Public Health 185 (2020) 31–33

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# A three-generation family cluster with COVID-19 infection: should quarantine be prolonged?

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ARTICLE INFO

*Article history:*
Received 23 April 2020
Received in revised form
20 May 2020
Accepted 20 May 2020
Available online 30 May 2020

*Keywords:*
COVID-19
SARS-CoV-2
Family cluster
Prolonged quarantine

ABSTRACT

*Objectives:* Families are a transmission route for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) because of the close contact. Monitoring of the viral load will be a valuable method to reduce the optimal number of quarantine days, especially in presymptomatic and symptomatic carriers of their households. The traditional three-generation families living together are seen frequently in East Asia, including in Taiwan.

*Study design:* We report on a family cluster with six individuals infected with coronavirus disease in Taiwan.

*Methods:* The current public policy in Taiwan is quarantine for at least 14 days, based on the incubation period, or until the patient has tested negative three days in a row using the SARS-CoV-2 reverse transcription polymerase chain reaction. Details on the onset date of clinical symptoms, throat swab conversion, and course of disease were collected from medical records retrospectively.

*Results:* In the household of this three-generation Taiwanese family, the infection rate was 60%. The ratio of males to females was 4:2, and the age range was 11–85 years. The prevalence of asymptomatic disease was 33.3% (2/6). The longest throat swab conversion time was 37 days, and the estimated course of disease from symptoms to first conversion of throat swab was 59 days.

*Conclusions:* Large families, including three-generation families in a single dwelling, should be monitored when the index case is found. Presymptomatic and symptomatic family members could be quarantined for an appropriate duration which, in our experience, is 2 months.



Coronavirus disease (COVID-19) became a pandemic in 2020.[1] Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmits via social activity of family, friends, and coworkers.[2,3] Families are a transmission route for SARS-CoV-2 because of close contact.[4] The current public policy is quarantine for at least 14 days, based on the incubation period[5] or until the patient has tested negative three days in a row using the SARS-CoV-2 reverse transcription polymerase chain reaction (RT-PCR). Monitoring the viral load will be a valuable method to reduce the optimal quarantine days, especially in asymptomatic carriers.[6] Identifying asymptomatic carriers within a family is important to guide quarantine policy.[7] In East Asia, grandparents, parents, and children living together is a common tradition, a pattern also seen in Taiwan.[8] Our study aimed to investigate a three-generation family cluster of COVID-19.

We report a family cluster with six individuals infected with COVID-19 in Taiwan. Details on the onset date of clinical symptoms, throat swab conversion, and course of disease were collected from medical records retrospectively.

The household cluster with COVID-19 infection status is summarized in Table 1 and Supplemental Fig. 1. All dates mentioned henceforth are in 2020. Patient 1 is an 85-year-old, bed-ridden man with diabetes, hypertension, and continuous ambulatory peritoneal dialysis who was admitted to the hospital with pneumonia on

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https://doi.org/10.1016/j.puhe.2020.05.043
0033-3506/

**Table 1**
Family infection status in family cluster.

| Characteristic | Patient Number | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Age (years) | 85 | 74 | 53 | 49 | 11 | 31 |
| Comorbidities | + | – | + | – | – | – |
| Probable cause of transmission | Taking care | Taking care | Taking care | Taking care | Hospital visit | Taking care |
| Symptoms onset | Feb. 9 | Jan. 29 | Jan. 31 | Jan. 29 | NA | NA |
| Symptoms status | SB | Sore throat | Cough, fever | Sore throat | NA | NA |
| Throat swab+ | Feb. 21 | Feb. 23 | Feb. 23 | Feb. 23 | Feb. 25 | Feb. 24 |
| Throat swab- | NA | Mar. 28 | Mar. 30 | Feb. 26 | Mar. 2 | Mar. 28 |
| Status | Mar. 20 Mortality | Apr. 6 Discharge | Apr. 6 Discharge | Mar. 6 Discharge | Mar. 13 Discharge | Apr. 1 Discharge |
| Virus conversion (days) | >29 | 35 | 37 | 4 | 7 | 34 |
| Course of disease (days) | >41 | 59 | 59 | 29 | 7 | 34 |

Course of disease: from symptoms to throat swab conversion or SARS-CoV-2 positive to negative in no symptomatic infection. SB: shortness of breath, NA: not applicable. The date of statistic was until April 1, 2020.

February 9. On February 16, his condition deteriorated, and he was intubated and transferred to the intensive care unit. Patient 1 tested positive by SARS-CoV-2 RT-PCR on February 21. Chest X-ray showed improved pneumonia, but he remained on a ventilator. Repeat testing was positive by SARS-CoV-2 RT-PCR. Patient 1 died due to bacteremia and profound septic shock on March 20. The course of disease was 41 days from the initiation of symptoms to death without sputum conversion.

Patient 2, aged 74 years, was patient 1's wife and was diagnosed with acute pharyngitis on February 6. She was confirmed as SARS-CoV-2 positive on February 23. Although confirmed with COVID-19 infection, she did not have fever or any other symptoms. Her throat swab was negative on March 28, and later, she had two sequential negative tests. The disease course was 59 days, and the duration of the throat swab conversion was 35 days.

Patient 3 is patient 1's 53-year-old elder son. On January 31, he had cough, fever, sore throat, and runny nose and was diagnosed as SARS-CoV-2 positive on February 23. Patient 3 took care of his father, including helping with peritoneal dialysis. His throat swab was negative on March 30 and, later, had two sequential negative tests. His disease course was 59 days with a throat swab conversion duration of 37 days.

On February 23, patient 4 (son of patient 1, patient 3's brother), aged 49 years, was confirmed to be SARS-CoV-2 positive, but without typical symptoms. Patient 4 had a sore throat on January 29 but did not seek medical treatment. He was a teacher and travelled around Wuhan and other cities of China in January. After returning to Taiwan, he joined patient 3 in caring for patient 1. His throat swab was negative on February 26 and later had two sequential negative tests. The disease course was estimated to be 38 days with the throat swab conversion duration of 4 days.

Patient 5 is patient 1's grandson. He visited patient 1 on February 11 and February 19 and was tested positive for SARS-CoV-2 on February 25. He did not develop any symptoms. His throat swab was negative on March 2, confirmed by two additional negative tests. The disease course was 7 days, and the throat swab conversion duration was 7 days.

Wives and daughters of patients 3 and 4 did not exhibit symptoms, although they lived together with the two patients. Their SAR-CoV-2 RT-PCR tests were all negative.

Patient 6 was patient 1's caregiver from February 11 to 16. She was quarantined in the hospital on February 24, as she was tested positive for SARS-CoV-2 but asymptomatic. Her throat swab was negative on March 28, showing a disease course and the throat swab conversion time of 34 days.

In the household of this three-generation Taiwanese family, the infection rate was 60%. The probable cause of transmission would be normal family interaction, such as taking care of older family members and routine visits. The ratio of males to females was 4:2, and the age range was 11–85 years. The prevalence of asymptomatic disease was 33.3% (2/6).

Our report shows that the youngest asymptomatic case had shorter throat swab conversion time and disease course. By contrast, elderly family members may experience severe pneumonia, particularly with comorbid diseases, and death.[9] Elder patients had longer throat swab conversion and prolonged potential quarantine duration even after symptoms had improved. This highly contagious disease, when found in a traditional family structure, transmits to other household members of different ages and has the potential to infect all family members. If there is an insufficient quarantine period, the grandparents with pneumonia who are admitted to the hospital could be the source of nosocomial infection, and the parents will then transmit it to their colleagues. In Taiwan, a high attack rate was observed within 5 days of detection of a symptomatic index case than observed >5 days.[10] The attack rate was higher among household family contacts than that in health care settings.

Presymptomatic and symptomatic patients have a risk of transmission to their family, as per epidemiologic studies in Taiwan. In our report, the longest throat swab conversion was 5 weeks, and the disease course was 2 months.

This case only includes 6 individuals, which limits efficient external validity of the results. However, three-generation family clusters may be a strong transmission factor of COVID-19 in East Asia countries, as different from that of Western countries. The possibility of different living arrangements being a factor in the transmission of COVID-19 is a topic that should be studied in the future.

We propose three practical policies. First, if the index case was found, immediate examination of three generations of family members, especially if they live together, should be conducted. Second, presymptomatic and symptomatic family members could be quarantined at hotels with suitable social distance or be isolated at the hospital until their three sequential throat swabs show negative results. Finally, the effective quarantine duration remains a mystery. In our experience, the possible duration would be 2 months.

## Author statements

### *Ethical approval*

For this retrospective observational study, the informed consent waiver was received from IRB and the patient privacy rights including any individual person's data in any form (including individual details, images, or videos) are observed. This study was

approved by the Institutional Review Board of Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation (approval number 09-X-041) and conducted in accordance with the amended Declaration of Helsinki.

*Funding*

The study was supported by a grant from the Taipei Tzu Chi Hospital [TCRD-TPE-107-38] and Buddhist Tzu Chi Medical Foundation [TCMF-A 109-05 (109)]. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

*Competing interest*

The authors declare that they have no conflicting interests.

*Authors' contributions*

MCY, PPH, and WLS collected the data. WLS and YCC conceived the idea and drafted the paper. YKW, MYP, CCL, and PSW reviewed the article. All authors read and approved the final manuscript.

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Public Health 185 (2020) 72–79

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Can the summer temperatures reduce COVID-19 cases?

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ARTICLE INFO

*Article history:*
Received 22 April 2020
Received in revised form
25 May 2020
Accepted 29 May 2020
Available online 7 June 2020

*Keywords:*
COVID-19
Coronavirus
SARS-CoV-2
Temperature
Cold environment

ABSTRACT

*Objective:* Despite huge global, national, and local preventive measures including travel restriction, social distancing, and quarantines, the outbreak of novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) develops the coronavirus disease 2019 (COVID-19) worldwide pandemic. SARS-CoV-2 emerging from Wuhan, China, took only three months to cover >200 countries worldwide by infecting more than 2.4 million people and killing more than 150,000 people. Although this infection at the early stage creates seasonal flu-like symptoms with a higher illness, it eventually causes a higher mortality. Epidemiological studies not only find the causes of many health issues but also suggest preventive measures. This study aimed to see the link between environment temperature and COVID-19 cases.
*Study design:* The monthly average environment temperature (MAET) and various COVID-19 cases of a country were collected and analyzed to see the relationship between these parameters.
*Methods:* Univariate analysis and statistical modeling were used to determine the relationship between environment temperature and different COVID-19 cases.
*Results:* This study found that the majorities of the countries having higher COVID-19 cases are located in the higher latitude (colder region) in the globe. As of 20th April data available, statistical analyses by various methods have found that strong negative correlations with statistical significance exist between MAET and several COVID-19 cases including total cases, active cases, and cases per million of a country (Spearman correlation coefficients were −0.45, −0.42, and −0.50 for total cases, active cases, and cases/per million, respectively). Analysis by the statistical log-linear regression model further supports that the chance of patients to contract COVID-19 is less in warmer countries than in colder countries.
*Conclusion:* This pilot study proposes that cold environment may be an additional risk factor for COVID-19 cases.



## Introduction

Within three months from emerging of the novel coronavirus at Wuhan city, China, in December 2019, this pandemic outbreak has spread largely across the world. On February 12, the World Health Organization has named the disease caused by novel coronavirus as coronavirus disease 2019 (COVID-19). Virologists have named this virus as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The results of genome sequencing obtained from the infected patients revealed that this novel virus belongs to coronavirus clusters and is closely related to other bat-derived coronaviruses, bat-SL-CoVZC45 and bat-SL-CoVZXC21, but this new coronavirus is somewhat related to SARS-CoV and MERS-CoV.[1] However, the origin of this virus is yet to be confirmed. In this stage, it may not be concluded that this virus has originated from animals (such as bats) or a chimeric virus.[2,3] It might be the case that bat coronaviruses after specific mutations can gain the ability to affect human beings.[3] A few recent studies have found that COVID-19 can develop faster in old age individuals, but the infection rate may or may not vary with age, gender, ethnicities, and races.[4,5] In general, this novel coronavirus infection develops symptoms such as those of seasonal flu including fever, cough, expectoration, myalgia, sore throat, and fatigue, but the severity of the illness could be more than that of influenza. Some patients may develop shortness of breath, pneumonia, severe acute respiratory distress syndromes, and multiorgan failure.[4,6] Accumulating evidence indicated that people having various diseases such as diabetes, hypertension, and

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https://doi.org/10.1016/j.puhe.2020.05.065
0033-3506/

cardiovascular diseases experience serious complication if they are infected with the SARS-CoV-2. The outbreak of the SARS-CoV-2 pandemic might be even more fatal than the most devastating influenza (Spanish flu) pandemic outbreak in 1918 that occurred a century ago because almost 2.4 million COVID-19 confirmed cases with more than 150,000 deaths have been reported from 200 countries within only three months of the evolving of this viral infection. Because seasonal flu is comparatively low in the summer as compared with winter, the general population along with various researchers think that the summer might drop the novel coronavirus infection rate.

Thus, this present study was aimed to see the link between temperature and COVID-19 cases. The results from our statistical analysis suggested that a negative relationship exists between various COVID-19 cases including total confirmed cases, active cases, and cases per million of the countries with the monthly average environmental temperature. This study suggests that a cold environment might be an additional risk factor for COVID-19 cases.

## Methods

### *Data collection*

The data of COVID-19 cases for each country were collected throughout time from 25th March to 18th April, 2020, from the website worldometers.info. The values of various COVID-19 cases were highly dynamic and changed rapidly in every day. Thus, in this study, we had analyzed separately the data of different dates, collected every six days intervals (25th March, 30th March, 6th April, 12th April, and 18th April, 2020) to see the consistency of the statistical results. In this study, we had included total cases and active cases because values of these two variables were there for all the countries throughout the study period and are gradually increased by the changed values of every day. The absolute values of total and active cases may depend on population density. Thus, we have also considered population adjusted data, that is, cases/million. Monthly average environment temperature (MAET) was obtained by making the average of average highest and lowest temperature of a specific month of the capital of a country, collected from the website climatestotravel.com.

### *Geographic location of countries*

The locations of various countries were pointed in a world map by using world map maker ArcGIS software described previously.[7] The top countries having at least 1000 coronavirus infection cases were marked in the world map.

### *Statistical methods*

#### *Univariate analysis*

The Spearman and Kendall methods for univariate analysis were used to test the null hypothesis between two variables described previously.[8,9] These methods provide the coefficient of correlation for observations which are not in linear relationship (mentioned as coefficient in tables). Both negative and positive correlations were denoted by negative and positive coefficients. Here, significant differences were considered for $P < 0.05$. In this statistical analysis, we had included all data available in the website worldometers.info.

#### *Statistical modeling*

In this study, we have considered three response variables as follows: (i) cases per million, (ii) total cases, and (iii) active cases. By simple graphs, it can be seen that there does not exist any linear relationship between temperature and COVID-19 considered variables. Therefore, we purpose a log-linear model to fit the COVID-19 case data with temperature. A log-linear model can be defined by the following equation:

$$\log(y_{ij}) = \beta_0 + \beta_1 x_i + \varepsilon_i, \quad i = 1, 2, \ldots, n; j = 1, 2, 3.$$

where $\beta_0$and $\beta_1$are the parameters of the model and n denotes the number of countries considered under study. The parameter $\beta_0$ gives the intercept on $y$-axis. The parameter $\beta_1$ is of more interest and can be interpreted as the $t$-unit increment in $X$ is to multiply the expected value of $Y$ by $e^{t\beta_1}$.

In this model, $x_i$ is an independent variable denoting the average temperature of a month of the $i$th country, whereas the response variable $Y_{ij}$ denotes the value of $j$th case for the $i$th country at the considered day. Here, $j$ will be 1, 2, and 3 for cases per million, total cases, and active cases, respectively. In particular, we can write the log-linear model for $j$=*1, 2,* and *3* as follows:

$$\left.\begin{aligned} \log(\textit{Cases per million}) &= \beta_0 + \beta_1 \times \textit{Temperature} + \varepsilon_i, \quad \textit{if } j = 1 \\ \log(\textit{Total cases}) &= \beta_0 + \beta_1 \times \textit{Temperature} + \varepsilon_i, \quad \textit{if } j = 2 \\ \log(\textit{Active cases}) &= \beta_0 + \beta_1 \times \textit{Temperature} + \varepsilon_i, \quad \textit{if } j = 3. \end{aligned}\right\}$$

An objective of giving a log-linear model is to show a trend in between temperature and other variables. It is expected that the outcomes from models will support our hypothesis under study based on univariate correlation coefficients.

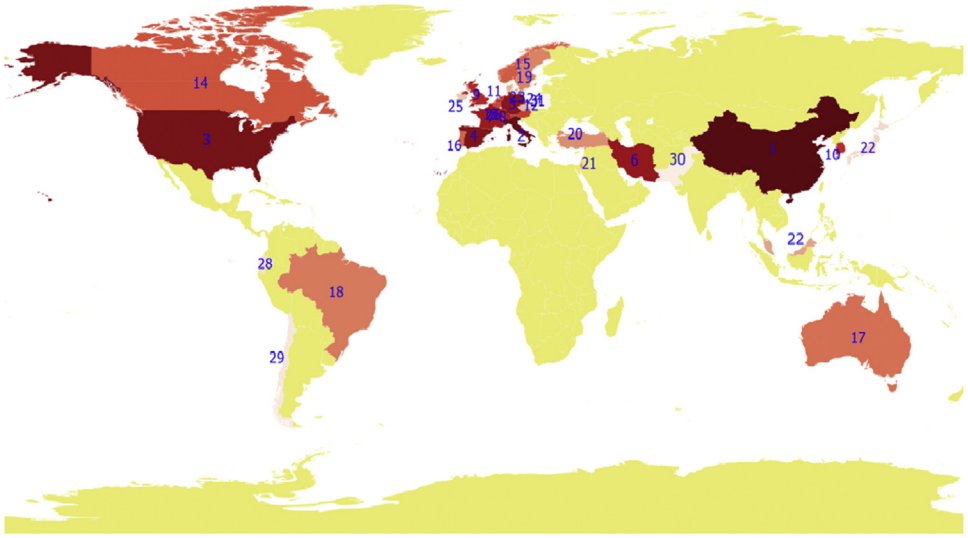
## Results

### *Geographical distribution of countries having higher COVID-19 cases*

The outbreak of novel coronavirus (SARS-CoV-2) was first reported in Wuhan, China, at the end of December 2019. In January 2020, a few individuals of other countries had also been infected with the coronavirus. However, by mid January 2020, the number of confirmed COVID-19 cases became more than 200. By March 25, 2020, almost 200 countries reported coronavirus infected cases, where thirty one countries were badly affected with more than 1000 confirmed cases. It was noticed that majority of the severely affected countries (27 of 31) are geographically situated on the similar latitude as Wuhan (30.59 $^0$N) or located toward the North Pole (Fig. 1). Except Ecuador, none of these twenty countries belong to the equatorial zone. Three countries of the Southern hemisphere (Australia, Brazil, and Chile) are located near by the Tropic of Capricorn. All these are relatively cold countries because of their geographical location. It was noticed that Hong Kong (22.31 $^0$N) and Taiwan (23.69 $^0$N), the territory/country neighboring China which are located away from Wuhan toward the equatorial side, had reported at least 10 COVID-19 confirmed cases by the end of January 2020. But till 25th March, 2020, the infected individuals were less than 500 in these two countries. Besides many reasons for spreading infection, cold environmental temperature could be an underestimated additional risk factor for COVID-19 cases.

### *Association between environment temperature and COVID-19 cases of a country*

The aforementioned initial observations had attracted our attention to see the link between environment temperature and the novel coronavirus infection cases of a country. Firstly, univariate analysis was performed between MAET and coronavirus infected



| Rank | Country Name | Lattitude |
|---|---|---|
| * | Wuhan, China | 30.59 |
| 1 | CHINA | 35.86 |
| 2 | ITALY | 41.87 |
| 3 | USA | 37.09 |
| 4 | SPAIN | 40.46 |
| 5 | GERMANY | 51.17 |
| 6 | IRAN | 32.43 |
| 7 | FRANCE | 46.23 |
| 8 | SWITZERLAND | 46.82 |
| 9 | UK | 55.38 |
| 10 | S. KOREA | 35.91 |
| 11 | NETHERLANDS | 52.23 |
| 12 | AUSTRIA | 47.52 |
| 13 | BELGIUM | 50.50 |
| 14 | CANADA | 56.13 |
| 15 | NORWAY | 60.47 |
| 16 | PORTUGAL | 39.40 |
| 17 | AUSTRALIA | -25.27 |
| 18 | BRAZIL | -14.24 |
| 19 | SWEDEN | 60.13 |
| 20 | TURKEY | 38.96 |
| 21 | ISRAEL | 31.05 |
| 22 | MALAYSIA | 4.21 |
| 23 | DENMARK | 56.26 |
| 24 | CZECHIA | 49.82 |
| 25 | IRELAND | 53.41 |
| 26 | LUXEMBOURG | 49.82 |
| 27 | JAPAN | 36.20 |
| 28 | ECUADOR | -1.83 |
| 29 | CHILE | -35.68 |
| 30 | PAKISTAN | 30.38 |
| 31 | POLAND | 51.92 |

**Fig. 1.** Geographical distribution of the top countries having at least 1000 COVID-19 confirmed cases as of 25th of March, 2020. Table shows the list of 31 countries with their latitudes. Here, minus value latitude depicts the country of Southern hemisphere. COVID-19, coronavirus disease 2019.

cases of a country, taking all the available data present in the website mentioned in method section. This website updates data every day for all countries. As per the data available in this website on 25th March 2020, coronavirus confirmed cases were reported from ~200 countries. Spearman statistical analysis found a negative correlation between MAET and coronavirus confirmed cases of a country (correlation coefficient: −0.54 and *P* value: <0.0001). Furthermore, this analysis found negative correlation between MAET and total active cases (Table 1). Our analysis also noticed a presence of a significant correlation between cases per million population and MAET (correlation coefficient: −0.47 and *P* value: <0.0001) (Table 1). All these statistical results indicated that a negative link might exist between COVID-19 cases and environment temperature of a country. Just to verify all these results, we had further analyzed all the data by the Kendall univariate method. Similar to the Spearman method, Kendall analysis also found the negative association between environment temperature and various COVID-19 cases mentioned earlier. The observed values were highly dynamic, and thus, we have further analyzed the data of every six days intervals (30th March, 6th April, 12th April, and 18th April, 2020) to see the consistency of the statistical results among the data of different days. It was noticed that all these results from the analysis of these days' data found similar results to the data of 25th March 2020 (Table 1). All these findings suggest that cold environment temperature might be sensitive to novel coronavirus (SAAR-CoV-2) infection.

### *Log-linear model fit study for finding the relationship between temperature and COVID-19 cases*

To verify and support the study of the earlier section, a log-linear model fitting approach has been adopted. The outcomes from modeling are shown in Table 2 and Fig. 2. In Fig. 2, a matrix plot was drawn among temperature and three previously mentioned cases for the observations collected at April 18, 2020. Here, the temperature is measured in °C while all other variables are represented on natural logarithmic scales, where the base is *e*. On the diagonal of matrix plot the histograms are plotted for temperature, cases per million, total cases and active cases respectively, and it is helpful to identify the nature of the variables. In upper matrix plots, Pearson correlation coefficients (now, variables are in linear relationship) were determined. It can be seen that a negative relationship exists among variables and temperature with correlation coefficient values −0.501, −0.455, and −0.426 for cases per million, total cases, and active cases, respectively. The log-linear model was also estimated and fitted for COVID-19 considered cases and temperature. In the lower matrix plots, all the fitted models are sketched. The estimated values $(\widehat{\beta}_0, \widehat{\beta}_1)$ of parameters $(\beta_0, \beta_1)$ are $(7.50, -0.14)$, $(9.10, -0.14)$, and $(8.15, -0.13)$ for $j = 1, 2,$ and $3$, respectively (Table 2). All estimators were also tested and the respective *P*-

**Table 1**
Univariate analysis between monthly average environment temperature and COVID-19 cases: countrywise analysis, as of 25th March to 18th April, 2020.

| Method | Cases per million | Total cases | Active cases |
|---|---|---|---|
| **25th March, 2020** | | | |
| Total country | 198 | 198 | 198 |
| Spearman | −0.47 | −0.54 | −0.54 |
| Kendall | −0.32 | −0.37 | −0.37 |
| **30th March, 2020** | | | |
| Total country | 200 | 200 | 200 |
| Spearman | −0.49 | −0.54 | −0.55 |
| Kendall | −0.34 | −0.37 | −0.37 |
| **6th April, 2020** | | | |
| Total country | 200 | 200 | 200 |
| Spearman | −0.50 | −0.49 | −0.49 |
| Kendall | −0.34 | −0.33 | −0.33 |
| **12th April, 2020** | | | |
| Total country | 200 | 200 | 200 |
| Spearman | −0.50 | −0.46 | −0.44 |
| Kendall | −0.34 | −0.31 | −0.31 |
| **18th April, 2020** | | | |
| Total country | 200 | 200 | 200 |
| Spearman | −0.50 | −0.45 | −0.42 |
| Kendall | −0.34 | −0.31 | −0.30 |

Note: *P* value corresponding to each test statistic is $*P < 0.001$. We have considered those countries having COVID-19 cases on at least 30th March, 2020 or before. COVID-19, coronavirus disease 2019.

**Table 2**
Log-linear model estimates for fitting the relationship between the environment temperature and COVID-19 cases: countrwise analysis;, as of 25th March to 18th April, 2020.

| Date | Parameter | Cases per million | Total cases | Active cases |
|---|---|---|---|---|
| March 25, 2020 | Total country | 198 | 198 | 198 |
| | Correlation coefficient | −0.4732 | −05368 | −0.5372 |
| | Estimated $\beta_0$ | 5.0537 | 6.9065 | 6.7650 |
| | Estimated $\beta_1$ | −0.1257 | −0.1437 | −0.1417 |
| March 30, 2020 | Total country | 200 | 200 | 200 |
| | Corr. Coefficient | −0.4812 | −0.5326 | −0.5349 |
| | Estimated $\beta_0$ | 5.6452 | 7.4464 | 7.2983 |
| | Estimated $\beta_1$ | −0.1243 | −0.1412 | −0.1430 |
| April 06, 2020 | Total country | 200 | 200 | 200 |
| | Correlation coefficient | −0.5074 | −0.4952 | −0.4957 |
| | Estimated $\beta_0$ | 7.1143 | 8.7121 | 8.4357 |
| | Estimated $\beta_1$ | −0.1557 | −0.1609 | −0.1594 |
| April 12, 2020 | Total country | 200 | 200 | 200 |
| | Correlation coefficient | −0.5030 | −0.4732 | −0.4471 |
| | Estimated $\beta_0$ | 7.367 | 8.9742 | 8.1017 |
| | Estimated $\beta_1$ | −0.1493 | −0.1550 | −0.1318 |
| April 18, 2020 | Total country | 200 | 200 | 200 |
| | Correlation coefficient | −0.5012 | −0.4558 | −0.4266 |
| | Estimated $\beta_0$ | 7.5013 | 9.1077 | 8.1521 |
| | Estimated $\beta_1$ | −0.1429 | −0.1484 | −0.1300 |

Note: Karl Pearson correlation coefficient is calculated for log-linear data. COVID-19, coronavirus disease 2019.

values are less than .0001. As the estimates of for all three cases are negative, the models show the decreasing behavior of variables with respect to temperature. In Fig. 2, to support the purposed log-linear model for fitting, we additionally present important characteristics using graphs such as residuals, Q-Q, and Cook's distance plot. The residuals and Q-Q plot showed that the data fulfill the assumptions of fitting a log-linear model. Here, it was observed that in the Q-Q plot, few observations on both the tails behave abruptly. The Cook's distance plot also shows similar behavior. These observations may also be treated as extreme values or outliers.

To establish the aforementioned findings, we used the observations particularly on other four days (25th March, 30th March, 6th April, and 12th April, 2020). We have noticed the consistency for estimated results and all models following the same pattern as the data obtained from dated April 18, 2020 (Supplementary Figs. S1–4). Sometime the slight differences in outcomes are obvious because few countries had contributed from early days, while others had participated significantly in the study later on. This effect has been discussed in Negative relationship exists between environment temperature and COVID-19 cases of the countries having at least 50 cases or more.

All these findings support our earlier establishment firmly that in warmer countries the chance of patients to contract COVID-19 is less than that in colder countries. Therefore, the results can be drawn firmly from univariate analysis.

*Negative relationship exists between environment temperature and COVID-19 cases of the countries having at least 50 cases or more*

It was noticed that all the countries under this study did not have the uniform COVID-19 observations till dated April 18, 2020. In fact, observation values of total cases (cases per million or active cases) are very low in countries lying in the hotter temperature zone. Therefore, observations from such countries may influence the performance of estimators significantly. Therefore, a comparative analysis has been performed for temperature and considered three variables as per the total number of cases (Table 3). Here, we grouped the countries as they have greater than or equal to 1, 50, 100, and 1000 total number of COVID-19 cases at the date of study. In Table 3, one row mentioned the number of countries comes under these groups at a particular day. We calculated Karl Pearson correlation coefficient for log-linear data with Spearman and Kendall correlation coefficients. Particularly, the mean, median, and standard deviation (SD) of temperatures were measured for a group designed as per total number of cases.

