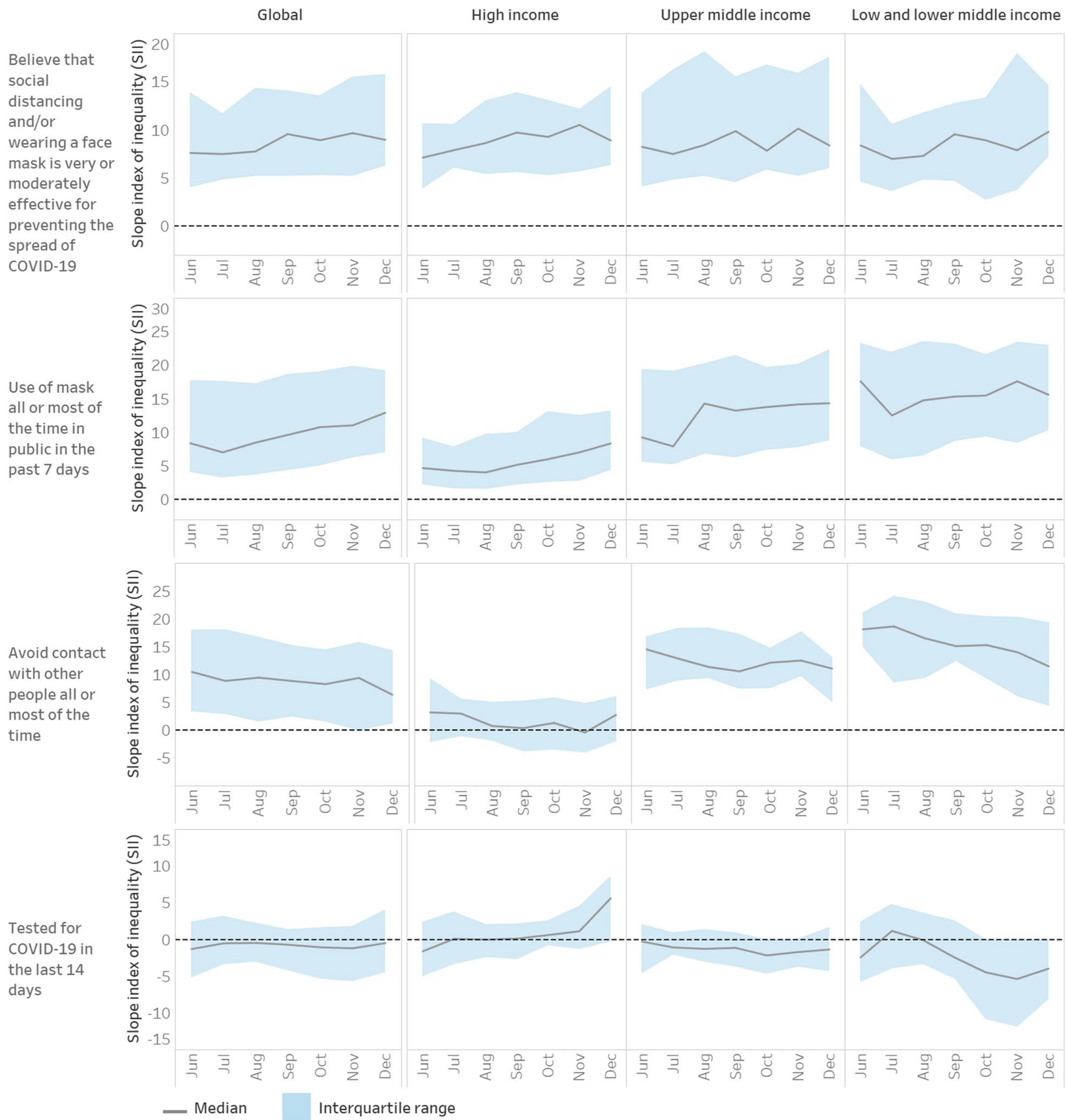


**Fig. 3** Change over time in education-related inequality in four COVID-19 prevention and testing indicators: crude Slope Index of Inequality (SII), globally and by country income group (UMD-CTIS, June–December 2021). Notes: The line indicates the median and the shaded area indicates the interquartile range (middle 50% of study country estimates). Black dashed line shows no inequality (zero)

significant negative correlation between SII and government policies, with inequality reducing with more strict facial covering policies.

The percentage of people avoiding contact with others was overall positively associated with the government stringency index (which reflects the strictness of 'lockdown style' policies that primarily restrict people's behavior). Unadjusted education-related inequality in social distancing was also weakly associated with these government responses, with inequality tending to be higher (favoring the most educated) in countries with more stringent requirements.