It was noticed that the number of countries was consistently increasing in each group from first day of study until today (Table 3). Other variables those have the influence of these designed groups in table were descriptive measures of temperature. For example, at dated 18th April for cases per million, the mean of temperature among groups varied from 19.8 °C to 15.5 °C and similarly for median of temperature from 22 °C to 13.5 °C with SD from 8.0 °C to 7.6 °C. These measures are getting a wider range, that is, average minimum and average maximum difference as approaches toward back days. Similar behavior can be seen for total case and active case columns in Table 3. If the number of a country in a group is lesser then respective temperature SD is also small. This is obvious because of as total cases restriction increases the countries in a group comes from a more homogenous temperature zone. So, as the restriction of total number of cases increases from 1 to 1000 the average temperature and SD decreases simultaneously. These homogenous temperature zones impact can be seen through the respective correlation coefficients directly. For example, at dated 18th April, 2020 for active cases as average temperature reduces from 19.8 °C to 15.5 °C/22 °C–13.5 °C for mean/median with number of countries from 200 to 78 and hence correlation coefficients increase drastically from −0.45 to −0.15, −0.42 to −0.12 and −0.29 to −0.07 for Pearson, Spearman and Kendall coefficient, respectively. The similar outcomes can be seen for other cases and as well as on other days. So, it can be interpreted as the correlation coefficient is decreasing because of it is calculated for within more homogenous time zone countries. That is why it is approaching toward the zero and trying to show an independent relationship with larger total number restriction. Here it is to be noted that as one is going backward in days for within group the correlation coefficients are performing consistently. So, the results drawn on the behalf of earlier table can be considered stable.

All these findings further suggest that a negative link exists between environment temperature and COVID-19 cases.

## Discussion

The recent ongoing pandemic of COVID-19 is growing rapidly throughout the world, which emerged in Wuhan, China, at the end

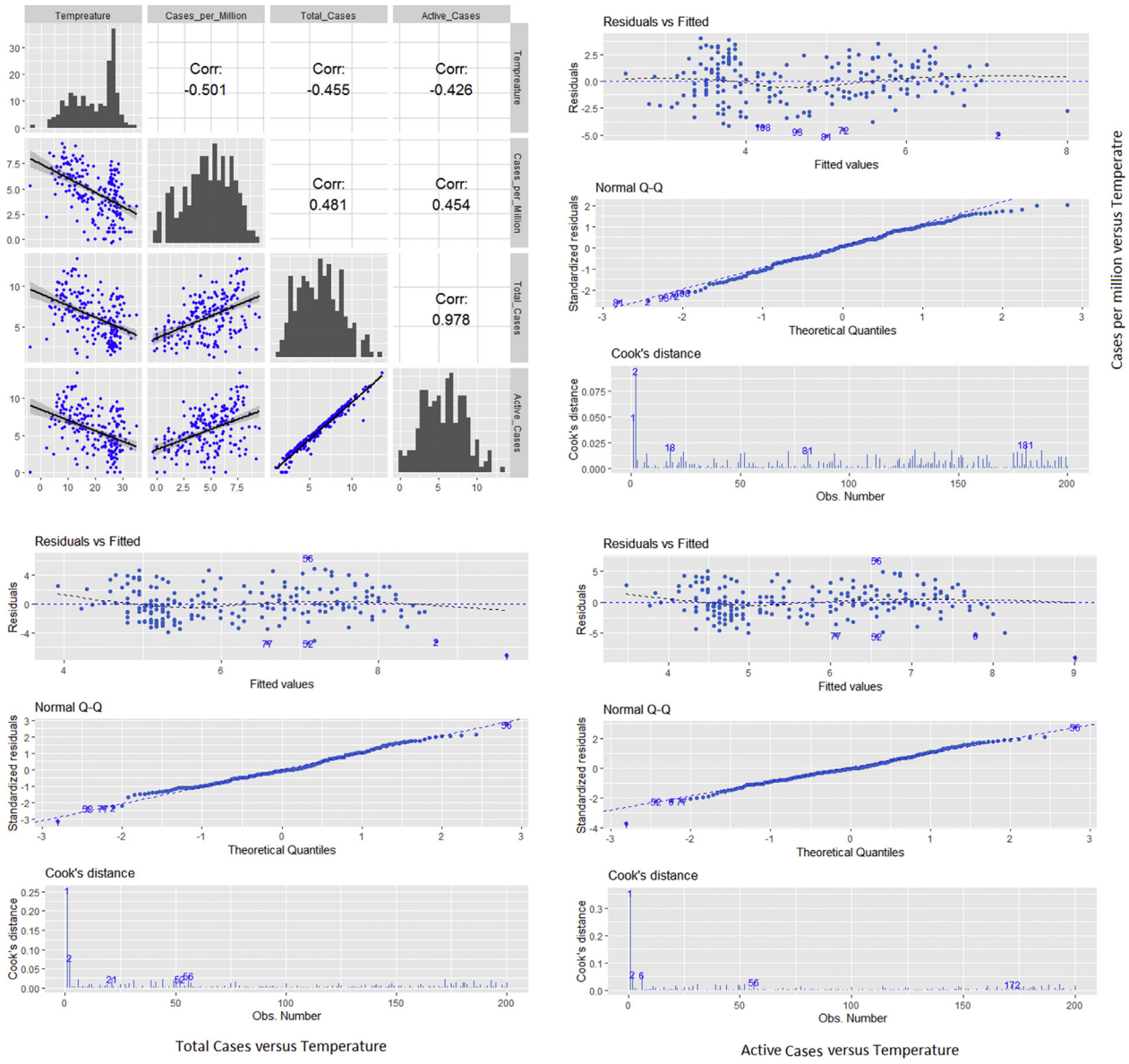



**Fig. 2.** A matrix plot among month average temperature (°C), cases per million, total cases, and active cases (except temperature all other variable are measured on logarithmic scale) of COVID-19 on April 18, 2020. COVID-19, coronavirus disease 2019.

of the year 2019. As of 18th April 2020, more than 2.4 million confirmed cases have been reported from 200 countries. This fatal outbreak has already killed almost 150,000 individuals worldwide. In the last few weeks, the numbers of infection cases and deaths had been found to increase with a tremendous high rate. To date, no medicines or vaccines are available for its treatment. All countries are strictly forcing various strategies such as travel restrictions, social distancing, and quarantines as preventive measures. To prevent infection, the travel connection between different countries, states, and cities has been restricted from the end of March, 2020. Various countries have also imposed curfews and lockdowns to prevent the direct contact between individuals. In this context, many people, scientists, researchers, and others think that novel coronavirus infection may be decreased as the summer comes, that is, as the environment temperature increases. It has been reported that infection and transmission of many virus types including influenza depends on air temperature and humidity.[10,11] However, no such report has yet been published in case of this viral infection and/or transmission. The recent report suggests that the viability of this new coronavirus greatly varies on different object surfaces such as stainless steel, plastic, cardboard, copper, and so on.[12] Here, object surface temperature might influence the longevity of the active virus particles. Thus, this study has given an attention to see the link between air temperature and COVID-19 cases. It was carefully observed that countries having larger COVID-19 cases are mostly located above of the latitude of Wuhan, which indicated that there might be a negative relationship between temperature and COVID-19 cases (Fig. 1). Next, the countrywise statistical analysis by various statistical methods has found a significant negative correlation between various COVID-19 cases including total cases, active cases, and cases per million of a country with MAET. Similar negative relationships between these two parameters at the MAET were found when the data of the countries having at least 50, 100, 1000 or more COVID-19 confirm cases (Table 3). All these observations suggest that low temperature might be a risk factor for COVID-19 cases. Next, we wanted to know whether the

**Table 3**
Comparative analysis among correlation coefficients and temperature variations for the countries having at least 50, 100, and 1000 COVID-19 cases.

| Total case ≥ | Cases per million | | | | Total cases | | | | Active cases | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 50 | 100 | 1000 | 1 | 50 | 100 | 1000 | 1 | 50 | 100 | 1000 |
| **25th March, 2020** | | | | | | | | | | | | |
| Total country | 198 | 112 | 91 | 31 | 198 | 112 | 91 | 31 | 198 | 112 | 91 | 31 |
| Pearson | −0.47 | −0.41 | −0.43 | −0.42 | −0.54 | −0.31 | −0.28 | −0.19 | −0.54 | −0.31 | −0.29 | −0.18 |
| Spearman | −0.47 | −0.40 | −0.43 | −0.31 | −0.54 | −0.30 | −0.24 | −0.10 | −0.54 | −0.31 | −0.26 | −0.10 |
| Kendall | −0.32 | −0.28 | −0.29 | −0.22 | −0.37 | −0.20 | −0.15 | −0.08 | −0.37 | −0.20 | −0.16 | −0.05 |
| Temperature mean | 17.84 | 13.71 | 12.86 | 8.98 | 17.84 | 13.71 | 12.86 | 8.98 | 17.84 | 13.71 | 12.86 | 8.98 |
| Temperature median | 21.00 | 12.75 | 12.00 | 6.50 | 21.00 | 12.75 | 12.00 | 6.50 | 21.00 | 12.75 | 12.00 | 6.50 |
| Temperature SD | 9.81 | 9.41 | 8.86 | 6.45 | 9.81 | 9.41 | 8.86 | 6.45 | 9.81 | 9.41 | 8.86 | 6.45 |
| **30th March, 2020** | | | | | | | | | | | | |
| Total country | 200 | 123 | 110 | 43 | 200 | 123 | 110 | 43 | 200 | 123 | 110 | 43 |
| Pearson | −0.48 | −0.42 | −0.44 | −0.55 | −0.53 | −0.37 | −0.34 | −0.32 | −0.53 | −0.38 | −0.34 | −0.31 |
| Spearman | −0.49 | −0.41 | −0.44 | −0.46 | −0.54 | −0.38 | −0.34 | −0.24 | −0.55 | −0.39 | −0.35 | −0.25 |
| Kendall | −0.34 | −0.28 | −0.31 | −0.32 | −0.37 | −0.25 | −0.22 | −0.14 | −0.37 | −0.26 | −0.23 | −0.15 |
| Temperature mean | 17.86 | 14.31 | 13.70 | 10.97 | 17.86 | 14.31 | 13.70 | 10.97 | 17.86 | 14.31 | 13.70 | 10.97 |
| Temperature median | 21.00 | 13.90 | 13.00 | 8.00 | 21.00 | 13.90 | 13.00 | 8.00 | 21.00 | 13.90 | 13.00 | 8.00 |
| Temperature SD | 9.78 | 9.41 | 9.39 | 8.88 | 9.78 | 9.41 | 9.39 | 8.88 | 9.78 | 9.41 | 9.39 | 8.88 |
| **6th April, 2020** | | | | | | | | | | | | |
| Total country | 200 | 137 | 125 | 61 | 200 | 137 | 125 | 61 | 200 | 137 | 125 | 61 |
| Pearson | −0.51 | −0.55 | −0.56 | −0.56 | −0.50 | −0.41 | −0.37 | −0.28 | −0.49 | −0.41 | −0.38 | −0.29 |
| Spearman | −0.50 | −0.54 | −0.55 | −0.58 | −0.49 | −0.41 | −0.38 | −0.30 | −0.49 | −0.41 | −0.38 | −0.29 |
| Kendall | −0.34 | −0.38 | −0.39 | −0.40 | −0.33 | −0.28 | −0.25 | −0.18 | −0.33 | −0.28 | −0.26 | −0.17 |
| Temperature mean | 19.84 | 17.81 | 17.30 | 15.32 | 19.84 | 17.80 | 17.30 | 15.32 | 19.84 | 17.81 | 17.30 | 15.32 |
| Temperature median | 22.00 | 16.50 | 15.50 | 14.00 | 22.00 | 16.50 | 15.50 | 14.00 | 22.00 | 16.50 | 15.50 | 14.00 |
| Temperature SD | 8.00 | 7.96 | 7.96 | 7.53 | 8.00 | 7.96 | 7.96 | 7.53 | 8.00 | 7.96 | 7.96 | 7.53 |
| **12th April, 2020** | | | | | | | | | | | | |
| Total country | 200 | 146 | 130 | 71 | 200 | 146 | 130 | 71 | 200 | 146 | 130 | 71 |
| Pearson | −0.50 | −0.52 | −0.56 | −0.50 | −0.47 | −0.42 | −0.37 | −0.20 | −0.45 | −0.41 | −0.36 | −0.20 |
| Spearman | −0.50 | −0.53 | −0.55 | −0.51 | −0.46 | −0.42 | −0.37 | −0.15 | −0.44 | −0.41 | −0.37 | −0.17 |
| Kendall | −0.34 | −0.37 | −0.38 | −0.35 | −0.31 | −0.28 | −0.24 | −0.08 | −0.31 | −0.28 | −0.24 | −0.10 |
| Temperature mean | 19.84 | 18.21 | 17.54 | 15.25 | 19.84 | 18.21 | 17.54 | 15.25 | 19.84 | 18.21 | 17.54 | 15.25 |
| Temperature median | 22.00 | 17.25 | 16.00 | 13.50 | 22.00 | 17.25 | 16.00 | 13.50 | 22.00 | 17.25 | 16.00 | 13.50 |
| Temperature SD | 8.00 | 7.92 | 7.93 | 7.50 | 8.00 | 7.92 | 7.93 | 7.50 | 8.00 | 7.92 | 7.93 | 7.50 |
| **18th April, 2020** | | | | | | | | | | | | |
| Total country | 200 | 155 | 136 | 78 | 200 | 155 | 136 | 78 | 200 | 155 | 136 | 78 |
| Pearson | −0.50 | −0.54 | −0.55 | −0.48 | −0.46 | −0.45 | −0.38 | −0.18 | −0.43 | −0.42 | −0.36 | −0.16 |
| Spearman | −0.50 | −0.55 | −0.57 | −0.49 | −0.45 | −0.44 | −0.38 | −0.14 | −0.42 | −0.41 | −0.36 | −0.13 |
| Kendall | −0.34 | −0.38 | −0.40 | −0.35 | −0.31 | −0.30 | −0.26 | −0.08 | −0.30 | −0.28 | −0.25 | −0.08 |
| Temperature mean | 19.84 | 18.71 | 17.90 | 15.51 | 19.84 | 18.71 | 17.90 | 15.51 | 19.84 | 18.71 | 17.90 | 15.51 |
| Temperature median | 22.00 | 18.50 | 16.50 | 13.50 | 22.00 | 18.50 | 16.50 | 13.50 | 22.00 | 18.50 | 16.50 | 13.50 |
| Temperature SD | 8.00 | 7.98 | 7.97 | 7.69 | 8.00 | 7.98 | 7.97 | 7.69 | 8.00 | 7.98 | 7.97 | 7.69 |

Note: Karl Pearson correlation coefficient is calculated for log-linear data. Temperature is in °C. COVID-19, coronavirus disease 2019; SD, standard deviation.

summer temperature can decrease this viral infection. Similar to our study, Chan et al.[13], 2011 reported that viability of other types of SARS coronaviruses was decreased with high temperature and low humidity environment. Their study also suggests that tropical countries have low risk of SARS coronavirus infection as compared with relatively cold countries. Thus, this present study gives a hint that the summer may reduce the SARS-CoV-2 infection/transmission rate as compared with the current season. Cold environment modulates many biological functions in our body. Our recent studies including other investigations have suggested that cold environment might be a risk factor for cancer diseases because cold adaption in long duration may provoke the cancer risk probably by altering various physiological and cellular functions with the influence of epigenetic changes and bringing mutations in tumor suppressor genes.[7,8,14–17] It was also reported that cold exposure decreased antitumor immunity to increase cancer growth and metastasis in an animal model.[18] Similarly, various studies documented that cold environment is relatively susceptible to viral infection because of suppression of immune responses.[19] Studies also reported the link between cold environment and asthma.[20] In regard to COVID-19, all people may not be infected upon exposure of this novel coronavirus. Some of them may be infected. Some infected people develop severe acute respiratory distress symptoms.[21] The recent clinical study reported that severe cases of this virus infected patients have lower monocytes, eosinophil, basophils, and T cells.[22] This viral infection may not vary much with respect to the age of the individual, but fatality is more in the case of old individuals.[21] The immune system of the elderly may not support enough to provide adaptive and boost immune responses to fight this novel coronavirus infection and its severity. In this situation, people living in cold environments might be an additional risk for COVID-19 severity. However, at this time, this study is unable to explain of how some cold countries have relatively higher coronavirus infected cases. Is it just the cold or are there additional factors? Second, is it possible that the warm temperature kills more viruses but also the ones that are able to grow are less virulent and cause less damage? Moreover, extended analysis with a large set of data is required to prove this negative link between environment temperature and COVID-19 cases.

The accumulating evidence reveals that the severity is more in cases of patients with COVID-19 having preexisting health issues such as diabetes, hypertension, obesity, cancer, and heart and kidney diseases.[23,24] All published reports state that the virus enters inside the cells by endocytosis process, where the viral spike proteins (S) interact with cell surface receptor angiotensin-converting enzyme 2 (ACE-2) proteins present over epithelial cells of the respiratory tract, lungs ,and other tissues.[25,26] It has also been suggested that this coronavirus enters in the circulation and infects various organ tissues (kidney, cardiac muscles, colon, adipocytes, and so on) having higher expression of ACE-2 on their cell surface.[27] Here, the host cell serine protease transmembrane Serine Protease 2 (TMPRSS2) primes spike glycoprotein (S) to facilitate infection.[26] For example, patients with type II diabetes may have high risk of coronavirus infection because of high expression of ACE-2 expression in the pancreas.[28] Similarly, adipose tissue may express more ACE-2 than lungs epithelial cells, thus obese people may have also high risk of this viral infection.[29] Studies reported that the patients with high body mass index had severe form of this virus infection.[30] It has also been suggested that some drugs used for the treatment of hypertension and diabetes may increase the expression of ACE-2 which invites the higher risk of virus infection.[23,24] All these findings suggest that the high expression of ACE-2 and TMPRSS2 in host cells is a great risk factor for this novel coronavirus infection. Moreover, implemented strategies for preventive measures to control the spreading of infection greatly vary from one country to others, which may also affect this negative relationship. Moreover, sensitivity of coronavirus (SARS-CoV-2) to temperature may vary from one mutant type to others. In addition, the efficacy of such infection may differ in various ages, races, ethnicities, and genders. Beside these, infectivity may also be dependent on various other local contextual factors such as hygiene practices, population crowding, and living style.[31]

This study has been carried out at a very early stage as COVID-19 became a worldwide outbreak. And due to some limitations, the comorbidity factors are not included at this study. In future work, we can upgrade the same result with great extent by considering additional covariates (e.g., factors such as diabetes, obesity, hypertension, cancers, and humidity of a country).

This pilot study proposes that high temperature may delay this novel coronavirus infection. Of course, experimental study can say whether and how cold environment augments coronavirus infection and/transmission.

## Author statements

*Ethical approval*

None sought.

*Funding*

None declared.

*Competing interests*

All authors declare that they have no conflict of interest.

*Acknowledgment*

C.C.M. is supported by University Grants Commission [30–49/2014 (BSR)], Department of Biotechnology, India [6242-P9/RGCB/PMD/DBT/CCML/2015], and Department of Science and Technology (India)-Russian Foundation of Basic Research [INT/RUS/RFBR/P-256]. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.05.065.

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Public Health 185 (2020) 128–129

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Letter to the Editor

# COVID-19, health rights of prison staff, and the bridge between prison and public health in Africa

Despite a range of international instruments designed to protect human and health rights of people deprived of their liberty, many African prisons are still not meeting minimum conditions and standards of care.[1] Human rights violations, systemic abuse, and deplorable environmental determinants of health continue. African prisons are generally operating over capacity and are characterized by old physical infrastructure, insufficient sanitation, ventilation and hygiene, severe congestion caused by high pretrial detention rates, and fragile prison health systems.[1–3]

Prison health research in Africa is historically of low priority and remains underdeveloped.[4] This letter is intended to draw attention to the lack of academic activity in this field and the particular lack of representation of the voices of people who work in prisons and their occupational health situation. The well-being, working conditions, health and safety concerns, and experiences of prison staff in the African prison environment are understudied and ill understood. The extant empirical literature has generally focused on stakeholder perspectives on the situation of incarcerated people and not that of prison staff. When prison staff have been consulted on the environmental determinants of health in prisons, they voice a deep concern for their health and that of their families and anxiety around biohazard risks (particularly airborne diseases such as tuberculosis [TB]).[5] Given the current COVID-19 pandemic and its devastating impact on African prisons and local communities, it is imperative that greater investment in occupational health research occurs.

The academic discourse on prison staff and their health situation in Africa is inadequate. This letter advocates not only for research into prison health determinants but also for greater academic research into existing prison health policies related to prison staff to assess gaps and inform policymaking efforts. Prison staff and prisoners are exposed to the same pathogens and the same hygiene and sanitation conditions; the same congested space; the same air for breathing; and the same water for washing, drinking, and cooking. They are also exposed to generally insufficient pathogenic disease control measures (diagnosis, treatment, and personal protective equipment) in prisons. The 'bridge' of disease transmission (for example, COVID-19, TB) between prison and community underpinned by visitors, prisoners, and the high turnover of prison staff cannot be underestimated. The health outcomes of prison staff (and their families) are potentially further compromised by their extremely low salaries and living situation close to poverty margins.

Research is warranted to enhance our understanding of the prison determinants of health and cultures which shape prison staff's responsiveness to threat of contagious and infectious diseases, the impact of prison conditions in terms of congestion, hygiene, ventilation, and sanitation, navigation of health risks, and work-related stress.[2–5] Information garnered can help to reduce future risks, tackle occupational health deficits, and identify what policies, practices, interventions, and mechanisms could be best used by authorities to improve prison occupational health standards and outbreak preparedness and to ensure safe working conditions in African prisons. This focused attention on the health and well-being of prison staff through research could also contribute to greater social accountability and buy-in from government and prison officials and fuel the upscaling of holistic prison health initiatives. Such a concerted and strategic research effort can support a positive shift to reforming African prison health operations and systems.

## Funding

The work was funded by the Medical Research Council (MRC) Grant, United Kingdom. Ref: MC_PC_MR/R024278/1.

## Competing interests

There is no conflict of interest.

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https://doi.org/10.1016/j.puhe.2020.06.037

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11 June 2020
Available online 25 June 2020

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Public Health 185 (2020) 60

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Letter to the Editor

# COVID-19 in Africa

As reported in more detail in an article recently published on the European Science-Media Hub website,[1] Africa, despite having the world's greatest infectious disease burden, has a weak epidemiological surveillance system. Even in Europe, with its more advanced information systems, the official data on the coronavirus disease 2019 (COVID-19) are controversial because of poor standardisation. The data on COVID-19 in several African countries are currently scarce and uncertain, which does not allow for an objective analysis of the present situation. Some evidence also shows that several African countries exert tight control over public data and information. The World Health Organization recently rebuked the Tanzanian government for refusing to share information on alleged Ebola cases, the country denying the existence of any such cases.[2] Furthermore, it is not uncommon for journalists disclosing information on COVID-19 to be subject to intimidation by public authorities.[3] Interpretation of the pandemic's trend in Africa should consider three major factors: the undernotification of cases, the slower development of the epidemic and a comparatively lower incidence to other continents. Previous epidemics were subject to catastrophic predictions (the AIDS epidemic in the 1980s–90s, the more recent Ebola epidemic), predictions which did not eventually occur. Therefore, caution should be exercised in regards to the extremely negative predictions of the present pandemic.

In health emergencies (especially epidemics), one of the most frequent risks in Africa is the suspension of essential prevention and treatment health services. The new SARS-CoV-2 emergency threatens to absorb resources destined for other preventable disease conditions, which – unlike COVID-19 – have known therapies: common paediatric infectious diseases, obstetric complications, vaccinations campaigns, etc. Avoidable morbidity and mortality of common diseases could therefore inflict more damage and claim more victims than the epidemic itself, as was the case in the recent Ebola epidemic.[4,5] Aid and, more importantly, other forms of sustainable assistance that would alter African socioeconomic trajectories – if and when they will be sent in the difficult times we are facing – will have to seriously consider the health systems.

Finally, in Africa, particularly in the sub-Saharan region, there are no nation-wide health systems capable of enduring a wave of patients suffering acute respiratory failure. The massive and short-term intensive care requiring assisted breathing and other organ-failure support would be very challenging. As in Europe, and likely on a greater scale, any epidemic pressure will have to be addressed with home care under supervised self-medication. Large-scale diagnostics will not be affordable, and so it will be necessary to prioritise triage based on clinical case definition or presumptive diagnosis.[6,7]

## Disclaimer

The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the affiliated organizations.

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7 May 2020
Available online 23 May 2020

https://doi.org/10.1016/j.puhe.2020.05.030

Public Health 185 (2020) 218–220

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# COVID-19 stay-at-home order in Tyrol, Austria: sports and exercise behaviour in change?

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ARTICLE INFO

*Article history:*
Received 23 May 2020
Accepted 19 June 2020
Available online 26 June 2020

ABSTRACT

*Objectives:* The aim of the study was to investigate differences in the frequency and types of engagement in sports before, during and after the coronavirus disease 2019 (COVID-19) stay-at-home order in Tyrol, Austria.
*Study design:* A representative population survey was conducted.
*Methods:* A sample of Tyroleans (N = 511) was questioned by a market research institute via an online questionnaire or telephone survey.
*Results:* During the stay-at-home order, participants engaged less in sports than before and after the restrictions. However, within-group analyses revealed increasing sport participation in less active groups when comparing the pre- and post-COVID-19 period.
*Conclusions:* Despite the restrictions during the stay-at-home order, respondents did engage in sports and promoted their health. Nevertheless, it is still necessary to investigate the long-term effects of the COVID-19 crisis on sports and exercise behaviour as well as the extent to which sports policy measures may be able increase sports participation.


## Introduction and study objective

Since the outbreak of coronavirus disease 2019 (COVID-19) in China in early December 2019,[1] the virus has continued to spread and reached almost every country in the world. Global disease control represents a major challenge. Governments and local authorities have to take political decisions balancing different interests and weighing the benefits and costs of the measures. On the side of benefits, measures may reduce the infection rate, prevent overloading the healthcare system and—finally—save human lives.[2] On the side of costs, quarantine and isolation measures may lead to mental and social problems[4] and have huge impacts on the global economy.[3]

The relationship between COVID-19 and sports and exercise behaviour has already been addressed in the literature, and the importance of exercising during the COVID-19 period was highlighted.[5] However, only a few studies have considered changes in sport participation during stay-at-home orders or when other drastic regulations were established to prevent further spread of the virus.[5–8] The extent to which a population's engagement in sports changed when compared with the period before, during and after restrictions has not yet been investigated. The Austrian province of Tyrol represents an interesting case for such research: on the one hand, the population of this region exhibits above-average participation in sports;[9] on the other hand, high infection rates have prompted policymakers to introduce drastic measures limiting people in everyday life and also in exercising. In contrast to other Austrian provinces, any kind of outdoor sports was prohibited in Tyrol until April 7, including jogging and hiking.[5]

The objective of this study was therefore threefold: first, to examine the change in sports and exercise behaviour over three periods, i.e. before the COVID-19 stay-at-home order (PRE-C19), during the COVID-19 stay-at-home order (DURING-C19) and after the COVID-19 stay-at-home order (POST-C19); second, to investigate whether or not the surveyed Tyroleans found the implemented COVID-19 (sports) restrictions appropriate; and third, to describe respondents' recommendations for future (sports) policies.

## Data and findings

From April 27 to May 4, a representative stratified survey was conducted (N = 511) online as well as by telephone. The maximum

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https://doi.org/10.1016/j.puhe.2020.06.042
0033-3506/

fluctuation range of the overall results was ±4%. Fifty-three percent of the respondents were women, and 47% were men. Most of the respondents (59%) were between 25 and 59 years of age. Twenty-one percent of the surveyed population lived in the state capital Innsbruck, and 79% lived in the various counties of Tyrol. More than half of the sample (57%) was employed; the others were either in education, retired, or working in the household. For better comparability, sports and exercise behaviour was measured using the questionnaire of the Eurobarometer 472 study,[10] which had also been applied in a previous sports participation study carried out in Tyrol in autumn 2019.[9] The perceived appropriateness of the COVID-19 regulations implemented by the government was measured using a Likert scale (ranging from 1 [strongly agree] to 5 [strongly disagree]), and suggestions for future (sports) policies were collected using open questions grouped by topic. The results of the present study and the previous studies are displayed in Table 1.

Within the study at hand, the participants were asked how often they engaged in sports or exercising in the PRE-C19, DURING-C19 and POST-C19 periods. This revealed interesting results: First, 19% of the respondents indicated that they had never or only seldom engaged in sports in the PRE-C19 period; this percentage more than doubled (41%) within the DURING-C19 period and fell again in the POST-C19 period (35%). Second, the majority of the respondents (58%) did engage in sports once to twice or three to four times a week in the PRE-C19 period; for the POST-C19 period, this figure was 47%, whereas the lowest value (36%) was registered for the DURING-C19 period. Third, remarkable results in terms of a change in sports participation between the PRE-C19 and POST-C19 period were found at an individual level: 30% of those who had previously exercised 5 times or more a week showed a reduced sports participation frequency in the POST-C19 period; for the category '3 to 4 times a week', the respective figure was 33%. On the contrary, among those who had previously engaged in sports only once or twice a week, one to three times a month or seldom, the percentage of people who became more active in the POST-C19 period was 35%, 45% and 44%, respectively. However, the ceiling and floor effect of the highest and lowest categories of physical activity must be considered here.

Before the restrictions, the respondents engaged in outdoor sports, such as biking (30%), walking (25%), hiking (24%), jogging (13%) or mountain biking (6%). During the quarantine measures, the respondents primarily went for a walk (32%). Other outdoor activities were prohibited and (thus) practised less frequently or not at all (hiking: 20%, jogging: 11%, mountain biking: 0%). In contrast, engagement in different forms of home training, such as fitness exercises (11%), aerobic/gymnastics (11%) or forms of home workout (6%), increased when compared with that in the PRE-C19 period. After the drastic restrictions were lifted, the survey participants increasingly engaged in outdoor sports, such as hiking (29%), walking (28%), biking (28%) or jogging (18%), whereas participation in home training declined when compared with that in the DURING-C19 period.

In total, 65% of the respondents found that the overall regulations implemented in context of the COVID-19 crisis in Tyrol were appropriate. Fifty-seven percent of the respondents agreed with the measures on practicing sports; however, 18% did not support these measures. Answering the open question related to sports policy recommendations, 22% of the participants spoke out in favour of promoting mass sports and supporting small sports clubs in their POST-C19 activities. Moreover, 7% of the respondents stated that politicians should establish appropriate COVID-19 precautions and rules for practising sports (7%), whereas 12% wanted sports to continue as it was before the pandemic. However, the majority of the respondents (48%) did not answer the open questions.

## Discussion and research directions

In summary, the surveyed Tyroleans engaged less in sports in the DURING-C19 period than in the PRE-C19 and POST-C19 periods. In the DURING-C19 period, the respondents switched to home training, largely avoided engaging in prohibited outdoor sports, but went for a walk. The retrospective assessment of sports participation frequency and practiced sports disciplines was in line with an earlier representative population survey.[9] However, it was observed that in certain groups—namely, those with low engagement in sports—up to 45% of the respondents reported increased sports participation frequency in the POST-C19 period compared with that in the PRE-C19 period. Comparing the percentage of respondents with increased frequency of sports participation with that with decreased frequency of sports participation (Table 1, columns Increase vs Reduction) brought to light some remarkable results: In the groups of respondents who had engaged in sports only seldom or one to three times a month in the PRE-C19 period, we could identify a difference of 15 and 20 % points, respectively, i.e. more people increased their sports participation than decreasing their individual sports participation.

The theory of falling opportunity costs could be used for interpreting the results. On the one hand, we could argue that the increase in sports participation might be associated with the increase in leisure time; on the other hand, there might be a shift in preferences. However, lack of time is the most frequently mentioned reason for not engaging in sports.[10] Furthermore, these first descriptive results raise the question if one of the most common aims of sports policy—namely, increasing sports participation in people who only rarely engage in sports—might by partly reached through a crisis, such as the COVID-19 pandemic. However, the reasons for this behaviour change are unclear. Perhaps, preferences have changed, and we can hope for a sustainable increase in sports participation. Both explanatory approaches are justified, and presumably, the underlying reasons are a mixture of both. However, whether this change will persist remains unclear.

**Table 1**
Frequency of exercising or playing sports (N = 511) in the PRE-C19 (before the stay-at home order on March 16, 2020), DURING-C19 (between March 16 and April 7, 2020) and POST-C19 (from April 7, 2020 onward) period in comparison with the results of the Eurobarometer 472 study[10] and the 2019 sports participation study in Tyrol.[9]

| Frequency | Stay-at-home order in Tyrol | | | | | EU 28[10] | Austria[10] | Tyrol[9] |
|---|---|---|---|---|---|---|---|---|
| | PRE-C19 | DURING-C19 | POST-C19 | Reduction[a] | Increase[b] | | | |
| 5 times a week or more | 7% | 10% | 13% | 30% | 0% | 7% | 4% | 8% |
| 3 to 4 times a week | 27% | 17% | 24% | 33% | 19% | 12% | 12% | 26% |
| 1 to 2 times a week | 31% | 19% | 23% | 26% | 35% | 21% | 22% | 30% |
| 1 to 3 times a month | 16% | 13% | 14% | 25% | 45% | 5% | 9% | 17% |
| Seldom | 10% | 20% | 9% | 29% | 44% | 9% | 13% | 11% |
| Never | 9% | 21% | 16% | 0% | 2% | 46% | 40% | 9% |

[a] Reduction: percentage of people indicating a lower category of sports participation in the POST-C19 compared with the PRE-C19 period.
[b] Increase: percentage of people indicating a higher category of sports participation in the POST-C19 compared with the PRE-C19 period.

Although this study has some limitations (e.g. retrospective survey method, no inferential statistics), our observations raised several questions in the context of the persistence of behaviour changes and their reasons. This is an area where further research could be started.

## Author statements

*Acknowledgements*

We would like to thank the Lebensraum Tirol Holding and the IMAD – Institut für Marktforschung und Datenanalysen for their support.

*Ethical approval*

None sought.

*Funding*

None declared.

*Competing interests*

None declared.

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Public Health 185 (2020) 119–126

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Does arts and cultural engagement vary geographically? Evidence from the UK household longitudinal study

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ARTICLE INFO

*Article history:*
Received 7 January 2020
Received in revised form
15 April 2020
Accepted 21 April 2020
Available online 30 June 2020

*Keywords:*
Arts and cultural participation
Geographical factors
Geographical and health inequalities
Spatial setting
Neighbourhood characteristics

ABSTRACT

*Objectives:* Previous studies have shown the beneficial impacts of arts participation and cultural engagement on health outcomes. However, this engagement is socially patterned and is also possibly influenced by geographical factors.
*Study design:* The aim of this study was to examine the association between geographical factors (spatial setting and neighbourhood characteristics) and arts and cultural engagement amongst adults in the UK.
*Methods:* Data analysed were from Understanding Society Wave 2 (2010/12) with a total sample size of 26,215. Logistic and ordinal regression was used to identify geographical predictors for the patterns of the engagement.
*Results:* Our results show that there are geographical differences in participation independent of individual demographic and socio-economic backgrounds. In particular, there was more evidence for differences in the participation based on neighbourhood characteristics (e.g. level of area deprivation). We also found some interactions between individual and geographical factors for cultural engagement but not for arts participation.
*Conclusions:* This study reveals a geographical and individual socio-economic gradient in arts and cultural engagement. Given the health benefits of arts engagement, improving access to arts and cultural programmes geographically may potentially help to reduce health inequalities.


## Introduction

Over the past two decades, more than 3000 studies have identified the positive impact of arts participation (actively engaging in arts activities such as music, dance or crafts) and cultural engagement (visiting cultural venues or heritage sites) on mental and physical health outcomes.[1] However, despite growing public awareness of the benefits of engagement and increased promotion of such activities within health care, including through direct referrals from healthcare professionals to arts activities, arts participation and cultural engagement (hereafter referred to collectively as 'arts engagement') remains uneven.[2]

To date, much research into factors affecting arts engagement has focused on individual-level characteristics. For example, studies have highlighted how arts engagement is socially patterned, with people of higher socio-economic status (SES) being more likely to engage in the arts.[3–5] One explanation for this is that people's engagement may be influenced by monetary resources, acquired tastes and cultural exclusion.[6] Furthermore, previous research has suggested that there are gender and ethnic differences in arts engagement, with women[7,8] and individuals who are part of the ethnic majority more likely to engage in these activities.[9]

However, arts engagement may also be shaped by geographical factors.[10,11] There is evidence that individual social, economic and behavioural outcomes are associated with neighbourhood conditions.[12] This stems from the concept of 'neighbourhood effects', which posits that factors such as environmental conditions, social processes, transportation and other local characteristics can directly and indirectly influence individuals' behaviours.[11,12] Therefore, it has been argued that neighbourhood risk factors in concert with individual characteristics can explain a larger proportion of individual behaviours than merely focussing on individual characteristics alone.[12] In considering how this occurs, researchers have proposed several theoretical mechanisms, two of which are particularly relevant to this study. First, geographical variations in arts engagement could be due to the characteristics of

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https://doi.org/10.1016/j.puhe.2020.04.029

places (such as number of arts venues, arts programmes, studios) shaping people's behaviours.[11] Arts funding is not geographically equal across countries. For example, in England, funding from Arts Council England (ACE) is greatest in London and lowest in the South West,[13] even though the South West has one of the highest arts participation rates across England.[14] Second, spatial differences in population composition such as the socio-economic characteristics of individuals living in an area may lead to collective behavioural influences on arts engagement.[3,11,15] Population composition has been found to influence a number of health behaviours such as food consumption,[16] smoking,[17] alcohol consumption[18] and physical activity.[19] But to date, very little research has been conducted to understand whether similar place-based effects exist for arts engagement.[11,20]

Examining the geographical patterns of arts engagement has particular policy relevance at present. First, the well-established evidence for the health benefits of arts engagement has attracted doctors to adopt 'social prescribing' schemes in many Western countries, including the UK,[21–23] North America[24] and Scandinavia.[25] Social prescribing is a place-based approach that is designed to improve well-being by putting patients in contact with local community activities. However, the importance of 'place' in affecting behavioural engagement with the arts is as yet unknown. Second, there is increasing interest in place-based funding to help improve the cultural capacity and capital of an area (particularly areas of high deprivation). For example, the 'Creative People and Places' funded by ACE offers financial support to arts-related projects in areas where involvement in arts and cultural activities is below the national average.[26] But it is unclear if and how the characteristics of the places chosen could affect individual behaviours. A fuller understanding of the relationship between geographical factors and arts engagement is therefore crucial for yielding useful information for public health action.

Therefore, in this article, we used a large nationally representative sample of adults living in the UK to examine whether both arts participation and cultural engagement vary geographically. We examined two main types of geographical factors: (i) the broad spatial setting as an indicator of geographical contexts, measured by regional locations within England and the urbanisation of areas, and (ii) neighbourhood characteristics as an indicator of local population composition, measured by the level of area deprivation and a geodemographic area classification. Furthermore, given that residential sorting means there is often a close association between place characteristics on the one hand and individual demographic and SES characteristics on the other (e.g. highly educated people are likely to live in wealthier areas, while poorer households can only afford less affluent places), we further explored the extent to which the association between geographical factors and arts engagement is moderated by individual demographic and socio-economic characteristics.

## Methods

We used data from Understanding Society; a large nationally representative UK household longitudinal survey.[27] Understanding Society follows over 50,000 individuals from over 30,000 households annually. The survey contains a rich set of variables including education, employment, social engagement and health. One attraction of Understanding Society is that participating households' addresses have been matched to the Office for National Statistics Postcodes Directory and then geocoded into a range of zoning systems (e.g. local government, health and census geographies). In this study, we used data from the Wave two interview (2010/12) which has an overall sample of 38,069. In our analysis, we included participants who provided full data across all measures ($N = 26{,}215$).

### *Measures*

In a previous study, we applied latent class analysis (LCA) to the same sample used in this study and identified two patterns of participation in arts activities and engagement with culture and heritage.[2] Arts participation was made up of five items (including playing a musical instrument and painting, drawing, printmaking or sculpture), whereas cultural engagement was made up of 14 items (including visited an art or craft exhibition, visited a musical or dancing performance, visited museums and heritage sites). A full list of the activities of arts participation and cultural engagement can be found in Appendix A. Respondents were asked whether or not they had engaged in each of the arts/cultural activities in the past 12 months.

For arts participation, the LCA identified four profiles of engagement: 'engaged omnivores', who took part in lots of activities (1.18% of our sample); people who mainly participated in either 'visual and literary arts' (4.54%) or 'performing arts' (4.63%) and people who were largely 'disengaged' (89.7%).[2] To ensure a more balanced sample between the groups, the sample was split into 'engaged' (which included individuals in the engaged omnivores, visual and literary arts and performing arts classes) vs 'disengaged' (those in the original disengaged class). For cultural engagement, LCA identified three profiles of engagement: 'rarely engaged', 'infrequently engaged' and 'frequently engaged'. For full details of the construction of the LCAs, refer our previous article.[2]

For geographical factors, we used each household's Lower Layer Super Output Area (LSOA) identification code. LSOAs are small spatial units used for the release of English and Welsh census data that are designed to be relatively socially homogenous and with boundaries that follow topographical features such as roads or railways. Four geographical variables were considered: rural-urban classification which indicates LSOA level of urbanisation (rural town and fringe vs rural village vs urban city and town vs urban conurbation); regions which include North (North East, North West and Yorkshire and the Humber), Midlands (East and West Midlands) and South (East, London, South East and South West) within England; Index of Multiple Deprivation (IMD 2015), which measures the relative deprivation for small areas according to various domains (e.g. income deprivation, living environment deprivation, crime; measured as most deprived 10% vs medium vs least deprived 10%) and the geodemographic Output Area Classification (OAC), which places LSOAs into 8 super groups on the basis of cluster analysis conducted using a swathe of standardised 2011 census variables (including demographic structure, household composition, housing, employment, SES and population density).[28] The OAC categorises LSOAs into cosmopolitan student neighbourhoods vs countryside living vs ethnically diverse professionals vs hard-pressed communities vs inner city cosmopolitan vs multicultural living vs suburban living vs industrious communities.

To isolate the independent associations between geographical factors and arts engagement, we also considered a range of individual- and household-level demographic and socio-economic predictors. Demographic factors included respondents' age, gender, ethnicity, whether the respondent was living alone, partnership status and whether respondents were responsible for children aged 16 years and younger. Socio-economic characteristics included educational attainment, current employment status and occupational SES, parental SES when respondents were aged 14 years, logged monthly household income and housing tenure. A full list of the predictors can be found in our previous study.[2]

*Statistical analysis*

To understand the associations between geographical factors and arts engagement, we used binary logistic regression models for arts participation and ordinal logistic regression models for cultural engagement. All analyses were weighted to account for non-response and uneven selection probabilities using the wave 2 cross-sectional weights supplied with Understanding Society.[29] Odds ratios (ORs) are presented to show the likelihood that an individual would belong to a certain outcome class relative to a given baseline scenario. An OR that is greater than one indicates a higher likelihood of being in the 'engaged' groups, while an OR that is lower than one suggests a lower likelihood of being in these groups. Given that arts participation and cultural engagement are likely to be associated at the household level (e.g. a person is likely to participate in arts activities if their family also engages in such activities), the 95% confidence interval (CI) in regression models was calculated by clustering standard errors within households.

In our main analyses, we ran four sets of models each for arts participation and for cultural engagement. The first models examined the association between geographical factors and arts and cultural activities by testing each of the factors individually. In our second model, we examined the association by including all geographical factors simultaneously in one model. To avoid standard errors being inflated (i.e. the 95% CI of the estimates getting too wide) by the inclusion of multiple geographical variables measuring similar things, we only included the measures with the strongest relationship to arts engagement in this simultaneous model and also in subsequent analyses. To understand whether the association between geographical factors and participation could be explained by individual demographic and socio-economic characteristics, the third model additionally included individual demographic factors, while the fourth model added individual SES controls.

In addition to our main analyses, we estimated several alternative specifications as robustness checks; results are presented in the online supplementary material. As an initial check, we reran the analyses by (1) omitting OAC and (2) omitting IMD from the models to assess whether the estimates were affected by including these two potentially collinear variables simultaneously. In addition, to assess whether geographical factors were associated with a certain type of arts participation engagers, we carried out analyses by using the four-fold category (i.e. 'engaged omnivore', visual and literary arts', 'performing arts' and 'disengaged') identified in our prior LCA[2] and by using multinomial logistic regression (relative risk ratios are presented). Finally, we performed several interaction analyses to test whether the effects of individual characteristics vary across places.

## Results

*Demographics*

The average age of our sample was 48 years (SD = 18.4), 55% were women and 91% were white. The distribution of arts participation and cultural engagement groups by demographic backgrounds and socio-economic characteristics was presented in our previous study.[2] Descriptive statistics showing the distribution of arts participation and cultural engagement by geographical factors are shown in Supplementary Tables 1 and 2

*Geographical factors and arts and cultural engagement*

*Arts participation*

Regarding spatial setting and using the 'disengaged' as the reference group, respondents who lived in Northern England or the Midlands were less likely to engage in arts activities than those who lived in the South (Table 1). However, there was no association between urbanisation and arts participation.

Regarding neighbourhood characteristics, respondents living in the 10% least deprived of LSOAs had a 21% higher odds of engaging in the arts, compared with those who were living in areas of a medium level of deprivation, and there was an indication that individuals living in the 10% most deprived areas had a lower odds of engaging in the arts ($P = 0.057$). Compared with people in industrious communities, those who lived in cosmopolitan student neighbourhoods had a 2.2 times higher odds of engaging in the arts. Those who lived in areas designated as countryside living, ethnically diverse professionals and inner city cosmopolitan had 32%, 27% and 91% higher odds of engaging in the arts, respectively. But there was no difference in participation amongst those living in hard-pressed communities or suburban or multicultural LSOAs.

When considering all geographical factors simultaneously, the associations between regions, IMD and OAC and arts participation remained (Table 2) (NB rural-urban classification was removed due to its limited effects and to avoid multicollinearity with OAC). Adjusting for demographic characteristics did not lead to attenuation of the findings. When adjusting for individual socio-economic factors, however, many results were attenuated. The only spatial differences that remained were a 14% lower odds of participating in the arts amongst those in the North than those in the South and a 19% higher odds of engaging amongst those living in the countryside than those living in industrious communities.

*Cultural engagement*

Regarding spatial setting, respondents who lived in rural town and fringe and rural villages had higher odds of being culturally engaged than those who lived in urban areas (Table 3). In contrast, people who lived in urban conurbations were less likely to engage in cultural activities. Compared with people living in the South, those residing in the North and Midlands had a lower propensity to be culturally engaged (North: OR = 0.80, 95% CI = 0.75–0.86; Midlands: OR = 0.78, 95% CI = 0.72–0.84) (Table 4).

Regarding neighbourhood characteristics, compared with people living in areas of medium deprivation, those who lived in the 10% least deprived areas had 2 times the odds of more likely being culturally engaged. People who lived in the 10% most deprived areas had a lower propensity to be culturally engaged (OR = 0.36, 95% CI = 0.32–0.41). Compared with individuals residing in industrious communities, cultural engagement is more frequent amongst people living in cosmopolitan student neighbourhoods (2.1 times higher odds), the countryside (1.5 times higher odds), areas of ethnically diverse professionals (1.4 times higher odds), inner city cosmopolitan areas (1.7 times higher odds) and suburban LSOAs (1.5 times higher odds). Conversely, people who lived in hard-pressed communities and LSOAs designated 'multicultural living' had a lower propensity to be culturally engaged (hard-pressed communities: OR = 0.52, 95% CI = 0.47–0.57; multicultural living: OR = 0.56, 95% CI = 0.49–0.63).

When considering all geographical factors simultaneously, the relationship for regions was attenuated, with just the Midlands showing lower participation than the South, although other findings remained. There was no attenuation when adjusting for individual demographic factors. When additionally adjusting for individual socio-economic factors, the relationship for regions was completely attenuated. However, the findings for deprivation remained. Furthermore, compared with people who lived in industrious communities, areas of cosmopolitan student neighbourhoods, countryside living and inner city cosmopolitan LSOAs still had higher odds of being culturally engaged, while people

**Table 1**
Logistic regressions estimating the relationship between geographical factors and arts participation: each geographical factor is included in individual models (weighted; $N = 26{,}215$).

| Geographical factors | Engaged vs disengaged | | |
|---|---|---|---|
| | OR | 95% CI | *P*-value |
| ***Spatial setting*** | | | |
| *Model 1 Rural-urban classification only* | | | |
| Rural town and fringe | 0.98 | 0.84–1.14 | 0.753 |
| Rural village | 1.15 | 0.98–1.35 | 0.080 |
| Urban conurbation | 1.00 | 0.90–1.12 | 0.994 |
| (ref: Urban city and town) | | | |
| **Pseudo R2** | **0.0002** | | |
| *Model 2 Regions only* | | | |
| North (North East, North West and Yorkshire and the Humber) | 0.77 | 0.69–0.86 | 0.000 |
| Midlands (East Midlands and West Midlands) | 0.82 | 0.73–0.93 | 0.002 |
| (ref: South (London, South East, South West and East)) | | | |
| **Pseudo R2** | **0.0020** | | |
| ***Neighbourhood characteristics*** | | | |
| *Model 3 Index of Multiple Deprivation only* | | | |
| Least deprived 10% | 1.21 | 1.05–1.40 | 0.007 |
| Most deprived 10% | 0.83 | 0.69–1.01 | 0.057 |
| (ref: Medium) | | | |
| **Pseudo R2** | **0.0009** | | |
| *Model 4 Output Area Classification only* | | | |
| Cosmopolitan student neighbourhoods | 2.23 | 1.75–2.85 | 0.000 |
| Countryside living | 1.32 | 1.13–1.54 | 0.000 |
| Ethnically diverse professionals | 1.27 | 1.09–1.49 | 0.002 |
| Hard-pressed communities | 0.89 | 0.75–1.05 | 0.173 |
| Inner city cosmopolitan | 1.91 | 1.48–2.46 | 0.000 |
| Multicultural living | 1.00 | 0.83–1.21 | 0.964 |
| Suburban living | 1.10 | 0.95–1.27 | 0.222 |
| (ref: Industrious communities) | | | |
| **Pseudo R2** | **0.0075** | | |

The bold values indicate Pseudo R2, which is a measure of how well variables of the model explain the arts engagement.
CI, confidence interval; OR, odds ratio.

living in hard-pressed communities and areas of multicultural living still had a lower odds of being culturally engaged.

### *Sensitivity analyses*

Results were not significantly different when IMD and OAC were omitted from the models (Supplementary Tables 3a and 3b). When using the four-factor model for different patterns of arts participation rather than a binary measure of engagement vs disengagement, lower participation amongst individuals living in the North was found for general engagement, visual and literary arts engagement and performing arts engagement, but there was lower engagement in the Midlands only for visual and literary arts engagement (Supplementary Tables 4a and 4b). Area deprivation appeared most important in relation to performing arts, as did living in the countryside. Living in a hard-pressed community was strongly related to a lower odds of being an engaged omnivore. There were no other major differences depending on the type of arts participation.

Finally, there were no interactions between individual and geographical factors for arts participation (results not shown). However, the positive associations between higher SES and education and cultural engagement are more pronounced in highly deprived areas and less pronounced in more affluent places (Supplementary Table 5a -5c).

## Discussion

While there is evidence that there is a social gradient across arts participation and cultural engagement, this study explores how patterns of arts engagement are also geographically patterned across the UK. Importantly, it extends existing studies which largely presented evidence on regional differences in arts engagement by assessing how both broad spatial setting and local neighbourhood characteristics may help explain these geographic divides.

Our results demonstrate that there are geographical differences in participation even after controlling for individual demographic and socio-economic backgrounds. In particular, individuals living in the North of England had lower odds of engaging in the arts, while those living in the countryside had higher odds, especially for engaging in performing arts activities. For cultural engagement, the geographical region was less important, but area deprivation predicted patterns of engagement; engagement was also higher amongst those living in cosmopolitan student neighbourhoods and in relatively affluent countryside areas but lower amongst those living in hard-pressed communities. In addition for cultural engagement, individuals who had a disjunction between their own SES and education levels and the level of deprivation where they lived had higher engagement.

Overall, there was some evidence that spatial setting predicted arts engagement. Rural-urban classification made no difference to arts participation, but did predict cultural engagement, with higher engagement in rural settings. Although museums are distributed across both urban and rural settings, many heritage sites are located in rural settings,[30] and so it is possible that local availability of cultural assets drives these differences. Geographical region did predict both arts participation and cultural engagement, with lower engagement in arts participation in the North and in cultural engagement in the Midlands than in Southern England. The finding for arts participation echoes government reports on participation.[14] However, for cultural engagement, this relationship was explained away by individual socio-economic factors, suggesting that region itself was less important than the wealth and education of individuals living within it.

There was much more evidence for differences in arts engagement based on neighbourhood characteristics. For arts

**Table 2**
Logistic regressions estimating the relationship between geographical factors and arts participation (weighted; $N = 26{,}215$).

| Geographical factors | Unadjusted | | | Adjusted for demographic factors | | | Adjusted for demographic and socio-economic factors | | |
|---|---|---|---|---|---|---|---|---|---|
| | Engaged vs disengaged | | | Engaged vs disengaged | | | Engaged vs disengaged | | |
| | OR | 95% CI | *P*-value | OR | 95% CI | *P*-value | OR | 95% CI | *P*-value |
| ***Spatial setting*** | | | | | | | | | |
| *Regions* | | | | | | | | | |
| North (North East, North West and Yorkshire and the Humber) | 0.87 | 0.77–0.98 | 0.022 | 0.85 | 0.75–0.95 | 0.006 | 0.86 | 0.76–0.96 | 0.011 |
| Midlands (East Midlands and West Midlands) | 0.92 | 0.81–1.04 | 0.166 | 0.90 | 0.79–1.02 | 0.109 | 0.95 | 0.84–1.09 | 0.472 |
| (ref: South (London, South East, South West and East)) | | | | | | | | | |
| ***Neighbourhood characteristics*** | | | | | | | | | |
| *Index of Multiple Deprivation* | | | | | | | | | |
| Least deprived 10% | 1.30 | 1.11–1.53 | 0.001 | 1.34 | 1.14–1.58 | 0.000 | 1.15 | 0.98–1.36 | 0.085 |
| Most deprived 10% | 0.97 | 0.78–1.22 | 0.810 | 0.97 | 0.78–1.21 | 0.780 | 1.15 | 0.92–1.44 | 0.217 |
| (ref: Medium) | | | | | | | | | |
| *Output Area Classification* | | | | | | | | | |
| Cosmopolitan student neighbourhoods | 2.17 | 1.70–2.78 | 0.000 | 1.66 | 1.29–2.13 | 0.000 | 1.20 | 0.92–1.56 | 0.174 |
| Countryside living | 1.27 | 1.09–1.48 | 0.003 | 1.35 | 1.15–1.58 | 0.000 | 1.19 | 1.02–1.40 | 0.032 |
| Ethnically diverse professionals | 1.18 | 1.01–1.38 | 0.040 | 1.14 | 0.98–1.34 | 0.098 | 0.99 | 0.84–1.16 | 0.901 |
| Hard-pressed communities | 0.91 | 0.75–1.10 | 0.319 | 0.83 | 0.68–1.00 | 0.052 | 0.98 | 0.81–1.19 | 0.831 |
| Inner city cosmopolitan | 1.79 | 1.38–2.32 | 0.000 | 1.51 | 1.15–2.00 | 0.003 | 1.20 | 0.91–1.57 | 0.193 |
| Multicultural living | 0.98 | 0.80–1.19 | 0.828 | 0.90 | 0.73–1.13 | 0.367 | 0.87 | 0.70–1.09 | 0.224 |
| Suburban living | 0.98 | 0.83–1.15 | 0.788 | 0.99 | 0.84–1.17 | 0.912 | 0.89 | 0.75–1.05 | 0.164 |
| (ref: Industrious communities) | | | | | | | | | |
| **Pseudo R2** | **0.0089** | | | **0.0365** | | | **0.0770** | | |

Note: Demographic factors include respondents' age, gender, ethnicity, whether or not living alone, partnership status and whether or not responsible for children under age 16. Socio-economic factors include educational level, SES, parental SES, monthly household income and housing tenure. The bold values indicate Pseudo R2, which is a measure of how well variables of the model explain the arts engagement.
CI, confidence interval; OR, odds ratio; SES, socio-economic status.

**Table 3**
Ordinal logistic regressions estimating the relationship between geographical factors and cultural engagement: each geographical factor is included in individual models (weighted; $N = 26{,}215$).

| Geographical factors | Cultural engagement (rarely engaged, infrequently engaged, frequently engaged) | | |
|---|---|---|---|
| | OR | 95% CI | *P*-value |
| ***Spatial setting*** | | | |
| *Model 1 Rural-urban classification only* | | | |
| Rural town and fringe | 1.17 | 1.06–1.29 | 0.002 |
| Rural village | 1.34 | 1.20–1.49 | 0.000 |
| Urban conurbation | 0.93 | 0.87–1.00 | 0.049 |
| (ref: Urban city and town) | | | |
| Cut 1 | 0.79 | 0.75–0.82 | |
| Cut 2 | 3.94 | 3.76–4.14 | |
| **Pseudo R2** | **0.0015** | | |
| *Model 2 Regions only* | | | |
| North (North East, North West and Yorkshire and the Humber) | 0.80 | 0.75–0.86 | 0.000 |
| Midlands (East Midlands and West Midlands) | 0.78 | 0.72–0.84 | 0.000 |
| (ref: South (London, South East, South West and East)) | | | |
| Cut 1 | 0.69 | 0.66–0.73 | |
| Cut 2 | 3.48 | 3.31–3.66 | |
| **Pseudo R2** | **0.0019** | | |
| ***Neighbourhood characteristics*** | | | |
| *Model 3 Index of Multiple Deprivation only* | | | |
| Least deprived 10% | 2.01 | 1.82–2.21 | 0.000 |
| Most deprived 10% | 0.36 | 0.32–0.41 | 0.000 |
| (ref: Medium) | | | |
| Cut 1 | 0.76 | 0.74–0.79 | |
| Cut 2 | 3.97 | 3.80–4.14 | |
| **Pseudo R2** | **0.0172** | | |
| *Model 4 Output Area Classification only* | | | |
| Cosmopolitan student neighbourhoods | 2.11 | 1.74–2.56 | 0.000 |
| Countryside living | 1.52 | 1.38–1.68 | 0.000 |
| Ethnically diverse professionals | 1.41 | 1.28–1.56 | 0.000 |
| Hard-pressed communities | 0.52 | 0.47–0.57 | 0.000 |
| Inner city cosmopolitan | 1.65 | 1.34–2.01 | 0.000 |
| Multicultural living | 0.56 | 0.49–0.63 | 0.000 |
| Suburban living | 1.51 | 1.38–1.65 | 0.000 |
| (ref: Industrious communities) | | | |
| Cut 1 | 0.84 | 0.79–0.90 | |
| Cut 2 | 4.46 | 4.17–4.76 | |
| **Pseudo R2** | **0.0240** | | |

The bold values indicate Pseudo R2, which is a measure of how well variables of the model explain the arts engagement.
CI, confidence interval; OR, odds ratio.

participation, living in a less deprived area was associated with greater engagement, but this was explained away by individual SES, and there was only limited evidence that living in certain types of neighbourhoods (i.e. countryside living) predicted engagement. However, for cultural engagement, neighbourhood deprivation remained a significant predictor, as did living in particular types of neighbourhoods, especially those that were cosmopolitan or in the countryside. This suggests that the collective behaviours of individuals living in the community, as well as sorting into neighbourhoods on the basis of cultural preferences, could be important predictors of cultural engagement.