**Table 3** Associations between national averages and education-related inequality and government policies related to social distancing, mask use, public health information and testing (UMD-CTIS, June–December 2021)

| Indicator | Government policy | Income group | National average | | Education | |
|---|---|---|---|---|---|---|
| | | | Correlation coefficient | *P*-value | Correlation coefficient | *P*-value |
| Believe that social distancing and/or wearing a face mask is very or moderately effective for preventing the spread of COVID-19 | Public information campaigns | Global | 0.059 | 0.131 | −0.007 | 0.855 |
| | | High income | 0.080 | 0.225 | −0.109 | 0.099 |
| | | Upper middle income | 0.029 | 0.683 | −0.022 | 0.753 |
| | | Low and lower middle income | 0.108 | 0.114 | −0.007 | 0.916 |
| Use of mask all or most of the time in public in the past 7 days | Facial coverings | Global | 0.404 | 0.000 | 0.050 | 0.203 |
| | | High income | 0.395 | 0.000 | −0.113 | 0.086 |
| | | Upper middle income | 0.489 | 0.000 | −0.323 | 0.000 |
| | | Low and lower middle income | 0.293 | 0.000 | −0.030 | 0.663 |
| Avoided contact with other people all or most of the time | Government Stringency Index | Global | 0.384 | 0.000 | 0.217 | 0.000 |
| | | High income | 0.524 | 0.000 | | |
| | | Upper middle income | 0.396 | 0.000 | 0.188 | 0.001 |
| | | Low and lower middle income | 0.335 | 0.000 | 0.277 | 0.000 |
| Tested for COVID-19 in the last 14 days | Testing policy | Global | 0.269 | 0.000 | 0.085 | 0.031 |
| | | High income | 0.534 | 0.000 | 0.030 | 0.652 |
| | | Upper middle income | 0.162 | 0.021 | 0.082 | 0.244 |
| | | Low and lower middle income | 0.028 | 0.683 | 0.127 | 0.061 |

Notes: Education-related inequality measured using crude (unadjusted) SII. For avoiding contact, the association between education-related inequality and Government Stringency Index for high income countries is not reported due to both positive and negative SII values making the correlation unmeaningful

Public information campaigns were scored from 0 "No COVID-19 public information campaign" to 2 "Coordinated public information campaign". Facial coverings policies were scored from 0 "No policy" to 4 "Required outside of home at all times". The Government Stringency Index records the strictness of 'lockdown style' policies that primarily restrict people's behavior on a 0–100 scale, and is calculated using a number of containment and closure policy indicators (including school and workplace closures, cancelling public events, restrictions on gatherings, closing of public transport, stay at home requirements, and travel bans). Specific government policies were scored on an ordinal scale. Testing policies were scored from 0 "No testing policy" to 3 "Open public testing"

While the percentage of people tested within the last 14 days was overall associated with government testing policies (apart from low/lower income countries), education-related inequality in testing was not associated with government testing policy.

## Discussion

Our study was the first to use globally-comparable data to examine education-related inequalities in four COVID-19 prevention and testing indicators across 90 countries and by country income grouping. Our results indicated widespread education-related inequalities in several settings that were largely sustained across the seven-month period (however, it should be noted that this is a relatively short time window to expect to see any substantial changes in education-related inequalities). Notably, patterns of inequality differed across country income groups and by non-pharmaceutical intervention indicators.

Across all countries, beliefs in the effectiveness of COVID-19 prevention practices were consistently higher overall among those with more education, regardless of country income level. These education-related inequalities in beliefs also persisted regardless of the extent of COVID-19 public information campaigns in countries. Previous qualitative research exploring the perceptions of non-pharmaceutical interventions reported that personal and cultural beliefs about how respiratory illnesses are caught and spread were likely to influence the perceived efficacy of non-pharmaceutical interventions; this research also highlights familiarity of the intervention, potential to reduce social stigma and capacity to demonstrate social responsibility or community mindedness as reasons why interventions may be viewed favorably [36]. Country-level acceptance of mask wearing, in particular, has been related to social and cultural expectations [37], which may also be a relevant consideration for social groupings within countries.

Our study offers new insights into inequalities in the uptake of non-pharmaceutical interventions across education subgroups in different country income groupings. Against a backdrop of effectiveness beliefs being more common among those with higher education levels, low/lower middle income countries also reported higher COVID-19 prevention practices (social distancing and mask wearing) among people with more education. In upper middle income countries, mask wearing was more common among the most educated, controlling for other factors. The finding that education levels are associated with social distancing and mask use is in line with results from previous studies conducted in single countries [15–19].