Borrowing the model of 'food environment' and health,[16] which explores how neighbourhood characteristics influence food consumption, three factors are key: (i) the availability of arts/cultural facilities, events and programmes in one's locale; (ii) the accessibility to the location of where arts/cultural activities are provided and the ease of getting to the location; and (iii) the affordability in terms of monetary resources to people living in the catchment area. These three elements are usually found in areas that are characterised as cosmopolitan, culturally developed, have lower levels of area deprivation and possibly have strong social ties within the neighbourhood (especially in rural areas);[11,16] precisely the three areas where we found higher levels of cultural engagement. Alternatively, people who live in hard-pressed communities, where the rate of unemployment is relatively higher and education level is lower, or areas of multicultural living where a high proportion of residents are non-white, may have a lower participation rate due to the inadequacy of these three elements. This finding echoes previous studies on the negative association between individual SES and ethnic minorities and arts and cultural participation[3–5,9,31] but extends these findings by showing how the impact of people with these characteristics living in a particular area could have a collective influence on behaviours, irrespective of individual characteristics.

It is also notable that we found some evidence of 'disjunction': individuals living in areas where their own material circumstances were at odds with the level of deprivation around them had higher patterns of engagement. Notably this went both ways (i.e. higher education/wealth in a more deprived area and lower education/wealth in a more affluent area). This suggests that whilst neighbourhood characteristics are important, they are not deterministic. It is possible that where individuals perceive a disjunction (i.e. people of higher educational attainment living in a more deprived area), they may still want to cultivate cultural tastes and preferences by engaging in the activities regardless of where they live.[32] Thus, they may make a specific effort to engage in cultural activities, for example, to display their gentrifying credentials. What remains unclear, however, is whether this engagement involves them staying within their home neighbourhoods or seeking cultural activities deliberately outside of their neighbourhood. It is also plausible that for people of lower educational attainment, the availability of recreational infrastructure (e.g. arts exhibitions/theatres) and the local conditions (e.g. the perceived neighbourhood safety) which are usually found in affluent areas could encourage arts engagement.

This study has a number of strengths including using a nationally representative sample and a rich set of variables to map comprehensively individuals' engagement in arts and cultural activities. Furthermore, we used four different geographical factors assessing both spatial setting and neighbourhood characteristics. However, there are also several weaknesses. For instance, while we identified the patterns of arts and cultural engagement across the country, we were unable to distinguish people who lacked opportunities to engage from those who were disinterested in engaging. Furthermore, the relationship between geographical factors and engagement may be affected by self-selection biases: people may choose to live in areas where there are more opportunities for arts and cultural engagement (e.g. cosmopolitan cities) because this is a particular interest for them. As such, our present study is not able to

**Table 4**
Ordinal logistic regressions estimating the relationship between geographical factors and cultural engagement (weighted; $N = 26{,}215$).

| Geographical factors | Cultural engagement (rarely engaged, infrequently engaged, frequently engaged) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted for demographic factors | | | Adjusted for demographic and socio-economic factors | | |
| | OR | 95% CI | *P*-value | OR | 95% CI | *P*-value | OR | 95% CI | *P*-value |
| ***Spatial setting*** | | | | | | | | | |
| *Regions* | | | | | | | | | |
| North (North East, North West and Yorkshire and the Humber) | 0.98 | 0.91–1.06 | 0.611 | 0.97 | 0.90–1.04 | 0.363 | 1.02 | 0.95–1.10 | 0.617 |
| Midlands (East Midlands and West Midlands) | 0.87 | 0.80–0.94 | 0.001 | 0.86 | 0.80–0.94 | 0.000 | 0.96 | 0.88–1.04 | 0.322 |
| (ref: South (London, South East, South West and East)) | | | | | | | | | |
| ***Neighbourhood characteristics*** | | | | | | | | | |
| *Index of Multiple Deprivation* | | | | | | | | | |
| Least deprived 10% | 1.78 | 1.60–1.98 | 0.000 | 1.80 | 1.61–2.01 | 0.000 | 1.45 | 1.29–1.62 | 0.000 |
| Most deprived 10% | 0.56 | 0.49–0.64 | 0.000 | 0.58 | 0.50–0.66 | 0.000 | 0.79 | 0.69–0.91 | 0.001 |
| (ref: Medium) | | | | | | | | | |
| *Output Area Classification* | | | | | | | | | |
| Cosmopolitan student neighbourhoods | 2.11 | 1.74–2.56 | 0.000 | 2.21 | 1.82–2.68 | 0.000 | 1.87 | 1.53–2.28 | 0.000 |
| Countryside living | 1.47 | 1.33–1.63 | 0.000 | 1.45 | 1.31–1.61 | 0.000 | 1.18 | 1.07–1.31 | 0.001 |
| Ethnically diverse professionals | 1.30 | 1.18–1.44 | 0.000 | 1.33 | 1.20–1.48 | 0.000 | 1.03 | 0.92–1.14 | 0.640 |
| Hard-pressed communities | 0.64 | 0.57–0.72 | 0.000 | 0.64 | 0.57–0.72 | 0.000 | 0.88 | 0.78–1.00 | 0.042 |
| Inner city cosmopolitan | 1.68 | 1.37–2.07 | 0.000 | 2.08 | 1.68–2.57 | 0.000 | 1.65 | 1.36–2.00 | 0.000 |
| Multicultural living | 0.62 | 0.55–0.70 | 0.000 | 0.83 | 0.73–0.95 | 0.009 | 0.86 | 0.75–0.99 | 0.032 |
| Suburban living | 1.21 | 1.10–1.34 | 0.000 | 1.19 | 1.08–1.32 | 0.001 | 0.93 | 0.84–1.03 | 0.144 |
| (ref: Industrious communities) | | | | | | | | | |
| Cut 1 | 0.81 | 0.75–0.87 | | 0.37 | 0.32–0.43 | | 1.89 | 1.15–3.11 | |
| Cut 2 | 4.35 | 4.02–4.69 | | 2.09 | 1.81–2.41 | | 14.01 | 8.51–23.06 | |
| **Pseudo R2** | **0.0302** | | | **0.0465** | | | **0.1328** | | |

Note: Demographic factors include respondents' age, gender, ethnicity, whether or not living alone, partnership status and whether or not responsible for children aged younger than 16 years. Socio-economic factors include educational level, SES, parental SES, monthly household income and housing tenure. The bold values indicate Pseudo R2, which is a measure of how well variables of the model explain the arts engagement.
CI, confidence interval; OR, odds ratio; SES, socio-economic status.

identify whether geography causally influences behaviours or whether personal interests play a role in residential selection. Future studies could examine whether the link between arts and health varies across locations, that is, whether geographical factors not only predict engagement but also act as a moderator for the health benefits of engagement.

Overall, this study found that arts participation and cultural engagement are associated with geographical factors independent of individuals' observed demographic and socio-economic backgrounds. In particular, it goes beyond describing regional variations in patterns of engagement to show that neighbourhood characteristics may be a stronger predictor for engagement behaviour than spatial setting and may have a greater relationship with cultural engagement than with arts participation. Understanding the role of geography in arts engagement is relevant to public health initiatives and interventions (e.g. the roll out of 'social prescribing' scheme delivered in various western countries) as it has the potential to increase engagement through redistributing resources (e.g. funding and cultural facilities) to various areas and providing opportunities to engage. Given the benefits of the arts, place-based interventions could help improve health and well-being on a population level by reaching individuals who are at risk of poor health/well-being and who have traditionally been excluded from artistic experiences due to geographical barriers. This could potentially help reduce health inequalities through equalising access to arts and cultural programmes.[33] However, this remains to be tested further through intervention place-based studies. Nevertheless, our study suggests the importance of considering geographical as well as individual-level predictors when devising policies to improve access to and engagement with the arts.

## Author statements

### *Ethical approval*

The University of Essex Ethics Committee has approved all data collection on Understanding Society main study and innovation panel waves, including asking consent for all data linkages except to health records. Respondents aged 16 years or older provided written consent to participate.

### *Funding*

D.F. is supported by the Wellcome Trust [205407/Z/16/Z]. H.W.M. is funded through the AHRC project HEARTS [AH/P005888/1]. This project is also supported by UCL Grand Challenges Award 'Environment and Wellbeing' [551987/100/156425 33002], the Leverhulme Trust [PLP-2018-007] and ESRC WELLCOMM project [ES/T006994/1].

### *Competing interests*

The authors have no conflicts of interest to disclose.

### *Author contributions*

H.W.M. conducted the data management and data analyses and provided input on the manuscript. R.C. and D.F. assisted with analytical issues and provided input on the analytical scheme and the manuscript. All authors are responsible for reported research and have participated in the concept and design, analysis and interpretation of data and drafting and revising of the manuscript.

### *Availability of data and materials*

Understanding Society - The UK Household Longitudinal Study (UKHLS) data are available from the UK Data Service https://discover.ukdataservice.ac.uk/catalogue/?sn = 6614. Data documentation is available from the Understanding Society website https://www.understandingsociety.ac.uk/documentation.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.04.029.

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Public Health 185 (2020) 348–355

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Evaluation of a dementia awareness programme in UK schools: a qualitative study

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ARTICLE INFO

*Article history:*
Received 4 December 2019
Received in revised form
3 April 2020
Accepted 25 May 2020
Available online 29 July 2020

*Keywords:*
Schools
Young people
Knowledge
Stigma
Dementia awareness
Dementia literacy

ABSTRACT

*Objectives:* 'Dementia Friends' is a programme used to raise awareness of dementia, developed by the Alzheimer's Society, which has been delivered across the UK to diverse populations, including adolescents. However, there is little evidence available with regards to adolescents' perceptions of the programme and its impact. This study aims to explore this in a group of adolescents from the south of England.

*Study design:* Focus group discussions.

*Methods:* Thirty adolescents aged between 11 and 16 years were recruited from two schools in East Sussex, England. All had participated in a Dementia Friends session in the past month. Focus group discussions were transcribed, coded and themes were created using inductive thematic analysis.

*Results:* Four themes were identified: (1) perceptions and experiences of dementia, (2) outcomes and learning from Dementia Friends session, (3) reactions to the Dementia Friends session and (4) identified future learning needs.

*Conclusions:* Adolescents had generally positive opinions about Dementia Friends, particularly the interactive nature of the session. Whilst they felt participating in Dementia Friends improved their attitudes and knowledge, they were often left wanting to learn more. Future research needs to empirically evaluate the extent to which Dementia Friends may improve attitudes and knowledge of dementia.



## Introduction

Raising awareness of dementia is seen as a key policy priority, both within the UK and internationally.[1–4] The Alzheimer's Society, a national third sector patient and carer advocacy group in England and Wales, has been a major advocate for raising awareness of dementia, in part through its Dementia Friends initiative, which 'tackles the stigma and discrimination people with dementia can face globally'[5] in a 45–60 min awareness session led by trained volunteers. Each session covers five key messages about dementia (i.e. Dementia is not a natural part of ageing, Dementia is caused by diseases of the brain, It is not just about losing your memory, It is possible to live well with dementia, There's more to a person [with dementia] than the dementia), followed by individuals making a pledge to do a dementia-friendly action. The Dementia Friends initiative has been successfully rolled out, being the UK's 'biggest ever initiative to change people's perceptions of dementia'.[5] It was launched in the UK in 2013 with the target of reaching one million people by 2015, by 2018 there were more than 2.5 million Dementia Friends in the UK.[6]

Inherently, educating young people about dementia is a positive aspiration. Theoretically, attitudes form at a young age and are more easily changed, but upon reaching adulthood, these attitudes remain more stable.[7–9] Similar to mental illness,[10,11] negative and stigmatising attitudes towards dementia already appear to exist amongst adolescents.[12–14,16] Conceptually, education is seen as an important means of reducing stigma towards dementia[17]

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https://doi.org/10.1016/j.puhe.2020.05.050
0033-3506/

and towards mental illness.[18] Localised dementia awareness initiatives aimed at adolescents and young people do exist (e.g. Dementia4schools), though it is notable that there are often not rigorously evaluated. One example of an evaluated initiative is the Australian Kids4Dementia programme.[19] The authors found a significant improvement in dementia attitudes in those who received the Kids4dementia programme (compared to controls).

Despite the potential theoretical benefits of dementia awareness programmes and limited evidence from other initiatives, it is still unclear whether Dementia Friends is effective in raising awareness, improving attitudes and meeting information needs across groups. To our knowledge, there has been no published literature about young people's involvement in the development or evaluation of Dementia Friends. Even within adults, there is limited evidence about the benefits of the Dementia Friends initiative. For example, Dementia Friends improved self-reported knowledge about dementia and confidence in engaging people with dementia in student nurses.[20,21]

In this study, we set out to explore adolescents' reaction to of a Dementia Friends information session and how it affected their perceptions of dementia. Our research questions were:

1. How does Dementia Friends training affect adolescents' attitudes and knowledge of dementia?
2. What do adolescents think about Dementia Friends sessions and their content?

## Methods

### *Design*

A series of focus group discussions (FGDs) were completed to generate data for inductive thematic analysis. Methods are reported in accordance with the **COnsolidated criteria for REporting Qualitative research** (COREQ) Checklist.[22] Refer to Appendix A in the supplementary material for the completed COREQ Checklist.

### *Participants and setting*

An opportunistic sample of two secondary schools (teaching children aged 11–16 years) participated in the study. Schools geographically close to Brighton were prioritised, due to our collaboration with Brighton and Hove Dementia Action Alliance. Characteristics of the school were available from a government portal and were correct as of April 2020 and reflect the 2018/2019 academic year.[23]

- School 1: Located in Brighton and Hove. Mixed gender, community school. Within the school, the number of students whose first language is not English was below the national average of mainstream secondary schools (5–10%), whilst the number of students eligible for free school meals at any time during the past 6 years was also below the national average of mainstream secondary schools (20–25%).
- School 2: Located in East Sussex. Mixed gender, community school. Within the school, the number of students whose first language is not English was below the national average of mainstream secondary schools (0–5%), whilst the number of students eligible for free school meals at any time during the past 6 years was also below the national average of mainstream secondary schools (10–15%).

Working alongside teachers at the schools, classes of adolescents participated in the Dementia Friends sessions. Only adolescents who participated in the session, participated in this research. In recognition of the difficulties of lesson planning and classroom management, adolescents invited to participate in the research were selected by the teacher. Teachers were instructed to invite a mixture of male and female students with a range of academic abilities but were asked to keep in mind that these adolescents would need to be confident enough to engage in the discussions. An *a priori* decision was made to complete four FGDs or until thematic saturation occurred.

Thirty adolescents took part in four focus groups. Participant characteristics are presented in Table 1. No participants who were approached refused participation or dropped out.

### *Dementia Friends session*

The Dementia Friends session was led by an experienced 'Dementia Friends Champion' (EJ). A Dementia Friends Champion is a volunteer who tries to support people within their communities to improve the lives of people with dementia, through sharing information about dementia. Dementia Friends are trained to deliver Dementia Friends sessions.[24] As of April 2019, EJ has trained more than 1400 Dementia Friends, which include young people. EJ is a volunteer at the Dementia Action Alliance, a retired social worker and has lived experience of caring for someone with dementia.

The Dementia Friends session had EJ facilitate discussion amongst a class of adolescents, which covers five key messages:[25]

- Dementia is not a natural part of ageing
- Dementia is caused by diseases of the brain
- It is not just about losing your memory
- It is possible to live well with dementia
- There's more to a person (with dementia) than the dementia

### *Procedure*

After the classes (approximately 30 adolescents in each) participated in the Dementia Friends session, the teacher identified groups of 6–8 adolescents to be invited to participate in the research. Parents/guardians of the selected adolescents were sent information about the research and provided consent for their

**Table 1**
Participant characteristics split by focus group.

| Participant characteristics | Group 1 (n = 8) | | Group 2 (n = 6) | | Group 3 (n = 8) | | Group 4 (n = 8) | | Total (n = 30) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | N (%) | Mean (SD) | N (%) | Mean (SD) | N (%) | Mean (SD) | N (%) | Mean (SD) | N (%) |
| Age | 12.4 (0.5) | | 12.2 (0.4) | | 14.6 (0.5) | | 14.50 (0.53) | | 13.5 (1.25) | |
| Gender: Male | | 2 (25.0%) | | 4 (66.7%) | | 5 (62.5%) | | 4 (50.0%) | | 15 (50.0%) |
| Ethnicity: White British | | 6 (85.7%) | | 5 (83.3%) | | 7 (87.5%) | | 8 (100.0%) | | 26 (89.7%) |
| I have come across people living with dementia: Yes | | 5 (62.5%) | | 6 (100.0%) | | 7 (87.5%) | | 7 (87.5%) | | 25 (83.3%) |
| I have watched TV shows or movies: Yes | | 5 (62.5%) | | 4 (66.7%) | | 6 (75.0%) | | 6 (75.0%) | | 21 (70.0%) |
| I have looked after someone with dementia: Yes | | 3 (37.5%) | | 2 (33.3%) | | 3 (37.5%) | | 1 (12.5%) | | 9 (30.0%) |

child's participation. All adolescents were provided an information sheet describing the aims of the study and an opportunity to opt-out of the research, being informed that it was voluntary.

FGDs were run during class time within the school setting. The facilitator introduced the FGD and provided the group rules and asked a series of questions to the group in a semistructured format. Discussions were audio recorded, no field notes were taken. FGDs lasted approximately 30 min each.

FGDs were completed within a month of the Dementia Friends session (typically the following week). All FGDs were completed between January and March 2019.

### *Measures and topic guide*

All participants were asked to complete a set of demographic information (e.g. age, gender, ethnicity) alongside their previous experiences of dementia, using an existing questionnaire.[14,15]

The topic guide was developed in collaboration with the research team, who have experience working with people with dementia (in clinical, research and care worker capacities) and children (in a research capacity). The questions broadly covered three key topics: (1) whether the Dementia Friends session affected their attitudes and knowledge, (2) what they thought about the current session and (3) how the session could be improved. Refer to Appendix B in the supplementary material.

### *Analysis*

Descriptive data (mean, standard deviation (SD), frequency) of demographic information and previous contact were reported for each FGD and as a whole sample.

Audio recordings were transcribed verbatim by the facilitator of the FGDs, imported into QSR International's NVivo 12 software and subjected to thematic analysis. Two transcripts were initially independently coded by two researchers (NF and LJH). The two researchers then reviewed and compared the two coding frameworks, discussing differences and to ensure that no codes were missing. If differences were identified, the two researchers discussed why this was the case and whether this was superficial (e.g. choice in terminology) or something more complex, and the two authors continued to discuss the frameworks until consensus was achieved. LJH continued coding the remaining transcripts.

Codes were then inductively grouped into themes.

### *Ethics and rigour*

All the FGDs were led by a single female researcher (LJH). LJH has previous experience of facilitating FGDs in both adults and adolescents, and at the time of the FGD, was a Research Assistant in dementia. LJH has previous experience in the care sector. In three of four FGDs, LJH was joined by a male researcher (NF), who has experience in running FGDs in adolescents. Neither the teaching staff nor the Dementia Champion (EJ) was involved in the FGDs to ensure that participants could speak freely. The Dementia Champion (EJ) was however given an opportunity to discuss the findings and review the transcripts, following the formation of themes. This allowed EJ to provide insight and interpretation of the findings, without introducing bias within the data analysis. Participants were not consulted about the transcripts or provided feedback about the findings derived from the FGDs.

The FGD facilitators had no existing relationship with the participants, although they introduced themselves and described their job roles and the research aims. All participants were provided food and drinks before the start of the FGDs to help create a social and relaxed environment. As participants for each FGD were recruited from a single class, therefore participants within each FGD had an existing relationship with each other. No formal incentives or reimbursement were supplied. However, participants may have felt motivated to participate as they would be taken out of their usual lesson to participate.

Ethical approval was obtained Brighton and Sussex Medical School Research Governance and Ethics Committee.

The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

## Results

From the analysis, four overarching themes were identified: (1) perceptions and experiences of dementia, (2) outcomes and learning experiences from Dementia Friends session, (3) reactions to the Dementia Friends session and (4) identified future learning needs. A coding tree is presented in Fig. 1.

### *Theme one: perceptions and experiences of dementia*

The first theme was related to adolescents' views and experiences of dementia in general.

#### *Personhood*

Participants had an overall positive perception of dementia and a positive outlook of people who live with dementia, which according to participants existed before the Dementia Friends session. Participants held the view that despite the impairments that people with dementia might have, it is possible to live well with dementia. Participants had a strong sense of personhood in those with dementia, they believed that people with dementia were still people who deserve to be treated the same as everyone else. Participants did not describe these views in relation to any specific teachings or experience and appeared to reflect a broader sense of personhood to all, not just dementia. Example quotes can be found in Table 2.

#### *Sources of information*

The main source of information for participants about dementia was the media, with some discussion that family and television commercials also provided information about dementia. The media information about dementia was seen primarily as negative and conveying an inaccurate picture of dementia.

### *Theme two: outcomes and learning experiences from Dementia Friends session*

The theme of outcomes and learning experiences encompassed participant perceptions of how the session changed their knowledge, understanding and perceptions of dementia.

#### *New understanding about dementia*

Another subtheme identified was that participants did not fully understand what dementia was before the session or how dementia affects individuals. Participants highlighted the changes to their knowledge and understanding about dementia from taking part in the session. They learned that there are lots of different types of dementia, not just one or a small number. A great deal of discussion surrounded learning more about the way that memories are affected in dementia and that dementia is not just about memory loss. The most salient point of discussion for participants was that they gained new understanding about the feelings that people with dementia can experience, irrespective of the memory impairment they may have. This new understanding helped

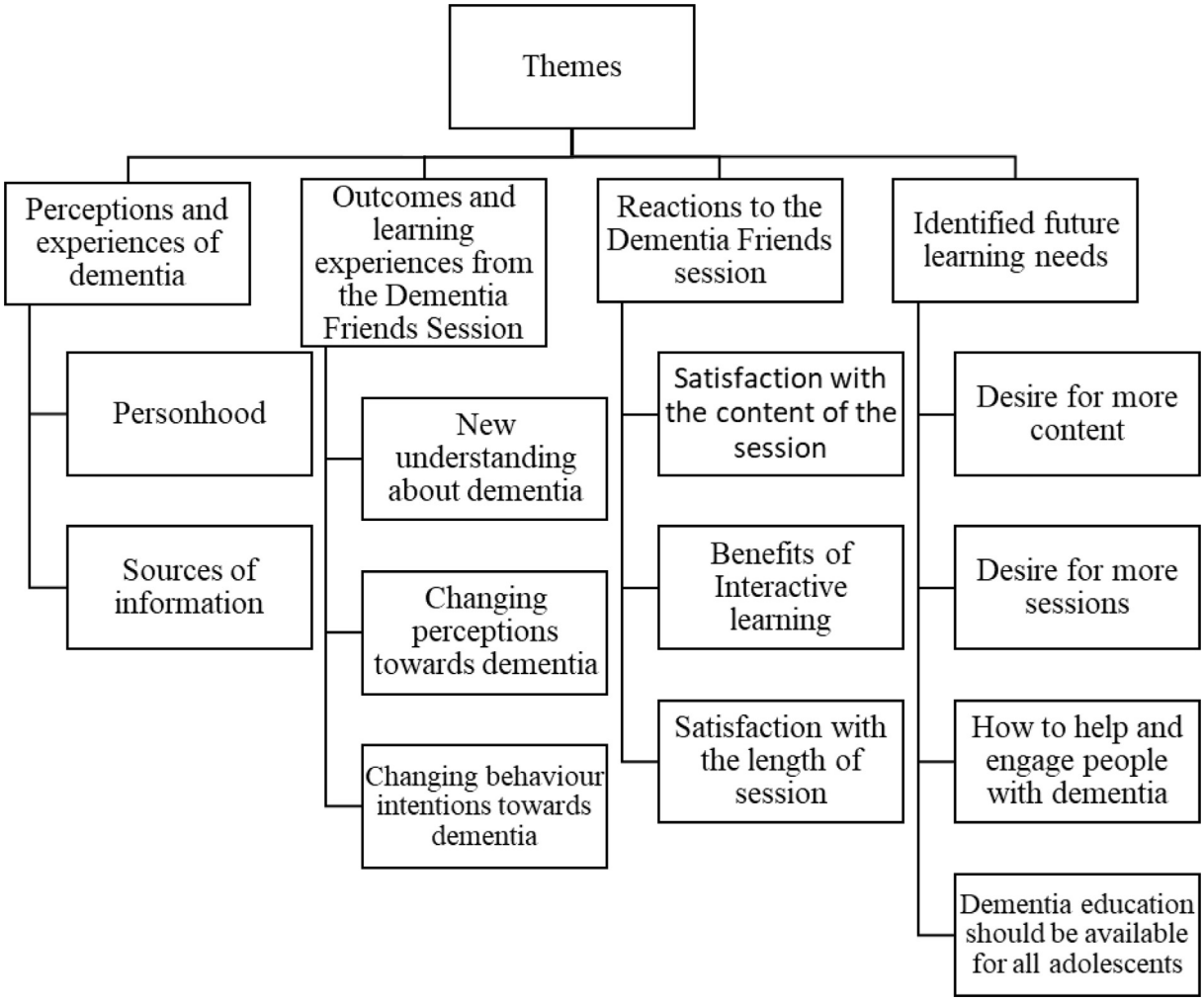


**Fig. 1.** Coding tree depicting the themes and subthemes identified during the thematic analysis of transcripts.

participants know more about dementia and what people are feeling, and this would be especially useful for people who have interactions with people with dementia.

*Changing perceptions towards dementia*

Closely linked to new understanding, participants also discussed the ways that the session changed their pre-existing perceptions of dementia. There was a lessening of the negative perception of dementia with participants discussing that taking part in the session helped them feel more positive and empowered to visit and support someone with dementia. Because of the session, they would know what to expect and have more understanding of what to do. The feelings of personhood and positivity that participants had were strengthened as a result of Dementia Friends.

*Changing behaviour intentions towards dementia*

Participants discussed the intention to spend time with and work with people with dementia in the future. Participants' willingness to spend time with people with dementia could be attributed in part to the level of empathy they felt toward people with dementia. Some participants stated that they would want people to visit and spend time with them if they had dementia, so they are willing to do this for people now. When asked if they would consider working with people with dementia in the future, participants showed some positivity toward this. They described feeling more inclined to work with people with dementia in the future because they now have more understanding about dementia and know what to expect when engaging with people with dementia.

*Theme three: reactions to the Dementia Friends session*

This theme captured participants' general perceptions about the Dementia Friends session. Participants were able to recall the content of the session clearly. There was a great deal of positivity about the Dementia Friends session with participants being satisfied with the session, including its length, content and methods of teaching.

*Satisfaction with the content of the session*

There was an overall sense of satisfaction with the session, with conversations often being focussed on positive aspects of Dementia Friends rather than negative ones. Participants found the session to be interesting, understandable and interactive. There was a great deal of satisfaction with and positivity of the content and delivery of the session, including the session facilitator. These factors were seen as making the session useful and containing the right amount of information that was interesting, engaging and understandable for the adolescent participants.

**Table 2**
Summary of themes, subthemes and participant quotes.

| Themes | Example quotes |
|---|---|
| **Theme one: perceptions and experiences of dementia** | |
| Personhood | • *"I think you can live well with it. It's not a really, really terrible thing, because like, you can still do everyday things, like people like us. But like you just, sometimes can't remember things right, can't do things properly'* (female, focus group 2)<br>• *"They're just normal people, they have dementia but there's no like, they're not different and people with dementia should be treated the same way, and they should be treated with care because obviously they can forget stuff, and they're just people so they're just the same as us, there's nothing different with them'* (female, focus group 1)<br>• *"Even if you do have dementia, you're still a person, you are, well, you're still human'* (male, focus group 1) |
| Sources of information | • *"[the media] doesn't portray a good like equal sided opinion of it [dementia], so it was good to have the woman [EJ] come in to like, both opinions of it, it can still be negative on the media'* (female, focus group 4) |
| **Theme two: outcomes and learning experiences from Dementia Friends session** | |
| New understanding | • *"I thought it was really informative, there was obviously some parts that I think a few people knew in the class but I think the majority of it, because it's not really spoken about a lot and I think it, a lot of people learnt a lot from it, whether it was like, little parts of the illness or, the fact there's lots of different types, how it affects you, because I think most people thought it just affected how you thought, like I especially didn't know that it could really affect your everyday life like trying to do simple tasks like your mobility and stuff'* (female, focus group 4)<br>• *"it gave me more like awareness of it [dementia], because before like I just thought it's just that you forget things, but like with that class I learned that they do forget things but they remember like old memories and they keep their feelings and everything'* (female, focus group 2)<br>• *"because my Gran has dementia, I could, because of that, I can like know more things about what she's feeling'* (male, focus group 2)<br>• *"I didn't know you like you still remember like the emotions so I thought that you just forget like everything'* (female, focus group 4) |
| Changing perceptions towards dementia | • *"It made me feel more positively about the people that have it'* (female, focus group 2)<br>• *"Like before the thing [dementia awareness class], I thought like dementia was like an illness it was just a terrible thing, and now I kind of realized it's not that bad'* (male, focus group 2)<br>• *"After the session I feel like I'd find it much easier to go see someone with dementia and what it's like, because I know kind of what I'd be expecting and if I saw them doing certain things I'd know how to deal with it a bit more than before'* (male, focus group 3)<br>• *Participant: 'If someone's like living with dementia you still see them as who they are not just what they have, like if someone has dementia you don't just see them as someone suffering from dementia, they're still a family friend, a parent, a carer, like they're still the same person, you may just need to adjust what you say or how you live around them, but they're still the same person'. Interviewer: 'do you think you had that opinion before or did it change because of the session'. Participant: 'I had that opinion already but it came a bit more stronger like after'* (female, focus group 3) |
| Changing behaviour intentions towards dementia | • *"I would like to [spend time with people with dementia] as well, like, and then it might, because we might learn about what dementia is and it might help them, it might help us like, understand if they forget something and I'd just like to spend time with them a bit more'* (female, focus group 1)<br>• *"I'd want more friends to come and see me, so I wouldn't mind spending time with someone with dementia'* (female, focus group 1)<br>• *"yeah I would work with them [people with dementia] because I know more about it than I did, it's like easier to understand how they're feeling'* (male, focus group 2) |
| **Theme three: reactions to the Dementia Friends session** | |
| Satisfaction with the content of the session | • *"The staff [facilitator] are really like nice and trying to engage everyone like with the games, and I think people that wouldn't usually like get involved I think they were trying to listen because she was really genuinely quite a nice person, friendly, and it came across'* (female, focus group 4)<br>• *"I think everyone should receive the same because they might feel, it might like help people that have people with dementia, it might make them feel like they can open up, but then it could help other people in the class who don't have a family member with dementia, and like, they might not know a lot about it, and then they might be put in another session because people might think they have someone with dementia so they know, or they might not 'cause [trails off]'* (female, focus group 1) |
| Benefits of Interactive learning | • *"everyone was kind of focused and involved, she kept everyone kind of not just slipping out of concentration everyone was focusing on what she was talking about'* (male, focus group 3). |
| **Theme four: identified future learning needs** | |
| Desire for more content | • *"I think possibly like, if they could go more in depth on how it happens, and not just the … effects, but more about the causes'* (male, focus group 2)<br>• *"because she [EJ] was saying about some of the signs of it, like the early signs of it like losing your short term memory and stuff and I think it's good for you to, because then you can look out for your family members, try kind of like sense how they're going'* (female, focus group 4)<br>• *"I think that [being taught by someone with dementia] would be quite an emotional way for it to be brought across, I think that would really affect the students more than just someone who doesn't have it, but obviously that might be more difficult for the person to do it than someone else just coming up and telling them about it'* (female, focus group 4)<br>• *"It [being taught by someone with dementia] would probably reach more people than if it was a teacher'* (male, focus group 4). |
| Desire for more sessions | • *"Personally, I think it would be good to have a refresher session because they can tell you about how people get it or like, what goes on like in their mind and loads of other stuff about it as well'* (male, focus group 2)<br>• *"maybe if we had like two more sessions in it or something and like, maybe one could be like with a person with dementia and the other could be like how to like help people'* (female, focus group 1). |
| How to help and engage people with dementia | • *"what you could do just as one person, um like actually do, obviously we know um part of dementia friends is like an awareness but like, that's just almost an awareness, what actions you could take if you had a family member with dementia'* (female, focus group 4)<br>• *"actively how you could help that person and or other people in your community maybe anywhere local who does like, because obviously you have places like the hospice, or like nursing homes, is there anywhere like around us a lot of people with dementia can get help from that we can like support'* (female, focus group 4) |
| Dementia education should be available for all adolescents | • *"I agree that everyone should have the same lessons because even if you don't have a family with dementia now then you can't say the same for in the future when you haven't had the same lessons so you can learn all about it'* (female, focus group 1)<br>• *"later on they may have a family member who has dementia and then not having that lesson may really like make them stuck or whatever'* (female, focus group 1). |

*Benefits of interactive learning*

The interactive elements of Dementia Friends are a prespecified component of the initiative and is central to all sessions. These interactive elements were perceived to be one of the most positive aspects of the session. Participants described that the interactive tasks in the session allowed everyone to get involved and focus on what was being taught. This was seen as a more effective way of learning compared with more traditional methods of teaching (i.e. teacher lecturing and student notetaking, textbooks and pen-and-paper assessment) as it was better at helping participants remember the content of the session.

The benefit of the interactive nature of the session was particularly evident in one focus group that had recently had a talk about another topic. The talk had no interactive elements to it; participants described it as boring and stated that comparatively, the Dementia Friends session was more fun, and they were able to learn and remember more in comparison.

*Satisfaction in the length of session*

Overall, the length of the session was seen as acceptable and appropriate. The Dementia Friends sessions within this study lasted 50 min to 1 h, though ultimately the length of time is dependent on how long it takes to cover the predefined content. Participants believed that the session was long enough to enable them to understand and remember the content of the session but was not too long that people lost their focus or concentration. Again, when comparing the length of the Dementia Friends session with other talks, participants described the length as long enough to provide the needed information without becoming boring or with unnecessary information.

*Theme four: identified future learning needs*

The theme of future learning needs captured participants' desire to learn more about dementia. Despite their satisfaction with the length and content of the session, participants discussed the changes to the session that would be beneficial to their learning. This included adding in more content and more sessions.

*Desire for more content*

Participants discussed some of the ways that they would change the content of the session; this included more content they would like to have included and changes to the existing content. There was a desire to learn more information than that was provided in the session and to learn more in depth about the information that was provided. In particular, participants wanted to know more factual information such as the different types of dementia (above and beyond that multiple types of dementia exist), what causes dementia, the symptoms of dementia and how to help people in a practical way. There was a belief that this would enable participants to help others in the future, so that they could 'spot' signs of dementia, especially in family members.

Participants were keen to learn from people with dementia. They believed that this would be better at raising awareness and a more emotive and impactful way of learning compared with more traditional methods. Learning from people with dementia or from others such as carers would provide a different perspective and have a greater impact on adolescents.

*Desire for more sessions*

Participants discussed their positivity toward having more sessions. This included having more sessions to accommodate the inclusion of extra content (see above) and being able to accommodate learning from others such as people with dementia. Their discussions also included having a refresher session that could recap the first session with the addition of the desired extra content. The timing of extra sessions was discussed with short time periods between sessions (approximately two weeks) being seen as preferable.

*How to help and engage people with dementia*

Participants wanted to know how they could help people with dementia. Linked to the desire to learn more about dementia, this included how to deal with particular symptoms such as forgetting and what they could do more generally to help such as giving to charity or volunteering in places such as care homes. Participants also suggested some ways that they could help people.

Closely linked to helping people, participants showed a keen interest in learning how to engage with people with dementia. This included learning how to socialise with people with dementia and how to approach them to help them talk about and remember their day. There was also a sense of wanting to know how to help in the community, such as helping to support local organisations such as hospices and care homes.

*Dementia education should be available for all adolescents*

The Dementia Friends session, and dementia education more generally, was seen as important to be available to everyone regardless of their past experience with dementia. For example, participants believed that everyone in school should have the same information provided to them because it might be useful if a relative were to be diagnosed with dementia in the future.

## Discussion

This study aimed to explore the opinions of adolescents and impact of, on a one-off dementia information session, Dementia Friends. Four themes appeared to form as a result of the FGDs, related to existing perceptions and experience of dementia, learning and outcomes from Dementia Friends, their reaction to the session and their future learning needs.

Using this method, we are able to describe a more in-depth understanding of the impact of Dementia Friends, as perceived by the adolescents who participated in it. It challenged and corrected misinformation that they had gleaned from the media; supporting previous research that has found that most of adolescents' experiences of dementia come from media, such as TV and movies.[13,14] The negative portrayal of dementia, or use of dementia as an insult, within western media has been highlighted.[26,27] In this study, after the session, adolescents were able to identify that the media portrayal of dementia was generally negative and that this was the first opportunity they had to formally learn about dementia. Adolescents were able to recall that they viewed people with dementia were still people (i.e. personhood) before Dementia Friends session, but the content reinforced these beliefs. This indicates that Dementia Friends might align with the opinion of young people with previous experience of dementia who feel that dementia education should instil views of personhood.[12]

Despite adolescents recognising there were different information needs depending on whether they had previous dementia experience, there was the view that the Dementia Friends session was informative. However, Dementia Friends was perceived as only the start of their learning journey, as many participants were left wanting to learn more. Whilst there was variation in the type of additional information participants wanted, many requested further details about risks and risk reduction and the practicalities of how to help and engage with those with dementia. The causes and risks of dementia have previously been flagged by UK adolescents as an interesting topic to learn about.[28] Understanding risk factors of

dementia at a young age might be particularly important considering that modifiable risk factors for dementia exist across the lifespan.[29]

There are important limitations to the research presented here. First, it was carried out in just two schools in one area in one country. Second, only one Dementia Friends Champion (EJ) gave the training. Third, the participants for the groups were chosen, without any formal criteria, by the teachers. Therefore, at most we can conclude is that the themes reported here only reflect the findings of a small selection of adolescents; no efforts were made to triangulate the findings with other sources. Fourth, the content here represents the views at a single time point, several weeks after a Dementia Friends session. It is possible that adolescent views about the session, and dementia more generally, may be different over a longer period, particularly once contextualised with additional experiences of dementia (e.g. dementia in the media). As such, future research should consider exploring the long-term impact of Dementia Friends on attitudes towards dementia. There are however a number of strengths. First, it is positive that staff within participating schools were highly motivated to offer the Dementia Friends session to their students, thus increasing the likelihood that their students were also engaged with the session. Second, all selected participants completed the FGD. Finally, having a single Dementia Friends Champion (EJ) run all the Dementia Friends sessions ensured that there was consistency between classes in terms of teaching style and knowledge. However, it is important to recognise that the quality of the session will differ depending on the confidence, experience and abilities associated with the Dementia Friends Champion. Within the present study, EJ had both lived experience of dementia and was an experienced Dementia Champion, which may be reflected in the positive feedback provided by the adolescents.

There is still a need to understand whether the self-reported improvements to attitudes and knowledge reported here and elsewhere reflect quantifiable improvements. In fact, recently we have demonstrated that attitudes do not significantly improve in adolescents following a Dementia Friends session.[30] FGDs may lead to participants to exaggerate, down play or withhold their opinions depending on the social context,[31] whilst people tend to overestimate their abilities in social and intellectual domains.[32] Understanding the effectiveness of Dementia Friends will provide evidence for policy makers and educators to adopt such an initiative but also consider its value compared with other dementia awareness initiatives and consider the potential influence of certain participant characteristics. For example, within the Kids4Demenita programme, the authors were able to provide an effect size for the initiative to improve dementia attitudes and also able to identify adolescents who had not heard of dementia before the session benefited more.[19]

Educating adolescents about dementia within secondary schools (aged 11–16 years) does not appear to be a common practice.[33] However, the use of a one-off dementia awareness class, such as Dementia Friends, may be acceptable to schools that have limited time and resources to introduce a more comprehensive alternative. The need to combat stigma towards dementia is pressing. The Dementia Friends session is seen as enjoyable and engaging by adolescents, which is essential in the success of any awareness programme. It is positive that adolescents felt there were benefits to their knowledge and attitudes towards dementia; however, future research is needed to quantify the value of such interventions.

## Author statements

### *Acknowledgements*

This research would not have been possible without the adolescents who participated in this study. The authors are very grateful to them and to the teachers and head teachers within the schools who helped facilitate the research.

### *Funding*

This research was funded by the University of Sussex Research Development Fund (RDF9-006).

### *Competing interests*

No potential conflict of interest was reported by the authors.

### *Author contributions*

NF wrote the first draft of the article, planned the study, collected the data, performed the analyses and revised the article. LJH collected the data, revised the article and contributed to the analysis. EJ facilitated the Dementia Friends session, contributed to the analysis and revised the article. SP helped plan the study and revised the article. AWG helped plan the study and revised the article. KG helped plan the study and revised the article. SB helped plan the study and revised the article.

## Appendix. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.05.050.

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Public Health 185 (2020) 27–29

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# Examining the effect of social distancing on the compound growth rate of COVID-19 at the county level (United States) using statistical analyses and a random forest machine learning model

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ARTICLE INFO

*Article history:*
Received 10 April 2020
Accepted 13 April 2020
Available online 28 April 2020

*Keywords:*
Shelter-in-place
Social distancing
COVID-19
SARS-CoV-2
Machine learning
Statistics

ABSTRACT

*Objectives:* The goal of the present work is to investigate trends among US counties and coronavirus disease 2019 (COVID-19) growth rates in relation to the existence of shelter-in-place (SIP) orders in that county.
*Study design:* This is a prospective cohort study.
*Methods:* Compound growth rates were calculated using cumulative confirmed COVID-19 cases from January 21, 2020, to March 31, 2020, in all 3139 US counties. Compound growth was chosen as it gives a single number that can be used in machine learning to represent the speed of virus spread during defined time intervals. Statistical analyses and a random forest machine learning model were used to analyze the data for differences in counties with and without SIP orders.
*Results:* Statistical analyses revealed that the March 16 presidential recommendation (limiting gatherings to ≤10 people) lowered the compound growth rate of COVID-19 for all counties in the US by 6.6%, and the counties that implemented SIP after March 16 had a further reduction of 7.8% compared with the counties that did not implement SIP after March 16. A random forest machine learning model was built to predict compound growth rate after a SIP order and was found to have an accuracy of 92.3%. The random forest found that population, longitude, and population per square mile were the most important features when predicting the effect of SIP.
*Conclusions:* SIP orders were found to be effective at reducing the growth rate of COVID-19 cases in the US. Counties with a large population or a high population density were found to benefit the most from a SIP order.



Novel coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2] or coronavirus disease 2019 [COVID-19]) originated in the province of Wuhan, China, in December 2019, after which it spread rapidly across the globe owing to infected persons exhibiting little to no symptoms within the first five days of contracting the virus.[1] The devastation and infection rate triggered by the virus caused the World Health Organization to declare it a global pandemic. There are currently more than 170 countries infected with COVID-19, and all 50 states in the United States (US) have confirmed cases according to the Centers for Disease Control and Prevention. In the US, community transmission has become the prominent mode of transmission of the virus.[2] It has therefore become imperative that the effectiveness of the primary forms of limiting social contact used by local and national governments be evaluated. Enough data at the county level are now available to provide a fair assessment of the efficacy of the presidential guidelines issued on March 16, 2020, instituting a form of 'social distancing' by limiting gatherings to 10 or fewer people. Data are additionally sufficient to assess the efficacy of county-level shelter-in-place (SIP) orders versus counties that did not issue any SIP orders after the guidelines issued on March 16.

County metrics were obtained from the US Census Bureau, USA Counties (2011) data sets from the 2010 census.[3] The data included in this study are latitude, longitude, population, median age, number of physicians, median income, population per square mile, and water use per capita. Counties were placed into one of the two

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https://doi.org/10.1016/j.puhe.2020.04.016

bins: (1) counties that had confirmed cases of COVID-19 before issue of guidelines on March 16 and experienced a SIP order on or after March 19 (186 counties, referred to as wSIP); and (2) counties that had confirmed cases before March 16 and experienced no SIP order (60 counties, referred to as noSIP). A Student t-test was used to compare two groups for significance. Analysis of variance with the Tukey post hoc test was used to compare multiple groups. Significance was defined as $P < 0.05$. All data are reported as mean ± 95% confidence interval. There were no statistically significant differences in the US census data between the wSIP and noSIP groups apart from latitude ($P < 0.0001$) and the number of physicians ($P = 0.04$). The wSIP group had a latitude of 39.47 ± 0.75, which places it in the northern US, compared with the noSIP group with a latitude of 34.6 ± 1.16°, placing it further south. The difference in number of physicians is a function of latitude with a lower mean number of physicians in the south (1697 ± 500) compared with the north (2677 ± 538).

The number of confirmed COVID-19 cases in each county was collected from local health department data and county/state press releases from January 21 to March 25. Confirmed cases from March 26 to 31 were obtained from The New York Times coronavirus data repository.[4] The two data sets were compared to ensure consistency between the collected values. Data collection stopped on March 31 because the mean number of days with confirmed cases was approximately the same as that before issue of guidelines on March 16, after March 16 but before the institution of a SIP order, and after March 16 with a SIP order. This allowed for comparison of these time intervals with an equal number of days (7.62 ± 0.35).

Compound growth was calculated using the following equation: (final confirmed cases/first confirmed cases)^(1/number of days). Fig. 1 shows the compound growth rate for the wSIP (1.39 ± 0.044) and noSIP (1.30 ± 0.059) groups before the issue of presidential guidelines on March 16, the compound growth rate after March 16 for the wSIP (1.30 ± 0.023) and noSIP (1.21 ± 0.016) groups, and the compound growth rate for the wSIP group (1.19 ± 0.011) after the SIP orders went into effect. The lower compound growth rates seen in noSIP data are due to the difference in latitude between the two data sets and suggest that southern states experienced a slower spread of the virus at the onset. This makes sense, given that before March 16, the hot spots for COVID-19 were northern states such as Washington, New York, and Illinois. The noSIP compound growth rates were normalized to the compound growth rate of wSIP data before March 16 to account for geographical differences. The normalized compound growth rates after March 16 were shown to be statistically similar between the wSIP and noSIP groups ($P > 0.05$, Fig. 1). This indicates that the presidential guidelines had the same magnitude of effect on reducing the compound growth rate by 6.6 ± 1.4% between the wSIP and noSIP groups before the wSIP group instituted a SIP. After instituting a SIP order, compound growth rate of the wSIP group decreased an additional 7.8%, for a total decrease of 14.4 ± 1.6% from the compound growth rates before March 16. This indicates that the effects from the presidential guidelines and SIP orders were additive in the US. This is reasonable, considering the virus is thought to spread by virus-containing airborne droplets and orders for social distancing limit the interaction of people who could potentially be infected.[5] A study modeling the effect of social distancing from China indicated a strong association with both a decrease in the rate the virus spreads and the implementation of social distancing.[6]

A random forest machine learning model was trained to predict the compound growth rate after a SIP order was given in a county. The random forest was chosen as it has been shown to have the highest accuracy in disease prediction.[7] The model achieved a mean absolute percentage error of 92.3% in the test data set. The three most important features were population, longitude, and population per square mile in predicting the compound growth rate after a SIP order was instituted in a county. The data for these features were split into four equal groups to explain how these features matter for the model in predicting the compound growth rate after a SIP order was issued. Counties that instituted a SIP order with a longitude between −79.7102° and −97.2363° had the largest decrease in compound growth rate at 10.4% compared with 8.2% for counties outside of that longitudinal range. Counties with the highest populations between 143,962 and 984,8011 saw the largest

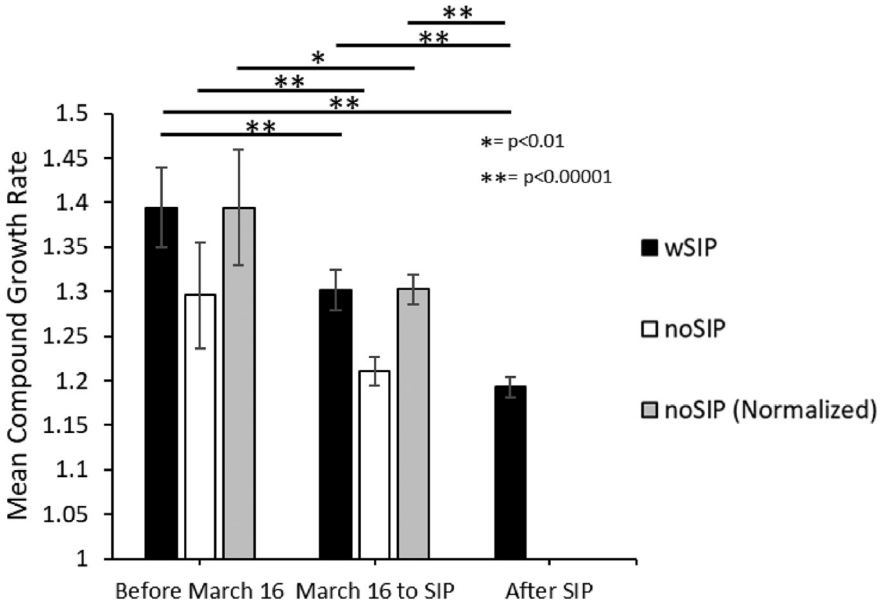


**Fig. 1.** Mean compound growth rate of counties that had confirmed cases (1) before the presidential guidelines issued on March 16, (2) from March 16 to issuance of SIP, and (3) from issuance of SIP to March 31 (black bars) compared with counties with confirmed cases (1) before March 16 and (2) after March 16 and noSIP (white bars). Statistical analyses indicated no differences in summary data for the two groups except for latitude, indicating that counties with a SIP order were further north and those without a SIP order were predominately located in the south. The counties without SIP were normalized to those with SIP before March 16 to account for this difference (gray bars). SIP = shelter-in-place; wSIP, with SIP; noSIP, no SIP.

percent reduction after instituting a SIP order at 10.5%, compared to counties with a lower population between 7457 and 142,151 at 8.2%. Similar to population, population per square mile showed the largest reduction in compound growth rate in counties with a population per square mile between 405.8 and 1755.5 at 11.6% compared with counties with a lower population density of 2.1–405.6 at 8.9%.

In conclusion, the data suggest that at a county level, in the US, the SIP order is effective at decreasing the compound growth rate of COVID-19 (Fig. 1). The counties that have the largest impact from a SIP order are ones with a large population or a high population density, as indicated by the random forest feature importance.

## Author statements

*Acknowledgments*

The authors wish to thank William Glenn Bond and Meredith B. Cobb for their input and edits of the manuscript.

*Ethical approval*

Ethical approval was not required as this study made use of publicly available data.

*Funding*

None.

*Competing interests*

None declared.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.04.016.

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Public Health 185 (2020) 298–305

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Factors influencing health behaviours during the coronavirus disease 2019 outbreak in China: an extended information-motivation-behaviour skills model

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ARTICLE INFO

*Article history:*
Received 3 April 2020
Received in revised form
15 June 2020
Accepted 30 June 2020
Available online 9 July 2020

*Keywords:*
Information-motivation-behaviour skills model
COVID-19
Health behaviours
Perceived stress

ABSTRACT

*Objectives:* This study explored the factors influencing health behaviours during the coronavirus disease 2019 (COVID-19) outbreak in China. The impact of perceived stress and positive perception of interventions on health behaviours in China were assessed using the extended information-motivation-behaviour skills (IMB) model.
*Study design:* Cross-sectional survey.
*Methods:* The Questionstar online survey tool was used to construct a structured questionnaire based on the IMB model. Between 14 and 22 February 2020, during the peak of COVID-19 epidemic in China, 2449 participants were recruited by snowball sampling on WeChat and Tencent QQ social media platforms in China. Data were collected through an online questionnaire, and structural equation modelling was performed to evaluate the extended IMB model.
*Results:* Health behaviours were assessed using a scoring system (total score range: 8–40); the average health behaviour score in this study was 34.62 ± 4.44. The term 'health risk stress' refers to the impact that perceived stress has on health, and this was experienced by 39.9% of participants. Only 35.9% of participants answered all seven questions on COVID-19 information correctly. The final model showed that information, motivation, behavioural skills, heath risk stress and positive perception of interventions had significant direct effects on health behaviours. Health behaviours were positively associated with the positive perception of interventions but negatively associated with health risk stress. Behavioural skills had the greatest impact on health behaviours.
*Conclusions:* In the face of public health emergencies, the extended IMB model has been used as a theoretical framework to construct more effective interventions. The government should pay attention to publicity and guidance, strengthen positive interactions with the public and disclose relevant information in a timely manner to gain trust and to maintain the positive public perception of the interventions. In terms of health education, the government should focus on behavioural skills, promptly rectify ineffective prevention information and raise awareness about the disease to relieve stress and anxiety in the population.


## Introduction

On 30 January 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus-2 as the sixth public health emergency of international concern.[1] As of 14 June 2020, there were 7,690,708 confirmed cases and 427,630 deaths worldwide.[2] WHO

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https://doi.org/10.1016/j.puhe.2020.06.057

risk assessment is very high. In addition to public health, COVID-19 poses a serious threat to global economic and social development.

To curb the development of the epidemic to the greatest extent, the Chinese government and other relevant departments concentrated their medical resources on the treatment of infected persons and adopted a series of comprehensive prevention and control measures based on the principles of controlling transmission sources, cutting off transmission routes and protecting vulnerable populations.[3] At the same time, relevant departments and organisations released timely and accurate information about COVID-19, actively carried out health education and provided residents with authoritative, detailed and specific operational prevention and control guidelines.[3] In addition, it was very important for residents to follow the instructions, adopt appropriate health behaviours and maintain good health habits, such as correctly wearing a mask and avoiding outings or gatherings. These measures help to control the epidemic and reduce the risk of infection.

The aforementioned prevention strategy is consistent with the theory of the information-motivation-behaviour skills (IMB) model, which classifies the factors affecting the occurrence and changes of preventive behaviour into three components of information, motivation and behaviour skills.[4] IMB is a well-proven method that can predict and promote health behaviours.[5] It has been widely used in AIDS prevention,[6,7] health promotion,[8,9] public health,[10,11] chronic disease management,[12,13] vaccination[5] and other fields. The IMB model can be easily converted into intervention practice and has broad applicability.

This study adds two factors to the original IMB model—perceived stress and positive perception of interventions. Stress and anxiety in the population tends to increase during public health emergencies,[14] which may have a negative impact on health behaviours. In addition, residents' positive perception of government interventions could also have an effect on health behaviours, such as the degree of understanding and support of intervention measures.

Therefore, based on the extended IMB model, this study explores the factors influencing Chinese residents' health behaviours during the COVID-19 outbreak, and assesses the impact of perceived stress and positive perception of interventions on health behaviours. The results of this study provide scientific basis for relevant departments and institutions to establish targeted comprehensive intervention programmes and prevention measures.

## Methods

### *Study design and participants*

This study collected data via a cross-sectional survey. Questionstar, an online survey questionnaire tool, was used to prepare a structured questionnaire that was guided by the IMB model. Between 14 and 22 February 2020, corresponding with the peak of the epidemic in China, the snowball sampling method was used to recruit participants on WeChat and Tencent QQ social media platforms in China. Data were collected through an online questionnaire. Each participant could become a 'seed' and expand the sample size by sharing the questionnaire with their social network. Participants were required to read the informed consent and agree to participate before gaining access to the questionnaire to complete. Inclusion criteria were as follows: (1) aged ≥18 years old; (2) ability to use smart electronic devices (e.g. computers, tablets, mobile phones); and (3) agree to participate in this study (i.e. provide informed consent). Exclusion criteria were as follows: (1) suffering from a mental health illness (such as anxiety neurosis or depression) in the past year; and (2) response times of <1 min or >30 min.

### *Quality control*

To reduce bias, the following quality control was carried out: (1) each item was set as a mandatory question to ensure the integrity of the data; (2) each internet protocol address was limited to one submission to avoid repeated filling/participation; and (3) real-time monitoring in the background recorded participants' response time.

### *Measures*

We developed structured questions by referring to relevant literature relating to the IMB model[4,5,15] and studies on health behaviours during infectious disease outbreaks,[16,17] the WHO and the National Health Council of the People's Republic of China on the prevention of COVID-19.[18,19] After a pilot test of the survey, we revised and optimised the items based on the opinions of participants and finalised the contents of the questionnaire.

### *Demographic variables*

Demographic characteristics included age, gender, education level, marital status, personal monthly income, region, province of residence, occupation and past history of mental health illness.

### *Knowledge/information*

This section of the questionnaire included knowledge about the COVID-19 incubation period, transmission and prevention, with a total of seven items (Table 1, I1-I7). As the survey questions included incorrect information/rumours about disease, the correct answers were revealed after submitting the questionnaires. Possible answers to items I1—I7 were 'Yes', 'No' and 'I don't know'. Items I1—I4 were assigned one point for 'No', items I5—I7 were assigned one point for 'Yes', other answers were assigned 0 points. Cronbach's alpha = 0.607.

### *Motivation*

The motivations of participants towards their health behaviours were mainly divided into individual motivation and social motivation, which were measured by six items (Table 1, M1-M6). Participants answered using a five-point Likert scale, ranging from 1 (completely disagree) to 5 (completely agree). The higher the score, the higher the motivation. Cronbach's alpha = 0.558.

### *Behavioural skills*

Self-efficacy and the ability to effectively execute health behaviours were used to evaluate behavioural skills, with a total of eight items (Table 1, BS1-BS8). Participants answered using a five-point Likert scale, ranging from 1 (completely disagree) to 5 (completely agree). The higher score, the more the behavioural skills related to the health behaviours. Cronbach's alpha = 0.774.