In high income countries (which, to date, have tended to have the highest COVID-19 case rates [38]), despite beliefs in the effectiveness of social distancing and mask use being higher among the most educated, there was little education-related inequality in social distancing and mask use. It is challenging to directly compare these results to those from other data sources, since this is, to the best of our knowledge, the first large-scale study that describes education-related inequalities in social distancing, mask wearing practices and prevention beliefs across multiple high income countries using samples of this scale.

Together with other forms of evidence, the patterns in education-related described in this study may help to inform the development and deployment of public health messaging campaigns for COVID-19. There is increasing recognition that COVID-19 messaging and the promotion of non-pharmaceutical interventions should be equity-oriented, accounting for inequalities related to education, health literacy and socioeconomic circumstances. A review published by the World Health Organization Regional Office for Europe underscored the importance of considering distinct audiences within and across populations, and deliberately considering equity to ensure diverse groups are reached, including practical and financial supports to promote the acceptance, uptake and adherence to public health measures [39].

Previous studies suggest that factors other than education level may also be related to mask use in high income countries. Badillo-Goicoechea et al. (2021) used the same UMD-CTIS data source to study mask use across 38 countries, the majority of which were high income countries [14]. They found several sociodemographic factors (older age, female gender, education, urbanicity) to be associated with higher mask usage, while participation in social behaviors deemed more optimal and risky in the context of the current pandemic (such as going out to large public events, restaurants, cafes, shopping centers, or socializing outside of the household) was associated with lower face mask usage. In a subnational study in the United Kingdom, which reported lower adherence to social distancing rules among those with advanced university degrees, low vulnerability to COVID-19, and less control over social distancing behaviors were also associated with non-adherence [40]. Among young adults in Switzerland, non-compliance with social distancing was also found to be higher among individuals with higher education [41].

We found that more stringent government policies on social distancing were associated with higher levels of education-related inequality overall, although the association was weak. This may be related to the type of living and working conditions among people with lower levels of education and the consequential lower abilities to social distance, despite government policies or guidance. Being able to work from home, which tends to be more common among people with higher education, has been shown in previous studies to increase education-related inequalities in social distancing practices [42].

Our finding that stricter mask-wearing policies were significantly associated with higher mask use in public settings was also reported in a study of mask use by Badillo-Goicoechea et al. (2021) [14]. We additionally reported preliminary findings that the level of education-related inequality in mask use was not associated with government policies around mask-wearing in high income and low/lower middle income countries. This may indicate that while mask use policies may influence the national rate of mask use, they may not be effective in addressing the situation of inequality in low/lower middle income countries (where there is lower mask use among the least educated groups). In contrast, in upper middle income countries, increased stringency of government policies on facial coverings was associated with lower levels of education-related inequality – indicating, perhaps, a stronger tendency to comply with mask policies regardless of education level. These are, however, only general observations of trends across countries; we used an aggregate measure of government policy and did not explore the impact of any particular policy.

Education-related inequalities in testing rates were low in general and across country income groupings, with variation observed across countries. The level of education-related inequality was not found to be associated with government testing policies. Testing capacity is a factor that has been often cited as a determinant of testing prevalence, particularly in lower income countries where weaker laboratory infrastructure and resources have remained hurdles for scaling up access to testing [43], and may explain why education-related inequalities were low overall and variable across countries.

The UMD-CTIS is subject to several limitations, many of which are common to web surveys and self-reported data. These are described in detail elsewhere [44]. Digital surveys include selected populations that are not necessarily representative of the wider population. They can have nonresponse bias (as the decision to take the survey may be correlated with other factors) and sampling bias (as not everyone in every country has a Facebook app account or uses their account regularly – particularly in countries with low internet penetration). Missing survey responses, particularly for questions that appear later in the survey, can be an issue if the order of survey questions does not occur at random. Moreover, sampling weights were based only on attributes in Facebook profiles, and therefore could be subject to error. We were also unable to control for certain factors that have been shown in other studies to be correlated with COVID-19 prevention behaviors due to these not being collected in UMD-CTIS, such as race/ethnicity and income level (although we used housing overcrowding as a proxy measure of economic status). Data for the United States of America were not included in this study as these were collected in a separate survey; however, we do not expect this exclusion to change the overall results. Moreover, it was beyond the scope of this study to control for potential biases caused by COVID-19 levels and containment measures in the analysis.