### *Perceived stress*

Perceived stress was measured to evaluate the degree of stress caused by factors considered to be unpredictable or uncontrollable, or that were overwhelming.[20] The Chinese version of the Perceived Stress Scale was used in this study,[17] with a total of 14 items (Table 1, PS1-PS14), of which PS4, PS5, PS6, PS7, PS9, PS10 and PS13

**Table 1**
Constructs of the extended information-motivation-behavioural skills (IMB) model.

| Constructs | | Items |
|---|---|---|
| Information | I1 | Could antibiotics prevent COVID-19? |
| (Crobach's $\alpha = 0.607$) | I2 | Could taking Shuanghuanglian oral liquid prevent COVID-19? |
| | I3 | Could a room fumigated with vinegar kill SARS-CoV-2? |
| | I4 | Could gauze masks or activated carbon masks prevent COVID-19? |
| | I5 | Could hot water at 56 °C kill SARS-CoV-2 for 30 min? |
| | I6 | In general, is the longest incubation period for COVID-19 14 days? |
| | I7 | Is the main transmission method of COVID-19 by droplet transmission and contact transmission? |
| Motivation | M1 | I thought COVID-19 was very contagious. |
| (Crobach's $\alpha = 0.558$) | M2 | Taking appropriate health behaviours could reduce the risk of infection. |
| | M3 | I was very afraid of COVID-19. |
| | M4 | I thought COVID-19 was serious. |
| | M5 | My family was very supportive of my health behaviours. |
| | M6 | I was aware of any confirmed or suspected cases of COVID-19 within a radius of 1 km. |
| Behavioural skills | BS1 | I actively paid attention to real-time information of COVID-19. |
| (Crobach's $\alpha = 0.774$) | BS2 | I understood the importance of home isolation during the COVID-19 pandemic. |
| | BS3 | I grasped the difference between a common cold and COVID-19. |
| | BS4 | I could put on the mask correctly. |
| | BS5 | I could take temperature correctly. |
| | BS6 | I could follow community or village committee regulations. |
| | BS7 | I took the initiative to learn preventive measures for COVID-19. |
| | BS8 | Even though the supply of masks and disinfectants was insufficient, I still actively tried to acquire them. |
| Health behaviours | HB1 | Advise family members to wash their hands frequently, wear masks, etc. |
| (Crobach's $\alpha = 0.835$) | HB2 | Wash hands frequently at home. |
| | HB3 | Reduce group activities like outings and gatherings. |
| | HB4 | Keep a safe distance from strangers when going out (at least 1 m). |
| | HB5 | Cover mouth and nose with a tissue or elbow when coughing or sneezing to avoid possible transmission to others. |
| | HB6 | Wear a mask when going out. |
| | HB7 | Implement a healthier diet to improve nutrition level. |
| | HB8 | Perform appropriate exercises at home. |
| | HB9 | Pay attention to opening of windows to ventilate the home (at least twice a day). |
| Perceived stress | PS1 | In the past month, how often have you successfully dealt with day-to-day problems and annoyances? |
| (Crobach's $\alpha = 0.829$) | PS2 | In the past month, how often have you felt that you were coping effectively with important changes that were occurring in your life? |
| | PS3 | In the past month, how often have you felt confident about your ability to handle your personal problems? |
| | PS4 | In the past month, how often have you felt anxious about something that happened unexpectedly? |
| | PS5 | In the past month, how often have you felt unable to control the important things in your life? |
| | PS6 | In the past month, how often have you felt nervous and 'stressed?' |
| | PS7 | In the past month, how often have you found that you could not cope with all the things that you had to do? |
| | PS8 | In the past month, how often have you felt that things were going your way? |
| | PS9 | In the past month, how often have you been angered because of things that happened outside of your control? |
| | PS10 | In the past month, how often have you found yourself thinking about things that you have to accomplish? |
| | PS11 | In the past month, how often have you been able to control irritations in your life? |
| | PS12 | In the past month, how often have you felt that you were on top of things? |
| | PS13 | In the past month, how often have you felt difficulties were piling up too high to overcome them? |
| | PS14 | In the past month, how often have you been able to control the way you spend your time? |
| Positive perception of interventions | PPI1 | Prevention and control measures increased my confidence. |
| | PPI2 | I understand the prevention and control management measures. |
| Crobach's $\alpha = 0.890$ | PPI3 | I supported prevention and control management measures such as closed management. |
| | PPI4 | Prevention and control measures could reduce my fear and anxiety. |
| | PPI5 | Prevention and control measures could prevent me and my family contracting COVID-19. |

COVID-19, coronavirus disease 2019.

were reverse items. Participants answered using a five-point Likert scale, ranging from 1 (never) to 5 (always). The higher the score, the greater the perceived stress of residents during the COVID-19 epidemic. When the total score was higher than 25, the perceived stress would impact health, which was defined as 'health risk stress'.[17] Cronbach's alpha = 0.829.

*Positive perception of interventions*

Positive perception of interventions refers to residents' perceptual evaluation of the government's epidemic prevention and control measures, with a total of five items (Table 1, PPI1-PPI5). The main contents were on understanding, support and evaluation of the policies. Participants answered using a five-point Likert scale, ranging from 1 (completely disagree) to 5 (completely agree). The higher the score, the higher the positive perception of interventions. Cronbach's alpha = 0.890.

*Health behaviours*

Health behaviours included prevention of infection of COVID-19, a healthy diet and appropriate exercise, with a total of nine items (Table 1, HB1–HB9). Participants answered using a five-point Likert scale, ranging from 1 (never) to 5 (always). The higher the score, the higher the frequency of positive health behaviours. Cronbach's alpha = 0.835.

*The extended IMB model*

In Fig. 1, the original IMB model is represented by solid lines, and the nine paths added in the study are represented by the dotted lines. Paths 1–4 were used to evaluate the positive impact of positive perception of interventions on health behaviours, and paths 5–8 were used to estimate the negative impact of perceived stress on health behaviours.

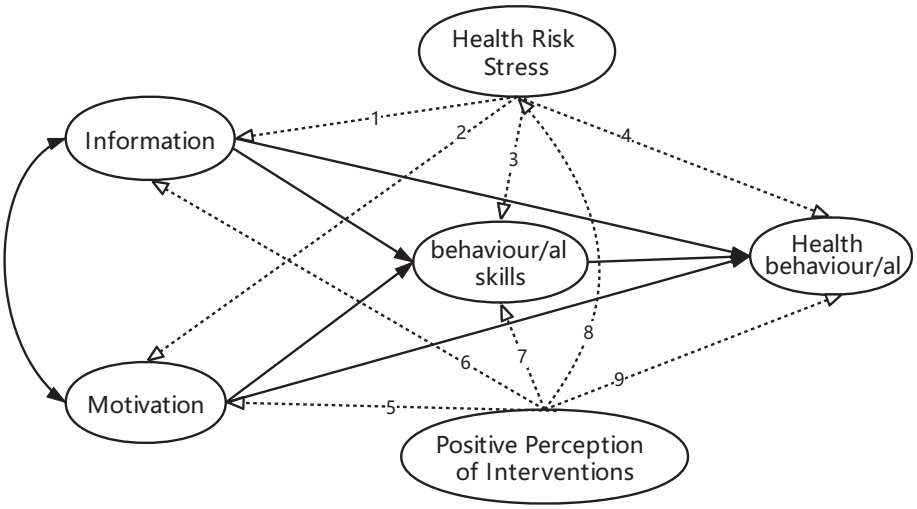


**Fig. 1.** The extended IMB model in present study. IMB, information-motivation-behaviour skills.

*Statistical analyses*

Statistical analyses were completed using SAS9.4. The measurement data of normal distribution were reported by mean ± standard deviation, and the count data were reported by frequency (N) and percent (%). The Pearson correlation coefficient and point double correlation coefficient were used to estimate the correlation between variables. Confirmatory factor analysis (CFA) was used to test the relationship between latent variables and observable variables of the measurement model. In each measurement model, when the factor loading of an item was not statistically significant ($P > 0.05$) or the standardised factor loading estimate was less than 0.4, the item was deleted. Structural equation modelling (SEM) was used to evaluate the extended IMB model. The model was considered to have a good fit if the ratio of chi-square to degrees of freedom was <5.0[21], root mean square error of approximation (RMSEA) < 0.08, goodness-of-fit index (GFI) ≥0.90, Tucker–Lewis index (TLI) ≥0.90 and comparative fit index (CFI) ≥0.90.[22] SEM and CFA were conducted using Amos 24.0. Bilateral $P < 0.05$ considered the difference to be statistically significant.

## Results

*Sociodemographic characteristics*

In total, 2533 participants completed the questionnaires; 2449 of these were valid. Table 2 shows the sociodemographic characteristics of the study participants. The majority of the participants were under the age of 40 years (70.5%), female (66.4%), employed (74.9%), with a personal monthly income <5000 RMB (70.4%) and lived in urban areas (72.8%). Most of the respondents (75.2%) came from Chongqing Municipality and Sichuan Provinces. In total, 39.9% of participants experienced health risk stress (i.e. perceived stress had an impact of their health). The percent of errors in the information for I1 to I7 were 21.9%, 19.1%, 19.3%, 18.3%, 25.7%, 8.1% and 12.3%, respectively. Only 35.9% of participants answered all seven questions on COVID-19 information correctly.

*Measurement model*

Table 3 presents the significant tests and the estimated CFA with the parameters from the extended IMB constructs. After removing item M6, the motivation latent variable retained five original items (M1-M5) that had a good fit (IFI = 0.973, CFI = 0.972 and RMSEA = 0.054). After deleting item BS8, the behavioural skill latent variable retained seven original items (BS1-BS7) that had a good fit (IFI = 0.961, CFI = 0.960 and RMSEA = 0.060). After removing item HB9, the health behaviours latent variable retained eight original items (HB1-HB8) that had a good fit (IFI = 0.983, CFI = 0.983 and RMSEA = 0.049). The five original items were reserved for the latent variable of positive perception of intervention (PPI1-PPI5), which resulted in a good fit (IFI = 0.968, CFI = 0.968 and RMSEA = 0.043).

The reliabilities of the scales in information, motivation, behavioural skills, perceived stress, positive perception of interventions and health behaviours were 0.607, 0.639, 0.768, 0.829, 0.890 and 0.844, respectively. In addition, all standardised factor loading estimates were >0.4 and significant ($P < 0.05$) in each measurement model.

*Correlation analysis*

The correlation coefficients among all constructs are presented in Table 4. The correlation coefficient between all constructs were statistically significant, except for between information and motivation ($r = -0.006$, $P = 0.716$), between positive perception of interventions and information ($r = 0.032$, $P = 0.109$) and between health risk stress and motivation ($r = -0.031$, $P = 0.123$). Therefore, these three paths were deleted in the extended IMB model, namely, 'Health Risk Stress → Motivation', 'Positive perception of intervention measures → Information' and 'Information → Motivation', respectively.

*Path analysis*

The final extended IMB model (Fig. 2) had a good fit; that is, $\chi 2/df$ ratio = 1511.733/309 = 4.892, GFI = 0.949, CFI = 0.939, TLI = 0.930, RMSEA = 0.041. Five factors had significant direct effects on health behaviours; namely, information ($\beta = 0.067$, $t = 3.408$, $P < 0.001$), motivation ($\beta = 0.192$, $t = 7.357$, $P < 0.001$), behavioural skills ($\beta = 0.464$, $t = 10.487$, $P < 0.001$), health risk stress ($\beta = -0.159$, $t = -8.110$, $P < 0.001$) and positive perception of interventions ($\beta = 0.072$, $t = 2.212$, $P = 0.027$). Health risk stress exerted indirect impacts on health behaviours through behavioural skills and information. Positive perception of interventions also

**Table 2**
Sociodemographic characteristics (n = 2449).

| | Variables | N | Percent(%) |
|---|---|---|---|
| Gender | Male | 823 | 33.6 |
| | Female | 1626 | 66.4 |
| Age (years) | 18–25 | 837 | 34.2 |
| | 26–30 | 463 | 18.9 |
| | 31–40 | 427 | 17.4 |
| | 41–50 | 486 | 19.8 |
| | 51–60 | 192 | 7.8 |
| | ≥61 | 44 | 1.8 |
| Education level | Elementary or below | 48 | 2.0 |
| | Junior high school diploma | 326 | 13.3 |
| | Senior high school diploma | 310 | 12.7 |
| | Advanced diploma | 728 | 29.7 |
| | Baccalaureate degree | 881 | 36.0 |
| | Master's degree or above | 156 | 6.4 |
| Marital status | Non-married | 1000 | 40.8 |
| | Married | 1353 | 55.3 |
| | Divorced | 77 | 3.1 |
| | Widowed | 19 | 0.8 |
| Personal monthly income (RMB) | ≤3000 | 845 | 34.5 |
| | 3001–5000 | 880 | 35.9 |
| | 5001–7000 | 365 | 14.9 |
| | 7001–10000 | 215 | 8.8 |
| | ≥10,001 | 144 | 5.9 |
| Region | Urban | 1783 | 72.8 |
| | Township | 394 | 16.1 |
| | Rural | 272 | 11.1 |
| Province of residence | Chongqing Municipality | 1408 | 57.5 |
| | Sichuang Provinces | 434 | 17.7 |
| | Gansu Provinces | 151 | 6.2 |
| | Jiangxi Provinces | 114 | 4.7 |
| | Others | 342 | 14.0 |
| Occupation | Employed | 1834 | 74.9 |
| | Students | 261 | 10.7 |
| | Unemployed or 'job-waiting' individuals | 268 | 10.9 |
| | Retirees | 86 | 3.5 |

exerted indirect impacts on health behaviours through behavioural skills, health risk stress and motivation.

In conclusion, the total effect coefficients of information, motivation, behavioural skills, health risk stress and positive perception of intervention on health behaviours were 0.156, 0.263, 0.464, −0.208 and 0.452, respectively. All variables accounted for 44.0% of health behaviours.

## Discussion

This study successfully constructed an extended IMB model, wherein information, motivation, behavioural skills and positive perceptions of interventions are positive factors, and health risk stress is a negative factor for health behaviours. Previous studies have found that IMB has certain intervention effects.[9,10,11] News media act as agents of information and persuasion during the COVID-19 pandemic;[23] therefore, the extended IMB model was used as a theoretical framework to implement health behaviour interventions for the public via various electronic devices. For example, the government or relevant organisations released prevention measures, health education and other important information about the epidemic via text messages in China.

Information and motivation have a direct effect on health behaviours, which means that acquisition of prevention knowledge, correctly understanding the severity, contagion, and lethality of COVID-19 and maintaining a strong prevention motivation may promote health behaviours directly, without the need for complex or novel behavioural skills.[4] However, the results indicated that residents are not confident about their knowledge. Approximately one-fifth of the respondents thought that taking antibiotics, consuming Shuanghuanglian oral solution or vinegar, or using gauze masks or activated carbon masks could prevent COVID-19. Such erroneous knowledge could lead to ineffective preventive measures by the population and increase the risk of infection. Therefore, it is necessary to target and proactively conduct health education for groups of different cultural levels and regions to improve residents' prevention knowledge.

Behavioural skills are indispensable for improving health behaviours[15] and long-term prevention behaviours depends on behavioural skills.[24] The results of this study validate the importance of behavioural skills, which are the mediating factor of information, motivation, perceived stress and positive perception of interventions. Behavioural skills are also the most important direct factors affecting health behaviours, in line with findings from other studies.[6,12,13] Therefore, the government advise the public on correct health behaviours, such as wearing masks, washing hands and the use of disinfectants, so that residents can obtain these skills to reduce the risk of infection. It is also necessary to guarantee the supply of protective materials.

In the face of public health emergencies, the level of anxiety will be related to the severity of the disease.[25] The results found that 39.9% of residents suffered from health risk stress. Health risk stress is negatively related to health behaviours, information and behavioural skills, which showed that excessive stress is not conducive to positive health behaviours, and that nervousness and being out of control can lead to negative coping styles. Individuals who maintain a high level of awareness of the danger and maintain a moderate level of stress are the most likely to adopt appropriate

**Table 3**
Constructs for information, motivation, behavioural skills, health behaviours, perceived stress and positive perception of interventions (n = 2449).

| Constructs items (total scores range) | β | P | Mean | SD | IFI/CFI | RMSEA | Crobach's α |
|---|---|---|---|---|---|---|---|
| Perceived stress (0–56) | | | | | | | |
| Score | | | 22.25 | 7.20 | | | 0.829 |
| Information (0–7) | | | | | | | |
| Knowledge score | | | 4.34 | 1.27 | | | 0.607 |
| Motivation (5–25) | | | | | | | |
| M1 | 0.470 | <0.001 | 23.15 | 2.67 | 0.973/0.972 | 0.054 | 0.639 |
| M2 | 0.413 | <0.001 | | | | | |
| M3 | 0.510 | <0.001 | | | | | |
| M4 | 0.669 | <0.001 | | | | | |
| M5 | 0.476 | <0.001 | | | | | |
| Behavioural skills (7–35) | | | | | | | |
| BS1 | 0.415 | <0.001 | 23.15 | 2.67 | 0.961/0.960 | 0.060 | 0.768 |
| BS2 | 0.451 | <0.001 | | | | | |
| BS3 | 0.444 | <0.001 | | | | | |
| BS4 | 0.671 | <0.001 | | | | | |
| BS5 | 0.675 | <0.001 | | | | | |
| BS6 | 0.630 | <0.001 | | | | | |
| BS7 | 0.609 | <0.001 | | | | | |
| Positive perception of interventions (5–25) | | | | | | | |
| PPI1 | 0.784 | <0.001 | 22.25 | 2.97 | 0.968/0.968 | 0.043 | 0.890 |
| PPI2 | 0.800 | <0.001 | | | | | |
| PPI3 | 0.785 | <0.001 | | | | | |
| PPI4 | 0.750 | <0.001 | | | | | |
| PPI5 | 0.758 | <0.001 | | | | | |
| Health behaviours (8–40) | | | | | | | |
| HB1 | 0.606 | <0.001 | 23.15 | 2.67 | 0.983/0.983 | 0.049 | 0.844 |
| HB2 | 0.760 | <0.001 | | | | | |
| HB3 | 0.711 | <0.001 | | | | | |
| HB4 | 0.718 | <0.001 | | | | | |
| HB5 | 0.707 | <0.001 | | | | | |
| HB6 | 0.561 | <0.001 | | | | | |
| HB7 | 0.584 | <0.001 | | | | | |
| HB8 | 0.430 | <0.001 | | | | | |

SD = standard deviation; IFI = incremental fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation.

**Table 4**
Correlation coefficients among model constructs (n = 2449).

| Constructs | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.Information | 1 | | | | |
| 2.Motivation | −0.006 | 1 | | | |
| 3.Behavioural skills | 0.187* | 0.184* | 1 | | |
| 4.Health behaviours | 0.161* | 0.245* | 0.494* | 1 | |
| 5.Health risk stress | −0.084[a], * | −0.031[a] | −0.203[a], * | −0.283[a], * | 1 |
| 6.Positive perception of interventions | 0.032 | 0.137* | 0.535* | 0.416* | −0.190[a], * |

*$P < 0.001$.
[a] Point biserial correlation coefficient with heath risk stress (perceived stress has an impact on health).

health behaviours.[14] Therefore, it is necessary for relevant departments to guide residents to treat the epidemic objectively, calmly and rationally, and to take effective intervention measures to reduce stress and anxiety in the population.

The total effects of positive perception of interventions on health behaviours are similar to the effects seen with behavioural skills. The positive perception of interventions is negatively related to health risk stress. It is not only a direct influencing factor of health behaviours but also indirectly affects health behaviours through motivation and behavioural skills. It was revealed that suitable prevention and control measures adopted by the government and relevant organisations could reduce the fear and anxiety of residents and improve health behaviours. Therefore, the government should provide accurate, open and transparent information on the situation of the epidemic, strengthen interactions with the public and win the trust of residents. When residents have a high level of trust in the government, stress significantly decreased.[26]

This study has some limitations, including: (1) the randomisation of the sample was poor; however, a large sample size was used to ensure a certain number of individuals in all categories, to minimise bias; (2) extrapolation of the results is limited to some extent; data mainly represented the regions of Chongqing and Sichuan or regions with similar pandemic severity. Chongqing Municipality borders Hubei Province (the epicentre of the epidemic) and is adjacent to Sichuan Province. Between 20 January and 22 February, the total number of confirmed cases in Chongqing Municipality and Sichuan Province was 573 (six deaths) and 526 (three deaths), respectively.[27] In view of the international nature of COVID-19 and its implications, future studies should include a broader sample.

This study has used the extended IMB model as a theoretical framework to construct more effective interventions during the COVID-19 epidemic in China. The government should pay attention to publicity and guidance, strengthen positive interaction with the public and disclose relevant information in a timely manner to gain

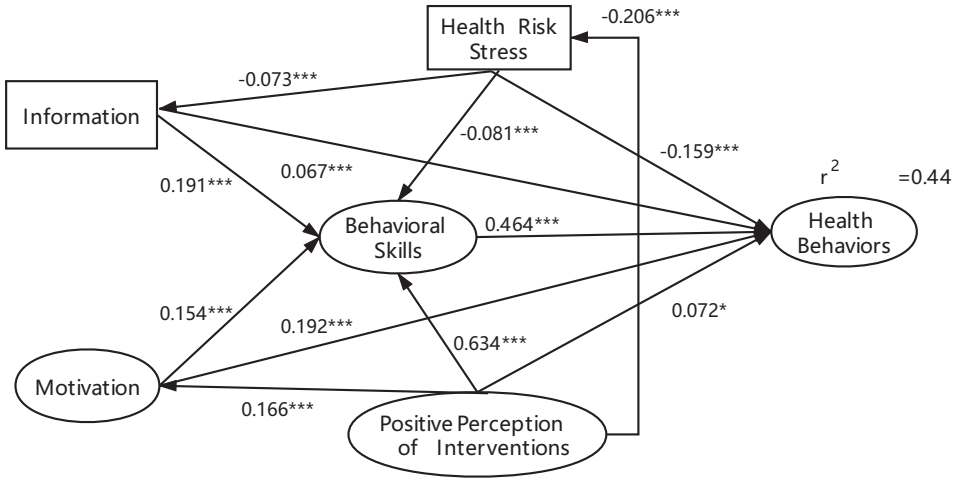


**Fig. 2.** The final extended IMB model. Coefficients are standardized path coefficients. Variables in eclipses represent latent variables, in squares observed variables. *$P < 0.05$. ***$P < 0.001$. IMB, information-motivation-behaviour skills.

trust and to maintain the positive public perception of the interventions. In terms of health education, the government should focus on behavioural skills, promptly rectify ineffective prevention information and raise awareness about the disease to relieve stress and anxiety in the population.

## Author statements

### *Ethical approval*

The study was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University Ethics (No.2020250).

### *Funding*

This work was supported by the National Key Project for Infectious Diseases of the Ministry of Science and Technology of China (grant numbers: 2018ZX10721102-005) and Chongqing Medical University New Coronavirus Emergency Research Special Project (grant numbers: CQMUNCP0305).

### *Competing interests*

None declared.

### *Acknowledgements*

The authors thank all individuals who volunteered to participate in this study and are grateful to ELSEVIER services in manuscript language polishing.

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Public Health 185 (2020) 209–211

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# Health locus of control and mortality: a population-based prospective cohort study

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ARTICLE INFO

*Article history:*
Received 16 March 2020
Received in revised form
26 April 2020
Accepted 1 May 2020
Available online 10 July 2020

*Keywords:*
Health locus of control
Health-related behaviours
Mortality
Prospective cohort study
Sweden

ABSTRACT

*Objectives:* The objective of the study was to estimate associations between health locus of control (HLC) and mortality.
*Study design & methods:* The public health survey in Scania 2008 was linked to the Swedish cause of death register. In this study of 10,757 men and 12,322 women aged 18–80 years, 421 men and 235 women died during the 5.3-year follow-up. Survival analyses were conducted.
*Results:* Respondents with only some or no internal HLC had significantly higher hazard rate ratios (HRRs) compared with respondents with high HLC. For women, the HRRs of those with low HLC did not significantly differ from the reference group after final adjustments for health-related behaviours.
*Conclusions:* HLC is a predictor of mortality, and this association is to an important extent mediated by health-related behaviours.


Health-related behaviours including tobacco smoking, alcohol consumption, leisure-time physical activity (LTPA) and diet are the main determinants of major chronic diseases such as cardiovascular diseases (CVDs) and cancer. Health-related behaviours are determined by socio-economic status (SES) and psychosocial and psychological factors. The SES gradients in smoking, LTPA and diet have been known for decades.[1] However, psychological factors such as health locus of control (HLC) are also important, particularly as determinants of health-related behaviours.

The HLC concept stems from social learning theory and the broader locus of control concept.[2] Internal HLC depicts a high personal belief that it is possible to affect one's own health. External HLC depicts the opposite.[3] Individuals with internal HLC are more likely to change health-related behaviours in a more 'healthy' direction. Patients with internal HLC are also more likely to prefer involvement in the decision-making process regarding their own treatment with regard to health care, whereas patients with external HLC are more prone to avoid such involvement and endorse paternalistic approaches.[4] LTPA and diet are the two health-related behaviours most strongly associated with HLC, probably because psychological, biological (dependency) and psychosocial stress factors are more important as determinants of smoking and alcohol consumption. These associations have been known for a long time.[5] However, to our knowledge, no studies have investigated associations between HLC and mortality. Such an investigation would clarify the temporal association.

The aim was to analyse associations between baseline HLC and mortality using survival (Cox regression) hazard analysis, adjusting for relevant covariates.

## Study population

The public health survey in Scania 2008 is a cross-sectional survey based on a stratified sample of the register population aged 18–80 years in Scania, the southernmost part of Sweden. A postal invitation letter including a questionnaire was sent, with three reminders to initial non-respondents. The questionnaire was also administered online. A total of 28,198 participants responded, yielding a 54.1% participation rate.

This study, connecting the baseline survey with prospective mortality data, was approved by the Ethical Committee (Etikprövningsnämnden) in Lund (No. 2010/343).

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https://doi.org/10.1016/j.puhe.2020.05.005

## Dependent variable

Mortality was followed prospectively from 27 August to 14 November 2008 (registration date of individual answers) until 31 December 2013 (5.3 years later) or until death (656 respondents of 23,079 in this study). A total of 10,757 men and 12,322 women were included, excluding 4983 respondents with missing values on any of the variables in this study (another 136 respondents were lost to follow-up). The causes of death were coded according to ICD10, but this study only concerns all-cause mortality. The Swedish ten-digit person number system enables connection of baseline data from the 2008 survey with the Swedish national cause of death register at the Swedish National Board on Health and Welfare by a third party (the private company Tieto). The person numbers were deleted before delivery to the research group.

## Independent variables

### *Health locus of control*

HLC was assessed by the question 'Do you believe that you can do anything by yourself to preserve a good health?' with the optional answers 'Yes, to a very high extent', 'Yes, to some extent' and 'No, own achievements not important'.

### *Sex*

The analyses were stratified by sex.

### *Age*

Age was analysed as a continuous variable.

### *Country of birth*

Country of birth was defined as born in Sweden or other country.

### *Socio-economic status*

SES (by occupation and relation to labour market) entails non-manual employees in higher, medium and lower positions, skilled and unskilled manual workers and self-employed/farmers. The categories outside the workforce entail the unemployed, students, early retired (before the age of 65 years), long-term sick leave, pensioners aged younger than 65 years and unclassified.

### *Marital status*

Marital status had four alternatives: married/cohabitating (partnership), unmarried, divorced and widow/widower.

### *Tobacco smoking*

Tobacco smoking was assessed with the question 'Do you smoke?' with the alternatives daily, non-daily and non-smoker.

### *Alcohol consumption*

Alcohol consumption was assessed with the question 'How often during the past twelve months have you been drunk?', with the alternatives 'daily or almost daily', 'several occasions per week', 'once per week', '2–3 times per month', 'once per month', 'once or a few times per half year' or 'more seldom or never'.

### *Leisure-time physical activity*

LTPA was assessed with the following four alternatives: regular exercise (at least three times per week at least 30 min/occasion, leading to sweating), moderate regular exercise (exercising once or twice per week at least 30 min/occasion, leading to sweating), moderate exercise (walking, cycling or equivalent activity status in leisure time less than 2 h walking, cycling or equivalent activity/week) and sedentary status (less than 2 h walking, cycling or equivalent activity/week). The three first alternatives were dichotomized as high LTPA and the fourth as low.

### *Intake of vegetables and root vegetables*

Intake of vegetables and root vegetables (except potatoes but including fresh, frozen, conserved, cooked, juices, soups) was assessed with 'How often do you eat vegetables and root vegetables?' with the alternatives 3 times/day or more, 2 times/day, once/day, 5–6 times/week, 3–4 times/week, 1–2 times/week and a few times per month/never.

### *Intake of fruits and berries*

Intake of fruits and berries was assessed with a corresponding question and the same alternative answers.

### *Statistical analyses*

Sex-stratified prevalence (%) of all variables was calculated (not shown in tables).

Hazard rate ratios (HRRs) with 95% confidence intervals (95% CIs) of mortality according to each survey variable at baseline were calculated in bivariate survival (Cox regression) models (not shown in tables). The multiple survival (Cox-regression) models calculating associations between HLC and mortality were adjusted for age (model 1), age, country of birth, SES and marital status (model 2) and model 2 + tobacco smoking, alcohol consumption, LTPA and consumption of vegetables and fruit/berries (model 3) (Table 1). Calculations were performed with SPSS software, version 25.0.

### *Results*

Among men, 68.0% reported high, 28.9% to some extent and 3.1% no internal HLC. The corresponding prevalence among women was 71.0%, 27.2%, and 1.8%, respectively. Distribution of country of birth, SES and marital status has been reported previously.[6] The prevalence of low LTPA was 13.4% among men and 10.3% among women. Among men, 11.9% were daily and 4.9% non-daily smokers and among women 15.0% and 4.7%, respectively. A total 48.8% of men and 70.7% of women had been drunk less than once/half year or never. A total 63.2% of men and 78.4% of women reported intake of vegetables once/day or more. A total 57.9% of men and 77.2% of women reported intake of vegetables once/day or more (not shown in table).

Among men, unemployed and respondents on long-term sick leave, unmarried, divorced and widowers, daily and non-daily smokers, low LTPA and more than one few occasions/half-year of being drunk had significantly higher HRRs (compared with higher non-manual employees, married/cohabitating, non-smokers, high LTPA and daily/almost daily drunk, respectively). The same patterns were observed for women, with the exception that unmarried, divorced and widowed women did not significantly differ from married/cohabitating women, while women with intake of fruit/berries less than once/day had higher HRRs (not shown in table).

Table 1 shows that in the age-adjusted model, the HRRs (95% confidence interval [CI]) of mortality were 1.66 (1.36–2.04) among men with some internal HLC and 3.25 (2.34–4.51) among men with no internal HLC compared with the control group of men with high

**Table 1**
Hazard rate ratios (HRRs) with 95% confidence intervals (95% CI) of 5.3-year mortality 2008–2013 according to health locus of control (HLC), adjusted for age (model 1), age, country of birth, SES and marital status (model 2) and age, country of birth, SES, marital status, tobacco smoking, alcohol consumption, leisure-time physical activity, vegetables/root vegetables consumption and fruit/berries consumption (model 3). All models stratified by sex. The public health survey in Scania 2008. $N = 10,757$ men (of which 421 died in 2008–2013) and $N = 12,322$ women (of which 235 died in 2008–2013), aged 18–80 years.

| HLC | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | HRR (95% CI)[a] | HRR (95% CI)[b] | HRR (95% CI)[c] |
| **Men** | | | |
| Yes, to a high extent | 1.00 | 1.00 | 1.00 |
| Yes, to some extent | 1.66 (1.36–2.04) | 1.61 (1.32–1.98) | 1.43 (1.16–1.76) |
| No, own achievement not important | 3.25 (2.34–4.51) | 3.04 (2.18–4.23) | 2.03 (1.42–2.90) |
| **Women** | | | |
| Yes, to a high extent | 1.00 | 1.00 | 1.00 |
| Yes, to some extent | 1.35 (1.03–1.78) | 1.34 (1.01–1.76) | 1.07 (0.80–1.42) |
| No, own achievement not important | 4.71 (3.08–7.20) | 4.51 (2.94–6.90) | 2.52 (1.59–4.00) |

HLC, health locus of control; SES, socio-economic status.
[a] Model 1 adjusted for age.
[b] Model 2 adjusted for age, country of birth, SES and marital status.
[c] Model 3 adjusted for age, country of birth, SES, marital status, tobacco consumption, alcohol consumption, leisure-time physical activity, vegetables/root vegetables consumption and fruit/berries consumption.

internal HLC. In final multiple-adjusted model (model 3) including all variables, the HRRs were reduced to 1.43 (1.16–1.76) among men with some internal HLC and 2.03 (1.42–2.90) among men with no internal HLC. The HRRs (95% CI) of mortality were 1.35 (1.03–1.78) among women with some internal HLC and 4.71 (3.08–7.20) among women with no internal HLC, compared with the female control group. In the final multiple-adjusted model (model 3), the HRRs were reduced to 1.07 (0.80–1.42) among women with some internal HLC and 2.52 (1.59–4.00) among women with no internal HLC. For both men and women, the main reduction in the HRRs was observed in model 3 compared with model 2.

## *Discussion*

HLC was significantly associated with mortality in the initial models, but the introduction of health-related behaviours in the final model substantially reduced all HRRs so that the association became statistically not significant for women who perceived internal HLC to some extent. For men who perceived internal HLC only to some extent, the HRR was reduced, although still significant. For men and women with no internal HLC, the associations remained strong (although reduced) and statistically significant in the final model, which suggests that for the group with no HLC other factors than health-related behaviours may also be involved. This no internal HLC group should be further investigated**.** Medication and treatment adherence[7] and coping strategies with regard to chronic conditions and diseases[8] have been suggested to also be influenced by internal HLC. The results for the considerably larger group with only some internal HLC confirm the notion that HLC mainly affects mortality through the four major health-related behaviours. HLC is a predictor of mortality, and this association is to an important extent mediated by health-related behaviours. No previous study has, to our knowledge, investigated HLC and mortality. For the broader group with somewhat decreased internal HLC, health-related behaviours seem to mediate the association. For the smaller group which lacks internal HLC, other factors such as medication and treatment adherence and coping strategies related to chronic conditions and diseases may be important.

This study is large, population based and prospective. The representativity of sociodemographic variables was satisfactory in the baseline survey. Consequently, the risk of selection bias is limited.[9] Mortality patterns and levels according to age and sex are in accordance with the general Swedish population in the early 2010s (not published). The age and sex variables and the mortality data stem directly from the national population register and the national cause of death register, which have very high validity. The HLC item is regarded as valid.[5,10] Relevant covariates were included.

HLC was significantly associated with mortality in the initial models, but the introduction of the health-related behaviours in the final model reduced all HRRs to such an extent that the association became statistically not significant for women who only perceived internal HLC to some extent. For men and women with no internal HLC, the associations still remained strong and statistically significant.

## Author statements

### *Ethical approval*

Ethical approval was granted by the Ethical Committee (etikprövningsnämnden) in Lund, Sweden.

### *Funding*

None declared.

### *Competing interests*

There are no conflicts of interest.

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Public Health 185 (2020) 364–367

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Human mobility and coronavirus disease 2019 (COVID-19): a negative binomial regression analysis

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ARTICLE INFO

*Article history:*
Received 29 April 2020
Received in revised form
2 July 2020
Accepted 2 July 2020
Available online 10 July 2020

*Keywords:*
Human mobility
COVID-19
Airports
Schengen countries

ABSTRACT

*Objectives:* This study aimed to examine the link between human mobility and the number of coronavirus disease 2019 (COVID-19)–infected people in countries.
*Study design:* Our data set covers 144 countries for which complete data are available. To analyze the link between human mobility and COVID-19–infected people, our study focused on the volume of air travel, the number of airports, and the Schengen system.
*Methods:* To analyze the variation in COVID-19–infected people in countries, we used negative binomial regression analysis.
*Results:* Our findings suggest a positive relationship between higher volume of airline passenger traffic carried in a country and higher numbers of patients with COVID-19. We further found that countries which have a higher number of airports are associated with higher number of COVID-19 cases. Schengen countries, countries which have higher population density, and higher percentage of elderly population are also found to be more likely to have more COVID-19 cases than other countries.
*Conclusions:* The article brings a novel insight into the COVID-19 pandemic from a human mobility perspective. Future research should assess the impacts of the scale of sea/bus/car travel on the epidemic. The findings of this article are relevant for public health authorities, community and health service providers, as well as policy-makers.


## Introduction

The globalized world, in which the scale of the movement of people is at unprecedented scale[1] is susceptible to the spread of diseases on a global scale. With sophisticated transport networks that have increased reach, the speed of travel, and the volume of passengers, 'pathogens and their vectors can now move further faster and in greater numbers than ever before'.[2] The global spread of coronavirus disease 2019 (COVID-19) that has led to the infection, and deaths, of thousands of people at a rapid scale, is indicative of how infectious diseases can become a global health problem that have the ability to reach more people, and at a faster rate, in an increasingly globalized world.

### *Human mobility and the spread of diseases*

Throughout history, in addition to human migration, trade caravans, religious pilgrimages, and military maneuvers played a central role in the spread of diseases.[3] During the Middle Ages, trade routes between Europe and Asia were instrumental in the spread of the plague into Europe.[4] In the 1500s, the population of the New World suffered from infectious diseases brought by European explorers. The second voyage of Christopher Columbus to the Caribbean in 1493 brought smallpox to the region. In the 1518 smallpox epidemic, thousands of indigenous inhabitants of the Caribbean region died.[5] In the 16th and 17th centuries, ships from Africa not only brought slaves but also smallpox and fever-carrying mosquitoes to the New World.[4] Overall, the pathogens carried by migrants had devastating consequences for native Americans who had no immunity for them.

The confluence of American troops with European and African troops in France, and the development of new virus strains, created a permissive environment for the 1918 influenza pandemic that resulted in the deaths of approximately 40 million people in a year.[6]

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https://doi.org/10.1016/j.puhe.2020.07.002
0033-3506/

The 1957 pandemic that erupted in China spread to the world within six months.[2] In 1972, a smallpox epidemic erupted in the autonomous province of Kosovo of (the then named) Yugoslavia on April 11th 1972. Epidemiologic and serologic investigations revealed that smallpox was imported to Yugoslavia from a hajj pilgrim who had visited Mecca and returned to the country by bus via Iraq (where smallpox cases were reported at the time). As a result of the smallpox outbreak, 175 people were infected, among which 35 people died.[7]

Global travel, given the unprecedented volume, speed, and reach, is an important factor in the rapid spread of current diseases.[8] The study by Olsen et al.[9] indicates that many severe acute respiratory syndrome (SARS)-infected people traveled on commercial aircraft. The study further revealed that after one flight carrying 120 people (among which one person was symptomatic), SARS developed in 16 people. Illness in passengers was related to the physical proximity to the symptomatic person.

*Human mobility and COVID-19*

While SARS spread to 37 countries (8000 cases) and Middle East respiratory syndrome (MERS) spread to 27 countries (2494 cases),[10] COVID-19 has spread to more than 200 countries and infected more than a million people in the world, initiating an unprecedented global crisis. Wuhan, the epicenter of the pandemic, is central China's major air and train transportation hub. As of 2019, in Wuhan, international outbound air travel constituted 13.5% of all outbound air travel, whereas the top 40 domestic outbound air routes constituted 81.3%. High air and train traffic across China due to the lunar new year Spring Festival, that started on January 10th 2020, appeared to have played a facilitating role in the spread of COVID-19 throughout the country and abroad.[10]

The first COVID-19 case outside China (a traveler from Wuhan) was reported to the WHO by the Thai government on January 13th 2020.[11] Three days later, the Japanese government informed the WHO of its first confirmed infection in a traveler from Wuhan.[12] Strikingly, owing to China's lockdown of the coronavirus-hit Hubei province on January 23rd, many people left Wuhan, which has resulted in the spreading of the diseases in and outside China.[13] Soon afterward, India, Philippines, Russia, Spain, Sweden, and the UK confirmed their first cases.

Based on the findings of the previous literature and the current trends in the spread of COVID-19, we hypothesize that in countries in which there is a high mobility of people, the number of COVID-19–infected people are correspondingly higher. We also hypothesize that there is a positive association between high numbers of airports in a country and high numbers of COVID-19–infected patients, and that Schengen countries are more likely to have higher numbers of COVID-19–infected patients than non-Schengen countries.

## Methods

*The dependent variable*

The dependent variable of this study is the number of COVID-19–infected people. The data on COVID-19 cases are extracted from the official site of WHO published as of April 3rd 2020.[14] We analyzed 144 countries for which the complete data on independent and control variables are available.

It should be noted that our dependent variable consists of cases that are reported to the WHO. Depending on the late development of/lack of testing equipment and the numbers of tests administered to individuals, the actual number of COVID-19–infected people in countries might be much higher. Lack of adequate testing, or some cases, any testing, in many countries might be affecting the availability and accuracy of data. For instance, the full impact of COVID-19 on India (the world's second most populous nation), Indonesia (the world's fourth most populous nation), African nations, and various smaller countries remains unknown. This constitutes a limitation to our study. As COVID-19 is reported to have emerged in China and then spread to other countries, we do not include China in our analysis.

*Independent variables*

We operationalize human mobility by looking at the number of airline passengers carried into the countries. The data are extracted from World Development Indicators.[15] Airline passengers include both domestic and international aircraft passengers of air carriers registered in the country. We note that the most recent data on the airline passengers is from 2018. Although the data does not correspond to actual human mobility as of 2020, we assume that the pattern of air travel is unchanged until the start of the pandemic. We measure airport numbers and the Schengen system as factors that facilitate human mobility. The data on airport numbers are extracted from the World Factbook of the Central Intelligence Agency.[16] We code Schengen countries as 1 and 0 otherwise.

*Control variables*

We control for population density in our analysis. In countries with high population density, people have contact with large numbers of people which facilitate person-to-person spread of many infectious diseases.[17] Furthermore, the elderly people are more susceptible to infections 'because of waning cell-mediated immunity and impaired host defenses but also because of chronic diseases and use of drugs and treatments that may be immunosuppressive'.[17] By bearing in mind the fact that there is no scientifically established relationship between immunity and the risks of contracting COVID-19 disease, we control for the percentage of elderly people in population our analysis. The data on population density and the percentage of elderly people (65 years and older) are extracted from World Development Indicators.[18]

*Model specification*

To analyze the variation in COVID-19–infected people across countries, we use negative binomial regression (NBR) model. NBR is based on the Poisson-gamma mixture distribution. It is useful for predicting count-based data. We choose this method because our dependent variable (the number of COVID-19–infected people) consists of only non-negative integer values and the variance of the dependent variable is greater than the mean.

The dependent variable is substantially positively skewed and kurtotic (skewness = 6.002, kurtosis = 43.308). Owing to the non-normal, highly-skewed and non-continuous nature of the dependent variable, standard linear regression techniques (such as ordinary least squares regression) are not suitable for this data set. Therefore, Poisson regression (PR) is the first-choice modeling technique and can be defined as follows:

$$P(Y_i = y_i) = \frac{\mu_i^{y_i} \exp(-\mu_i)}{y_i!} \quad (1)$$

where $P(.)$shows the probability of $Y$ infected people observed in the $i^{th}$country over a specified time period (until April 3rd). $y_i$ can take the values 0,1,2,… and $\mu_i$denotes the expected COVID-19–infected frequency for country $i$. In PR model, the expected

COVID-19–infected frequency ($\mu_i$ parameter) is estimated as a function of the vector of exploratory variables $x_i$ such that:

$$\ln(\mu_i) = x_i^T \beta \quad (2)$$

where $\beta$is a vector of estimated coefficients of exploratory variables including the percentage of elderly people in population, the logarithm of the population density, the number of airline passengers, the number of airport, and the Schengen system. The vector of coefficients is then estimated by maximizing the logarithm of the likelihood function given below.

$$\ln L(\beta) = \sum_i \left[ -\exp\left(x_i^T \beta\right) + \left(x_i^T \beta\right) y_i - \ln y_i! \right] \quad (3)$$

One of the important properties of the Poisson distribution is that the mean and the variance are equal to the $\mu_i$parameter. However, the assumption of identical mean and variance was not satisfied for the data used in this study ($\mu = 5,498.25$ and $\sigma = 21,577.85$). The greater ratio of variance to mean leads to overdispersion frequently caused by heterogeneity among observations. Thus, we apply NBR to overcome this problem of overdispersion. A gamma-distributed error term is added to Eq (2) to relax the PR assumption by including additional randomness.

$$\ln(\mu_i) = x_i^T \beta + \varepsilon_i \quad (4)$$

where $\varepsilon_i$follows gamma distribution with mean 1 and variance $\alpha$. The NBR distribution has a mean $\mu_i$and variance $\mu_i + \alpha\mu_i^2$, where $\alpha$is the overdispersion parameter used as a measure of dispersion. In analyzing the variation in the dependent variable, the following model is considered:

$$\begin{aligned} &\ln(\text{Num.of.COVID19 infected}) \\ &= \beta_0 + \beta_1 * (\text{old}) + \beta_2 * \left(\text{log\_popdensity}\right) + \beta_3 * (\text{log\_airtransfer}) \\ &+ \beta_4 * (\text{log\_}\textit{airportnumber}) + \beta_5 * (\text{Schengen}) \end{aligned}$$

## Results

Table 1 shows the estimates of model parameters ($\widehat{\beta}$), standard errors (Std Err of $\widehat{\beta}$), 95% confidence interval (CI) for the $\widehat{\beta}$ by profiling the likelihood function, incident rate ratios (IRRs) and goodness-of-fit statistics such as Cragg–Uhler pseudo-$R^2$, logarithmic likelihood, and Akaike information criteria (AIC).

The estimated coefficients of all variables used in this study are statistically significant (at least 95% confidence level) and in the positive direction. Countries that have higher volume of airline passengers (IRR = 3.161, $P < 0.01$); higher number of airports (IRR = 2.607, $P < 0.01$), higher population density (IRR = 2.403, $P < 0.01$), higher percentage of elderly population (IRR = 1.068, $P < 0.05$), and Schengen countries (IRR = 4.498, $P < 0.01$) are found to be more likely to have higher numbers of COVID–19 infected cases than other countries (see also Figure 1 in supplementary material).

**Table 1**
Estimation results of negative binomial regression.

| Variables | Estimate | Std err of $\widehat{\beta}$ | Conf. Int. of $\widehat{\beta}$ | IRR |
|---|---|---|---|---|
| Intercept | −5.203*** | 0.763 | (-6.649, −3.699) | 0.005 |
| Air transfer | 1.151*** | 0.138 | (0.901, 1.394) | 3.161 |
| Airport number | 0.982*** | 0.204 | (0.549, 1.401) | 2.670 |
| Schengen | 1.503*** | 0.431 | (0.622, 2.383) | 4.498 |
| Population density | 0.876*** | 0.216 | (0.308, 1.422) | 2.403 |
| Old | 0.066** | 0.025 | (0.017, 0.119) | 1.068 |
| Dispersion parameter | 0.567 | 0.058 | | |
| Pseudo-$R^2$ | 0.76 | | | |
| Log.Lik. | −1049.602 | | | |
| AIC | 2113.20 | | | |

[a] Schengen = 0 is taken as reference category; IRRs, incident rate ratios; AIC, Akaike information criteria.
*$P < 0.1$, **$P < 0.05$, ***$P < 0.01$.

## Discussion

This study answers the question of why some countries have higher numbers of COVID-19–infected people compared with others. Analysis of the data suggests a link between the scale of human mobility and the number of COVID-19 patients in countries. Our results indicate a positive association between the magnitude of airline travel and high numbers of COVID-19–infected patients. Furthermore, we find that countries which have higher number of airports, Schengen countries, countries which have higher population density and higher percentage of elderly population are found to be more likely to have more COVID-19 cases than other countries.

The quick spread of COVID-19 appears to be propelled by 'superspreading'. Superspreading refers to heightened transmission of the disease to at least eight contacts and has been observed for several infectious diseases including SARS, MERS, and influenza.[19] Our study suggests that better connected areas are more likely to be infected first and have more infections initially (but it is still too early to report the potential consequences on less well-connected areas that may become infected in due course).

There are a number of limitations in this article. Although we measured human mobility by looking at the volume of air travel, future studies can provide a comprehensive analysis on the impact of sea/bus/train/car travels on the spread of COVID-19. Patients zero and their travel history will provide important insights into cross-country comparisons. In addition, when a virus arrives in a country, its contagion and spread hinges on local transmission pathways and public health provision.[19] Efforts and (relative) successes of countries in handling the COVID-19 crisis should be analyzed in a comparative manner. Furthermore, we note that certain emerging trends might influence general applicability of the findings as we move into the future. For example, in addition to the reduced volume of travel, increased testing and future development of vaccines might also affect the applicability of the findings with passage of time.

Previous studies found that airport screening measures failed in halting the spread of viruses.[20] In the context of superspreading of COVID-19, airports are more likely to be rearranged so as to minimize the risk of contagion. Researchers should contemplate on new techniques and methods at airports for the maximum safety of passengers and staff against pandemical diseases. There are also issues that urgently need to be further studied, such as the link between public health provision and COVID-19 mortality rates. Our study indicates a positive relationship between the percentage of elderly population and COVID-19 cases. Recent developments reveal that the virus has the potential to affect all age cohorts. Future studies can comparatively examine the spread and the mortality rate of COVID-19 in countries with younger population and those with aging populations. Psychological impacts of the COVID-19 pandemic also need to be systematically studied. The long-term implications of the COVID-19 pandemic on countries' health systems and global health policymaking and management strategies will also provide interesting avenues of research for further researchers.

## Author statements

*Acknowledgements*

We would like to thank the two anonymous reviewers and editors of Public Health for their constructive comments.

*Ethical approval*

None sought.

*Funding*

None sought.

*Competing interests*

None sought.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.07.002.

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Public Health 185 (2020) 53–54

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/puhe

Letter to the Editor

# Human rights during the COVID-19 pandemic: the issue of female genital mutilations

While severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected millions and claimed more than 250,000 lives, experts are warning that the impact of other diseases neglected owing to the pandemic may be just as significant in the months and years to come. Specifically, when health systems are overwhelmed and people refrain from visiting health facilities owing to movement restrictions or fears of exposure to illness, both direct mortality and indirect mortality from preventable and treatable conditions increase.[1–3]

Female genital mutilation (FGM), also named female genital cutting, is acknowledged as a violation of human rights of women.[4] The United Nations Sustainable Development Goals called for the elimination of the practice by 2030.[5] FGM is referred to as any procedure involving the alteration or excision of external female genitalia without medical indication,[6] and three million women in the world are estimated to be at risk of undergoing this procedure annually.[6] It is a major public health problem in several countries in Africa and the Middle East,[6,7] being almost universal in seven African countries (prevalence >85%).[6] A report from the United Nations Children's Fund highlighted how this practice is still being widely carried out in 29 countries in Africa and in the Middle East, despite the fact that at least 24 of these countries have legislation or some form of decrees against FGM.[8] However, some evident progress is ongoing: under the new FGM amendment to the criminal law in Sudan that was approved very recently (April 22, 2020), anyone who performs FGM either inside a medical establishment or elsewhere faces three years of imprisonment and a fine.[9]

Studies conducted in different settings have clearly shown an adverse effect of FGM on psychological, sexual and reproductive health, leading to unfavourable outcomes.[10] This includes post-traumatic stress disorder,[11] dyspareunia and genitourinary complications. Adverse obstetric outcomes, such as increased risk of caesarean delivery, episiotomy and postpartum haemorrhage, are also more frequent.[12] Scar tissue, especially in women with FGM type III (infibulation) can result in obstructed labour or obstetric trauma.[13]

It is known that in situations of conflicts and disaster, gender inequality, gender-based violence and violation of human rights are likely to increase as the protection and health system are disrupted, leaving acts of violence unpunished and condoned by the societies. This applies to health emergencies as well, including the current coronavirus disease 2019 (COVID-19) pandemic. FGM, early marriage and violence against women and girls are life-threatening, health and human rights challenges, owing to unequal relations and patriarchal rules.[14] Survivors are left no choice or right of determination over their bodies, be it physical, sexual and reproductive health.

Estimates provided by Avenir Health, Johns Hopkins University (USA) and Victoria University (Australia) predict that significant levels of lockdown-related disruption over 6 months may cause significant delays in programmes to end FGM, potentially leading to around two million more cases of FGM over the next decade than would otherwise have occurred.[15] These striking figures become even more daunting when compounded with the expected additional 31 million cases of gender-based violence and the 13 million more child marriages over the next 10 years.[15] Support to continued access to reproductive healthcare services and protection of the rights and dignity of all women and girls remain even more critical in contexts such as the current pandemic. To do so, preparedness and response plans must incorporate and integrate FGM in gender-based violence and sexual and reproductive health programmes, including community awareness initiatives and activities, thus ensuring risk mitigation as well as remote and mobile case management.

Last but not least, participation of girls and women in decision-making for COVID-19 preparedness and response is fundamental to ensure that their perspectives are heard and represented at the central, subnational and local level.

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12 May 2020
Available online 25 May 2020

Public Health 185 (2020) 93–94

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Letter to the Editor

# Impact of nutritional status and anemia on COVID-19: Is it a public health concern? Evidence from National Family Health Survey-4 (2015–2016), India

The coronavirus disease 2019 (COVID-19) pandemic has now extended over the entire world, and has emerged as a prime public health threat. As of date 31st May, the total number of COVID-19 cases was approximately 6 million with about 0.36 million deaths over the world.[1] In India, the number of confirm cases are increasing day by day. As of date 31st May, the total number of confirmed COVID-19 cases in India was 190,535 with more than 5000 deaths.[2] The number of COVID-19 cases continues to rise, which requires an emergency public health response to combat the severity of the COVID-19 pandemic in India. The number of COVID-19 cases in India are not uniformly distributed, rather there are some hotspots where the maximum number of COVID-19 cases are recorded. A few major hotspot states were identified where the maximum number of COVID-19 cases were recorded to date. The major hotspot states were Maharashtra, Tamil Nadu, Delhi, Gujarat, and Rajasthan, respectively. More than 33% of the total COVID-19 cases were documented in Maharashtra, followed by 11% in Tamil Nadu, 9% in Delhi, 8% in Gujarat, and 4% in Rajasthan. More than 60% of the total COVID-19 cases were recorded from these five states in India. Now the basic question that arises in this context is why such high numbers of COVID-19 cases were recorded in these states. Recently, a number of research studies showed that COVID-19 is largely determined by a number of socio-environmental factors, such air temperature,[3–7] humidity,[8–10] environmental pollution[11] and smoking.[12] But to date, no study has assessed the impact of health status (e.g. nutritional status and anemia) on COVID-19. Considering this recent research gap, in this letter, we made an attempt to assess the impact of health status i.e. nutritional status and anemia on COVID-19 over the hotspot states in India. The data were collected from the National Family Health Survey- 4 (2015–2016). In many recent studies, health status of the people has an impact on COVID-19.[15–21] But the impact of nutritional status and anemia on COVID-19 remain unexplored.

The result of the study showed that the percentage of adults with below normal body mass index (BMI) (<18.5 kg/m$^2$) recorded higher in hotspot states as compared with others. For example, the average percentage of adults with BMI below normal was more than 20% in Maharashtra, Gujarat, and Tamil Nadu. BMI below normal indicates malnutrition and eating disorder condition. The result recorded that Gujarat had the highest percentage of women (27.2%) and men (24.7%) adults with below normal BMI (<18.5 kg/m$^2$) followed by Rajasthan (27% women and 22.7% men) and Maharashtra (23.5% women and 19.1% men). On the other hand, the highest percentage of adults (both male and female) with overweight or obesity was found in Tamil Nadu (29.55%) followed by Delhi (29.05%) and Maharashtra (23.6%). The percentage of adults with below normal BMI or obesity were very low where COVID-19 cases were low, such as in Arunachal Pradesh, Sikkim, and Mizoram. So, is there any relation between nutritional status and outbreak of COVID-19 cases? If the answer is 'YES', then it is really a big concern. The nutritional status of 'BIMARU' states (Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh) and the States included in 'Empowered Action group' (such as Rajasthan, Bihar, Uttar Pradesh, Madhya Pradesh, Odisha, Chhattisgarh, Uttaranchal, and Jharkhand) are not satisfactory. Even public health facilities remained big issues in these states.[13,14] If there is any relation between nutritional status and COVID-19 outbreak then it not a good indicators in accordance with NFHS-4 (National Family Health Survey-4) data. In recent studies it was well recognized that there is an impact of nutrition on COVID-19.[15–19]

The percentage of anemia among adults was highest in Gujrat (38.3%) followed by Delhi (37.95%), Tamil Nadu (37.75%), Maharashtra (32.8%), and as compared with those states where COVID-19 cases are relatively low such as Sikkim, Arunachal Pradesh, and Mizoram. The highest percentage of men and women with anemia was found in Gujrat (21.7%) and Tamilnadu (55.3%) among hotspot states. It is also really a great public health concern because many studies recorded the relationship between anemia and respiratory disease[20,21] such as COVID-19. It is again a big public health concern because the states under the notion of 'BIMARU' and 'EAG' are the most vulnerable. The percentage of adults with anemia is high in these states such as Uttar Pradesh (38.05%), Bihar (46.3%), Jharkhand (47.55%), Odisha (39.84%), and Madhya Pradesh (39.5%), as compared with Goa (21.15%), Manipur (18.45%), Nagaland (19.9%), and Sikkim (25.3%) where COVID-19 cases are relatively low.

From the overall analysis, it was clear that nutritional status and anemia has an impact on COVID-19 cases over the hotspot states of India. The results of the study showed that adults with below normal BMI, overweight or obesity, and anemia are the most vulnerable to COVID-19. From the data collected from NFHS-4 (2015–2016) and previous literature, it was well recognized that nutritional status and anemia had an impact on respiratory diseases such as COVID-19. The study was performed over the (five) hotspot states of India from where more than 60% of COVID-19 cases were recorded. The outcome of the study is not only a big public health concern for the hotspot states, but also for those which are likely to be hotspots in upcoming days. The percentage of adults with below normal BMI, overweight or obesity, and

https://doi.org/10.1016/j.puhe.2020.06.001

anemia are also high in states such as Rajasthan, Bihar, Uttar Pradesh, Madhya Pradesh, Odisha, Chhattisgarh, Uttaranchal, and Jharkhand. Although a number of initiatives were adopted by the Government of India, including Indian Council of Medical Research at the national level and implemented several public health measures to combat the COVID-19 pandemic under the World Health Organization's guidelines, an effective emergency public health response is urgent to mitigate the severity of the disease for hotspot states, as well as those states that are likely to be hotspots in the upcoming days.

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1 June 2020
Available online 9 June 2020

Public Health 185 (2020) 381–385

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/puhe

Original Research

# Maternal body mass index, smoking status and small for gestational age: an Australian retrospective cohort study

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ARTICLE INFO

*Article history:*
Received 10 March 2020
Accepted 13 May 2020
Available online 2 August 2020

*Keywords:*
Maternal obesity
Maternal smoking
Small for gestational age

ABSTRACT

*Objectives:* Both maternal body mass index (BMI) and smoking during pregnancy have been associated with a range of adverse maternal and infant birth outcomes. This study aimed to identify whether these independent variables had an interacting relationship with small for gestational age in an Australian obstetric cohort.

*Study design:* A retrospective cohort design used data from the Birthing Outcomes System of a major tertiary hospital in Australia.

*Methods:* A total of 14,487 singleton births between January 2008 and December 2013 were included in the analysis. Chi-squared tests and one-way analysis of variance were used for the comparison of categorical and continuous variables, respectively. Adjusted odds ratios (AORs) were calculated to determine the association of smoking status with the outcome variable of interest, and these are reported for each maternal BMI category.