Despite these limitations, there are several strengths to this study. Our analysis leveraged the largest ongoing data collection related to COVID-19 symptoms and behaviors, which allowed us to examine and compare trends across many countries. The survey has substantially large sample sizes, with data collected over a long time period in a real-time and continuous basis. This study has focused on differences between groups and trends over time, rather than the total population estimates, as non-response and coverage biases will tend to remain relatively consistent across groups and over time even if the point estimates are consistently biased. To control for age and sex sample size and composition issues, we employed post-stratification weighting, and excluded countries with particularly low sample sizes for age and sex subgroups from the study.

## Conclusions

In summary, our findings highlight important within-country education-related differences in COVID-19 preventative behaviours and testing. Beliefs in the effectiveness of COVID-19 prevention practices were consistently higher among the most educated regardless of country income group, and there were large education-related inequalities in mask usage and social distancing practices in low/lower middle and upper middle income countries favoring the most educated. Education-related inequalities in mask usage and social distancing were, however, lower in high income countries. More stringent government policies on social distancing were associated with higher levels of education-related inequality overall. Moreover, education-related inequalities tended to persist regardless of government policies on mask usage, testing and public information campaigns. These findings offer important insights for public health approaches to prevention that should account for socially differentiated living and working conditions. This study can serve as a benchmark to continue to monitor inequalities, highlighting the importance of designing public health policies and messaging campaigns that consider and target specific populations.

### Abbreviations

CI: Confidence interval; COVID-19: Coronavirus disease of 2019; OxCGRT: Oxford COVID-19 Government Response Tracker; RII: Relative index of inequality; SII: Slope index of inequality; UMD-CTIS: University of Maryland Social Data Science Center Global COVID-19 Trends and Impact Survey, in partnership with Facebook; UN: United Nations; WHO: World Health Organization.

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12939-022-01751-z.

**Additional file 1: Supplementary Table 1.** Four COVID-19 prevention and testing indicators disaggregated by education by country (UMD-CTIS, June-Dec 2021). National averages and estimates disaggregated by education level for four COVID-19 prevention and testing indicators in 90 study countries from the UMD Global COVID-19 Trends and Impact Survey, June–December 2021.

**Additional file 2: Supplementary Table 2.** Education-related inequality in four COVID-19 prevention and testing indicators by country: crude and adjusted Slope Index of Inequality (SII) and Relative Index of Inequality (RII) (UMD-CTIS, June-Dec 2021). Education-related inequality in four COVID-19 prevention and testing indicators in 90 study countries from the UMD Global COVID-19 Trends and Impact Survey, June–December 2021. Education-related inequality is measured using the Slope Index of Inequality (SII) and Relative Index of Inequality (RII). The first adjusted model (*Adjusted*) controlled for individual sociodemographic characteristics (age, sex, place of residence, and household overcrowding). The second adjusted model (*Adjusted2*) controlled for these characteristics plus the presence of health risk factors and COVID-like symptoms.

### Disclaimer

The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated.

### About this supplement

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### Authors' contributions

ARH, KK, AS and CVF conceptualized the study focus and design. CVF and KK processed, validated and analyzed the survey dataset. KK produced the data visualizations and drafted the manuscript with inputs from NB, which was revised by all authors. CVF is affiliated with the Inter-American Development Bank at the time of publication of the article. All authors read and approved the final manuscript.

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### Availability of data and materials

Survey microdata are not publicly available because survey participants only consented to public disclosure of aggregate data, and because the legal agreement with Facebook governing operation of the survey prohibits disclosure of microdata without confidentiality protections for respondents.

Deidentified microdata are available to researchers under a Data Use Agreement that protects the confidentiality of respondents. Access can be requested online (https://covidmap.umd.edu/fbsurvey/). Country-level aggregate weekly and monthly estimates for select indicators are also published by the University of Maryland (https://covidmap.umd.edu/api.html). The aggregate estimates and code used in this analysis are available from the corresponding author on reasonable request. The University of Oxford's COVID-19 Government Response Tracker (OxCGRT) is publicly available online [31].

## Declarations

### Ethics approval and consent to participate
The UMD Institutional Review Board (1587016–10) approved the UMD Global CTIS study. All respondents gave informed consent before participating in the survey. Informed consent was documented in the digital platform by the respondent (no witness required). This study did not include minors. None of the data that support the findings of this study included any identifiable human data.

### Consent for publication
Not applicable.

### Competing interests
The authors declare that they have no competing interests.

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