*Results:* Of the 14,487 women, 716 (4.9%) were underweight (BMI $\leq$18 kg/m$^2$), 7268 (50.2%) had healthy weight (BMI = 19–24 kg/m$^2$), 3658 (25.3%) were overweight (BMI = 25–29 kg/m$^2$), 1558 (10.8%) had class I obesity (BMI = 30–34 kg/m$^2$), 711 (4.9%) had class II obesity (BMI = 35–39 kg/m$^2$) and 576 (3.9%) had class III obesity (BMI = 40+ kg/m$^2$). Of all women, 10.8% reported being current smokers, 82.0% reported to have never smoked and 4.0% reported to have stopped smoking during or before pregnancy. Smokers with a BMI $\geq$40 kg/m$^2$ were 4.5 (AOR = 4.508; 95% confidence interval: 2.068–9.828) times more likely to give birth to a small-for-gestational-age infant than non-smokers within the same BMI category. This increased risk was not observed in women who ceased smoking before or during pregnancy.

*Conclusions:* Our study supports the efficacy of antismoking policies within maternal public health. In addition, greater support with respect to smoking cessation is indicated for women during pregnancy with an elevated BMI.



## Introduction

Globally, high body mass index (BMI) is a major public health challenge mirrored in Australia, where over the last 30 years, a steady rising prevalence of overweight and obesity has occurred. Perhaps, of greater concern is the increasing incidence of obesity in young women.[1] The Australian Health Survey reported 42.4% of women, aged 25–34 years, being overweight or obese.[2] Maternal obesity has been shown to increase the risk of caesarean section,[3] hypertensive disorders of pregnancy,[3] premature birth[4,5] and stillbirth.[6] Infants born to women with obesity are at increased risk of being small for gestational age and developing cardiovascular disease in the long term.[7] Numerous studies have demonstrated an increase in neonatal mortality associated with small-for-gestational-age (SGA) infants, defined as birthweight less than or equal to the 10th percentile for a given gestational age.[8] Prematurity, special care nursery admissions, intrapartum foetal compromise and cerebral palsy are more likely to be observed in SGA infants.[9]

In addition to maternal obesity, prenatal tobacco smoking remains one of the most common preventable causes of infant morbidity and mortality.[10,11] A meta-analysis conducted by Rayfield

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https://doi.org/10.1016/j.puhe.2020.05.029

and Plugge[12] included 39 studies with a total of 236,687 children from Asia, Europe, Australia and North and South America. Pooled adjusted odds ratios (AORs) demonstrated an elevated risk of maternal smoking in pregnancy for childhood overweight (OR = 1.37, 95% confidence interval [CI] = 1.28 to 1.46, $I_2$ = 45%) and childhood obesity (OR = 1.55, 95% CI = 1.40 to 1.73, $I_2$ = 24%). Maternal tobacco exposure affects nutrient and oxygen availability to the foetus through compromised maternal nutrient intake, absorption and placental transport capacity.[13–16] In contrast to non-smokers, women who smoke during pregnancy have up to a twofold increased risk of preterm birth and a 30% increase in stillbirth rates.[6] In Australia, a number of public health strategies have been implemented to reduce both tobacco smoke exposure and use in pregnant women.[17] Notwithstanding such efforts, between the years 2014 and 2015, 12.1% of Australian women still reported smoking tobacco daily.[18]

Despite the high prevalence of obesity and tobacco smoking during pregnancy, there is a paucity of evidence with regard to the differential effect of the combined influence of maternal pre-pregnancy BMI and smoking status on important foetal outcomes such as small for gestational age. A Chinese cohort study reported that passive smoking during pregnancy increased gestational diabetes mellitus risk in women independently and synergistically with pre-pregnancy obesity.[19] A retrospective study of an obstetric population in New Zealand identified maternal obesity and tobacco smoking as independent risk factors for birthing an SGA infant.[20]

To the best of our knowledge, no studies have conducted a simultaneous analysis of association between maternal pre-pregnancy BMI, smoking status and small for gestational age. Therefore, the aim of the present study was to examine the association between maternal pre-pregnancy BMI, smoking status and small for gestational age within an Australian obstetric population.

## Methods

### *Study design, setting, source of data and population*

The data for this retrospective cohort study were obtained from the Birthing Outcomes System (BOS) used by the tertiary institution where the study was conducted. This institution is the largest facility of its kind, servicing a catchment population of approximately 540,000. Between January 1, 2008, and December 31, 2013, there were 16,131 birth events recorded. Approximately 58% of women in this cohort presented in either their first or second trimester, with a further 3.0% presenting during their third trimester. The remaining cases either had implausible gestational ages recorded (15.7%) or no gestational age recorded (23.3%). Women who appeared more than once in the data set and having experienced more than one birth event during the study period were included in the study. Women with missing BMI data and variables of interest plus multiple pregnancies (twins and so on) were excluded, leaving 14,487 women for analysis.

### *Study variables and definitions*

Maternal pre-pregnancy BMI was calculated by either midwives or obstetricians from height and weight recorded at the woman's first antenatal consultation, which is routinely at 12–14 weeks of gestation. In the BOS, BMI values are rounded up or down to the nearest whole number according to scientific notation. BMI was categorised into six groups; underweight (≤18 kg/m$^2$); normal weight (19–24 kg/m$^2$); overweight (25–29 kg/m$^2$); obese class I (30–34 kg/m$^2$); obese class II (35–39 kg/m$^2$) and obese class III (40+ kg/m$^2$). All variables recorded in the BOS are classified using standard operating procedures developed by the tertiary institution where the study was conducted. Small for gestational age was calculated using Australian birthweight percentiles published by Dobbins et al.[21] Parity 0 was defined as a woman who has not yet birthed a baby, and parity 1 refers to a woman who has given birth to one baby.[21] Smoking status information is collected at a woman's first antenatal visit and routinely assessed by either obstetric staff or midwives throughout pregnancy.

### *Data analysis*

Continuous variables are reported as means ± standard deviations, and categorical variables are reported as frequencies (n) and relative frequencies (%). Chi-squared tests were performed to assess the association between categorical variables, and one-way analysis of variance was used for the comparison of continuous variables. AORs were calculated to determine the association of smoking status with outcome variables of interest, and these are reported for each maternal BMI category. The bivariate logistic regression models were adjusted for maternal age, relationship status, country of birth and parity. These were considered by clinicians as the most important and used in recent published articles on this topic.[3,19] Significance was set at the 5% level for two-tailed tests. Analyses were performed using Statistical Package for Social Sciences (SPSS) version 23 (IBM, Armonk, NY, USA).

## Results

Of the 14,487 women, 716 (4.9%) were underweight (BMI ≤18 kg/m$^2$), 7268 (50.2%) had healthy weight (BMI = 19–24 kg/m$^2$), 3658 (25.3%) were overweight (BMI = 25–29 kg/m$^2$), 1558 (10.8%) had class I obesity (BMI = 30–34 kg/m$^2$), 711 (4.9%) had class II obesity (BMI = 35–39 kg/m$^2$) and 576 (3.9%) had class III obesity (BMI = 40+ kg/m$^2$). Of all women, 10.8% reported being current smokers, 82.0% reported to have never smoked and 4.2% reported to have stopped smoking during or before pregnancy. Demographic data for this cohort can be found in Table 1.

AORs for birth outcomes comparing women who never smoked with those who ceased and were current smokers can be found in Table 2. When we compared women who reported to have never smoked with women who ceased smoking before or during pregnancy, no differences were detected in small for gestational age when adjusted for maternal age, relationship status, country of birth and parity. Current smokers compared with those women who reported to have never smoked were found to have at least 2-fold higher odds of birthing an SGA infant across all BMI categories. Women with a BMI of ≥40 kg/m$^2$ had the most significant increased risk of birthing an SGA infant, with an AOR of 4.51 (95% CI: 2.07–9.83).

## Discussion

This study identified that women with morbid obesity, who reported smoking at the time of delivery, were four and a half times more likely to give birth to an SGA infant than those women with morbid obesity who had never smoked. In addition, women with class I and II obesity who continued to smoke at 15 weeks of gestation had double the risk of having an SGA infant compared with women who ceased smoking. These findings suggest there could be an interaction between a high maternal pre-pregnancy BMI and smoking that increases the risk of giving birth to an SGA infant.

Interestingly, women who reported smoking cessation before 15 weeks of gestation had rates of birthing SGA infants similar to those of non-smokers. Small for gestational age has been found to be

**Table 1**
Sociodemographic characteristics of women stratified by maternal BMI ($n$ = 14,487).

| Characteristic | BMI ≤18 kg/m$^2$ (n = 716) | BMI, 19–24 kg/m$^2$ (n = 7268) | BMI, 25–29 kg/m$^2$ (n = 3658) | BMI, 30–34 kg/m$^2$ (n = 1558) | BMI, 35–39 kg/m$^2$ (n = 711) | BMI ≥ 40 kg/m$^2$ (n = 576) |
|---|---|---|---|---|---|---|
| **Smoking status** | | | | | | |
| Never, n (%) | 533 (74.4) | 6111 (84.1) | 2999 (82.0) | 1218 (78.2) | 560 (78.8) | 437 (75.9) |
| Ceased, n (%) | 28 (3.9) | 272 (3.7) | 142 (3.9) | 70 (4.5) | 31 (4.4) | 34 (6.0) |
| Current smoker, n (%) | 131 (18.3) | 643 (8.8) | 376 (10.3) | 226 (14.5) | 101 (14.2) | 92 (15.9) |
| Missing data, n (%) | 24 (3.4) | 242 (3.4) | 141 (3.8) | 44 (2.8) | 19 (2.6) | 13 (2.2) |
| **Maternal age** | | | | | | |
| Maternal age (years) | 28.46 (5.848) | 30.53 (5.405) | 30.79 (5.627) | 30.63 (5.805) | 30.85 (5.383) | 30.99 (5.565) |
| **Relationship status** | | | | | | |
| Single, n (%) | 120 (17.5)** | 625 (9.0)** | 360 (10.4)** | 183 (12.2)** | 86 (12.5)** | 63 (11.3)** |
| In a relationship (yes), n (%) | 565 (82.5)** | 6352 (91.0)** | 3116 (89.6)** | 1317 (87.8)** | 602 (87.5)** | 494 (88.7)** |
| **Country of birth** | | | | | | |
| Born outside of Australia, n (%) | 268 (38.8)** | 2288 (32.7)** | 904 (25.7)** | 302 (20.0)** | 103 (14.9)* | 58 (10.3) |
| **Indigenous status** | | | | | | |
| Non-Indigenous, n (%) | 665 (96.3)** | 6758 (97.9)** | 3361 (97.7)** | 1412 (96.4)** | 652 (96.4)** | 518 (95.4)** |
| Indigenous, n (%) | 25 (3.7)** | 143 (2.1)** | 80 (2.3)** | 53 (3.6)** | 24 (3.6)** | 25 (4.6)** |
| **Parity** | | | | | | |
| 0, n (%) | 351 (50.7)** | 3413 (48.6)** | 1475 (41.9)** | 628 (41.5)* | 243 (35.1) | 203 (36.1) |
| 1, n (%) | 215 (31.1)** | 2274 (32.4)** | 1200 (34.1)** | 484 (32.0)* | 228 (32.9) | 181 (32.1) |
| 2, n (%) | 77 (11.1)** | 927 (13.2)** | 536 (15.2)** | 233 (15.4)* | 116 (16.8) | 46 (8.2) |
| ≥3, n (%) | 49 (7.1)** | 412 (5.8)** | 306 (8.8)** | 169 (11.1)* | 105 (15.2) | 133 (23.6) |
| **Birth status** | | | | | | |
| SBL, n (%) | 5 (0.7) | 51 (0.7) | 16 (0.5) | 14 (0.9) | 6 (0.9) | 4 (0.7) |
| SDL, n (%) | 2 (0.3) | 30 (0.4) | 9 (0.3) | 6 (0.4) | 2 (0.3) | 2 (0.4) |
| Live born, n (%) | 685 (99.0) | 6945 (98.8) | 3492 (99.3) | 1494 (98.7) | 684 (98.8) | 557 (98.9) |
| **Birthweight status** | | | | | | |
| SGA, n (%) | 165 (23.9)** | 894 (12.8)** | 376 (10.7)** | 162 (10.7)** | 69 (10.0) | 53 (9.4)** |

*$P$ value < 0.05.
**$P$ value < 0.01.
$P$-values derived from the chi-squared test for categorical variables and one-way ANOVA for continuous variables.
ANOVA = analysis of variance; SGA = small-for-gestational age; SDL = stillborn during labour; SBL = stillborn before labour; BMI = body mass index.

associated with 5.8–30% of perinatal mortality in Australia and New Zealand.[21]

In our study, the reduction of SGA risk demonstrated in women who ceased smoking compared with those who continued smoking throughout pregnancy suggests that smoking cessation could be a highly effective antenatal strategy to reduce preventable infant morbidity and mortality.[22,23] However, data on the exact time of smoking cessation were not extensive enough to be further analysed in our study. Nevertheless, inclusion of women who reported ceasing smoking during pregnancy suggests that this behaviour may still be protective of adverse infant outcomes. From a public health perspective, cessation promotion should continue to target women who are currently pregnant and not just those of childbearing age. Interventions promoting smoking cessation have been successful in reducing the proportion of pregnant women who smoke, resulting in some improved pregnancy outcomes among women who quit smoking compared with those who continue. Despite this, in the general population, it is widely recognised that smoking cessation is associated with weight gain, with most of the gain occurring during the first 3 months after cessation.[24] Women who quit smoking before or during pregnancy may thus be at higher risk of excessive gestational weight gain (GWG). A study by Llambi et al.[25] reported that women who gave up smoking during the antenatal period increased GWG by 2.4 kg (95% CI = 1.3–3.4) after adjusting for pre-pregnancy BMI and other confounders in comparison with women who continued to smoke ($P$ < 0.001). GWG was slightly higher in women who quit smoking at any point during pregnancy. Although smoking cessation interventions during pregnancy should continue to be promoted, women who are successful in quitting smoking during the antenatal period should be provided with extra support as well as dietary and lifestyle interventions to facilitate appropriate weight gain.

Although the impact of maternal smoking on small for gestational age has been previously examined, there is comparatively little evidence as to the effect of smoking cessation on this adverse outcome. As such, this study contributes novel findings to the evidence base. Further investigation of the optimal methods to

**Table 2**
Adjusted odds ratios (AORs) for smoking status and small for gestational age, stratified by maternal BMI ($n$ = 14,487).

| BMI ≤18 kg/m$^2$ (n = 716) | BMI, 19–24 kg/m$^2$ (n = 7268) | BMI, 25–29 kg/m$^2$ (n = 3658) | BMI, 30–34 kg/m$^2$ (n = 1558) | BMI, 35–39 kg/m$^2$ (n = 711) | BMI ≥ 40 kg/m$^2$ (n = 576) |
|---|---|---|---|---|---|
| **Smoking status** | | | | | |
| **Never smoked vs. ceased smoker** (OR, 95% CIs) | | | | | |
| **Birthweight status** | | | | | |
| SGA 1.05 (0.259–4.27) | 0.847 (0.536–1.34) | 0.879 (0.430–1.80) | 1.27 (0.548–2.94) | 1.49 (0.477–4.65) | 1.58 (0.435–5.75) |
| **Never smoked vs. current smoker** (OR, 95% CIs) | | | | | |
| **Birthweight status** | | | | | |
| SGA 2.66 (1.42–4.99) | **3.14 (2.40–4.1)** | **1.92 (1.27–2.88)** | **2.03 (1.16–3.58)** | **2.37 (1.15–4.92)** | **4.51 (2.07–9.83)** |

Odd ratios and 95% confidence intervals from logistic models adjusted for maternal age, marital status, indigenous status, country of birth and parity. Statistical significance is indicated in bold text.
BMI = body mass index; CI = confidence interval; SGA = small-for-gestational age.

promote maternal smoking cessation to improve pregnancy outcomes is warranted.

### *Strengths and limitations*

Our study makes a significant contribution to the body of evidence that the combination of obesity and smoking during pregnancy is associated with an increased risk of having an SGA infant. The major strength of this research is the size of the cohort. The centralised data collection reduces potential bias within medical records as plausible risk factors and outcomes are routinely documented for women accessing antenatal services.

In our study, smoking status was included as a secondary exposure to maternal pre-pregnancy BMI and was only associated with small for gestational age. There are many potential explanations for this. First, in view of previous findings, maternal pre-pregnancy BMI might be an independent risk factor, and as such, it is not modified by smoking.

Data collected during antenatal care and recorded within the BOS may also risk an innate bias. Owing to the highly publicised adverse effects of smoking on health, it is possible that smoking is largely underreported by women in this cohort. Shipton et al.[26] found that reliance on self-reported smoking status underestimated true smoking by 25% in pregnant women living in Scotland. Furthermore, Dietz et al.[27] found that 22.9% of women who were actively smoking during pregnancy failed to disclose this behaviour.

In addition, the accuracy of data collection may also be impacted by the woman-practitioner relationship, the phrasing and understanding of questions, and potential assumptions made by health professionals. Although other approaches such as testing for exhaled carbon monoxide or urinary nicotine are potentially more reliable in assessing smoking status, these are associated with additional costs and time to both the healthcare system and burden on the pregnant woman herself. Furthermore, inconsistencies in coding of smoking status in terms of timing of smoking cessation and quantity of cigarettes smoked limited the depth and accuracy of analysis possible in this study. We were not able to test whether smoking had a dose-effective response when combined with maternal pre-pregnancy BMI or whether the timing of smoking cessation and quantity previously smoked modified the risk of small for gestational age. As such, standardised data collection procedures and uniformity in coding descriptions would be useful to provide more meaningful evidence.

Anthropometric measurements were taken, on average, at 12 weeks of gestation before any significant gestational weight change is typically observed. Nevertheless, these values are still only an approximation of pre-pregnancy BMI. We were not able to investigate the effects of GWG as such information is not regularly collected at the study hospital. We did not control for gestational hypertension in our analysis, a risk factor for small for gestational age, and this is an acknowledged limitation of our study.

The findings that smoking increases the risk of delivering an SGA infant and cessation reduces this risk affirm current public health messages in Australia.[17] Given that 10.8% of women in this cohort disclosed smoking currently, this is a figure that may be underreported and lower than that reported in other Australian surveys;[18] health promotion and its associated funding is still necessary to reduce preventable neonatal morbidity and mortality in Australia. Clinicians also have a responsibility to facilitate a safe and non-judgemental environment for expectant mothers to disclose participation in health risk behaviours and be equipped to support, motivate and enable these women to cease such behaviours.[28]

### *Conclusion*

In this study, a simultaneous analysis of maternal BMI and smoking status was conducted to identify whether these variables displayed an interaction that was associated with an effect on infant birthweight. Women who reported smoking throughout pregnancy were found to have a significantly increased risk of delivering an SGA infant compared with those who ceased smoking before or during pregnancy and those who had never smoked. In addition to affirming smoking cessation as an effective maternal public health action, this study advocates for the value of anthropometric measurements during the antenatal period, the need for screening tools to identify women at increased risk of obstetric complications and the need for standardised documentation within birth outcome–reporting systems.

## Author statements

### *Acknowledgements*

Only those who have made substantial contributions to the study and/or preparation of the MS have been made authors.

### *Ethical approval*

Ethical approval was granted by the Research Ethics and Governance Office that is responsible for the coordination and management of ethical and site governance review processes for the area health service (approval code = ETHLR.11.167).

### *Funding*

None declared.

### *Competing interests*

None declared.

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Public Health 185 (2020) 97–98

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Letter to the Editor

# Maternal mental health in India during COVID-19

On March 11, 2020, the World Health Organization declared the novel coronavirus disease 2019 (COVID-19) outbreak a global pandemic. This highly infectious disease spread across the world in a short span of time, infecting millions of people around the world. The affected countries are using different strategies to contain the spread of COVID-19. In the absence of effective treatment protocols and a vaccine, total lockdown of cities, even entire countries, and mandatory social distancing between people are presently the only means to slow the spread of the disease.

The rapid spread of COVID-19 has impacted many aspects of human life and activities. The drastic restrictions on economic activities have resulted in enormous economic losses and consequent loss of incomes and livelihood. Consequently, mental health of the population has become a public health concern and should be studied. Indeed, the outbreak has stimulated research on mental health concern.[1,2]

In the broader discourse on public health discourse, both maternal health and maternal mental health are usually overlooked. Maternal mental health is a public health problem in India. It is estimated that 10–35% of women around the world including India suffer from depression during pregnancy and postparum.[3,4] Pregnant women and new mothers are at an elevated risk of suffering from mental health problems. It has been observed that the uncertainty surrounding COVID-19 has led to higher levels of depression among women during and after pregnancy. Pregnant women may feel social isolation and have greater fear of infection for themselves, as well as their infants. Lack of health facilities and increasing number of home deliveries without the assistance of trained health workers heighten the distress and depression in these women. Owing to lack of sufficient and reliable evidence on the risk of transmission of infection of COVID-19 from mother to child, stress and depression among pregnant women and new mothers have increased.

India's public health facilities are burdened with patients being treated for COVID-19. Combined with the complete lockdown imposed throughout the country, pregnant women are finding it increasingly difficult to seek care and treatment from health facilities and providers. Here, it is important to note that more than half of pregnant women in India seek antenatal care in private facilities and 25% of deliveries take place in private health facilities, often in small clinics. With many private and small clinics shut, poor utilization of maternal healthcare services has resulted. Lack of access to maternal health care and the absence to face-to-face interactions with healthcare providers has added to the stress and depression that pregnant women are often prone to. Women with pregnancy complications and who had adverse pregnancy outcomes in earlier pregnancies may experience more severe depression which can have detrimental effects on the health and well-being of both women and fetus if not treated in the beginning.

The mental health issues and problems faced by women in rural India are even more serious. Owing to the lockdown and enforcement of social distancing norms, it is not possible for local health workers to reach every woman. In rural areas, most of the time, antenatal care services are provided in groups (usually 10 to 20 pregnant women at a facility). This is not possible in the present circumstances, and as a result, many pregnant and lactating mothers are left without medical care. Adding to the challenge is the involvement of the limited rural healthcare providers in COVID-19–related work.

The United Nations Population Fund recently estimated that unwanted pregnancies have increased sharply during the lockdown and that women are at a considerably higher risk of violence.[5] In India alone, it is estimated that 2.3 million unwanted pregnancies will occur which will also increase the likelihood of unsafe abortions. This scenario has serious implications for women's health, especially their mental health. Women with unwanted pregnancy experiences are known to suffer from severe depression during pregnancy and in the postpartum period. If such women also experience violence during this period, the effects on their well-being can be catastrophic.

The problem of mental health of women is multidimensional and complex. The Government of India had announced an immediate and total lockdown on 24 March, 2020, which was extended to 31 May, 2020. The lockdown was declared without proper planning and preparation which was clearly evident in the state's response to the plight of migrant workers who were left without food and shelter and no means of returning to their homes. These migrants were the worst affected due to loss of employment. Nearly half of the migrants seeking to return home were women in reproductive age. To reach their respective homes, thousands of migrant workers had started walking hundreds of kilometers back to their homes, exposing the women who were pregnant to even more stress and health risks.

Even in the past, the issue of maternal mental health was barely addressed by public and private healthcare providers. However, in a crisis situation similar to the present pandemic, it is necessary that health facilities give attention to pregnant and recently delivered women for possible symptoms of depression. Detecting and treating depression in the beginning could prevent detrimental long-term effects on maternal and infant health. Local healthcare providers should be trained to identify unwanted pregnancies and make available abortion facilities that are legal and safe, which could also reduce the burden of depression and unwanted pregnancies.

https://doi.org/10.1016/j.puhe.2020.05.062

Pregnant and recently delivered women should also be provided appropriate information about COVID-19, as well as counseling, for reducing stress. They must also be supported by their partners and community and encouraged to exercise and remain active for their mental health. Migrant women in the receiving states should be provided with basic antenatal and postnatal services. It is the government's responsibility to ensure their well-being and make the necessary effort to minimize the uncertainty which is the major cause of depression.

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24 May 2020
Available online 6 June 2020

Public Health 185 (2020) 266–269

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# Modeling the effect of area deprivation on COVID-19 incidences: a study of Chennai megacity, India

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ARTICLE INFO

*Article history:*
Received 28 May 2020
Received in revised form
6 June 2020
Accepted 8 June 2020
Available online 12 June 2020

*Keywords:*
COVID-19
Index of multiple deprivations
Geographically weighted principal component analysis
Poisson regression
Negative binomial regression

ABSTRACT

*Objectives:* Socio-economic inequalities may affect coronavirus disease 2019 (COVID-19) incidence. The goal of the research was to explore the association between deprivation of socio-economic status (SES) and spatial patterns of COVID-19 incidence in Chennai megacity for unfolding the disease epidemiology.
*Study design:* This is an ecological (or contextual) study for electoral wards (subcities) of Chennai megacity.
*Methods:* Using data of confirmed COVID-19 cases from May 15, 2020, to May 21, 2020, for 155 electoral wards obtained from the official website of the Chennai Municipal Corporation, we examined the incidence of COVID-19 using two count regression models, namely, Poisson regression (PR) and negative binomial regression (NBR). As explanatory factors, we considered area deprivation that represented the deprivation of SES. An index of multiple deprivations (IMD) was developed to measure the area deprivation using an advanced local statistic, geographically weighted principal component analysis. Based on the availability of appropriately scaled data, five domains (i.e., poor housing condition, low asset possession, poor availability of WaSH services, lack of household amenities and services, and gender disparity) were selected as components of the IMD in this study.
*Results:* The hot spot analysis revealed that area deprivation was significantly associated with higher incidences of COVID-19 in Chennai megacity. The high variations (adjusted $R^2$: 72.2%) with the lower Bayesian Information Criteria (BIC) (124.34) and Akaike's Information Criteria (AIC) (112.12) for NBR compared with PR suggests that the NBR model better explains the relationship between area deprivation and COVID-19 incidences in Chennai megacity. NBR with two-sided tests and $P$ <0.05 were considered statistically significant. The outcome of the PR and NBR models suggests that when all other variables were constant, according to NBR, the relative risk (RR) of COVID-19 incidences was 2.19 for the wards with high housing deprivation or, in other words, the wards with high housing deprivation having 119% higher probability (RR = $e^{0.786}$ = 2.19, 95% confidence interval [CI] = 1.98 to 2.40), compared with areas with low deprivation. Similarly, in the wards with poor availability of WaSH services, chances of having COVID-19 incidence was 90% higher than in the wards with good WaSH services (RR = $e^{0.642}$ = 1.90, 95% CI = 1.79 to 2.00). Spatial risks of COVID-19 were predominantly concentrated in the wards with higher levels of area deprivation, which were mostly located in the northeastern parts of Chennai megacity.
*Conclusions:* We formulated an area-based IMD, which was substantially related to COVID-19 incidences in Chennai megacity. This study highlights that the risks of COVID-19 tend to be higher in areas with low SES and that the northeastern part of Chennai megacity is predominantly high-risk areas. Our results can guide measures of COVID-19 control and prevention by considering spatial risks and area deprivation.


## Introduction

Coronavirus disease 2019 (COVID-19) is an epidemic illness that was discovered in Wuhan of China at the end of 2019. Shortly after, it rapidly spread worldwide to emerge as a 'Public Health

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https://doi.org/10.1016/j.puhe.2020.06.011
0033-3506/

Emergency of International Concern.' Subsequently, the World Health Organization declares COVID-19 as a global pandemic. As of May 22, 2020, COVID-19 has affected about 4.99 million people and claimed more than 327,738 deaths globally,[1] and these figures are increasing every day. In India, the first COVID-19 case was reported on January 30, 2020, in Kerala, and then, the number of cases increased gradually in all states and union territories except Daman and Diu, Nagaland, and Lakshadweep.[2] COVID-19 has mostly affected the urban areas, particularly the megacities of India, which became the epicenters of the COVID-19 spread. The geographic distribution of COVID-19 incidences showed that the disease was not uniformly affecting all parts of the Indian megacities but led to spatial clustering of cases.[3]

The existence of an inverse relationship between the socioeconomic status (SES) of populations and higher incidences of lower respiratory tract infection among populations in society was well recognized.[4] Despite the preliminary evidence of social inequality in COVID-19 incidences and the possibility of SES deprivation as a major contributor to COVID-19, research on the relationship between SES deprivation and COVID-19 incidences is inadequate. It has, therefore, become imperative that the role of SES deprivation in COVID-19 incidences be evaluated. To fill up the existing research gap, this study attempted to provide scientific evidence about the influence of SES deprivation on spatial clustering of COVID-19 hot spots in Chennai megacity.

In the absence of individual data, we have used ecological (or contextual) measures of SES deprivation to describe the inequalities in COVID-19 incidences. In this article, we have modified and improved the index of multiple deprivations (IMD) developed by Baud et al.[5] for Chennai megacity by incorporating specific indicators of SES deprivation that affect COVID-19, such as nonavailability to a drinking water source within premises or not having a toilet inside houses. The households (HHs) without having the availability of a drinking water source within premises were compelled to collect drinking water from community standposts and tube wells. Similarly, the HH not having a toilet inside houses also was compelled to use a community toilet. These situations will certainly reduce compliance with social distancing. Limited availability of community latrines, standposts, and tube wells certainly increases the chance of community transmission of the virus. Examining the spatial inequalities in COVID-19 incidences in Chennai megacity will provide important insights into the spatial pattern of the disease. The development of an IMD representing SES disadvantage would explore the linkages between living environment deprivation and COVID-19 incidences. Ultimately, the outcome of this study will provide useful insights to policymakers for targeted interventions to combat the COVID-19 pandemic.

## Methods

The study area is Chennai megacity (13.04°N–80.17°E), which is the fourth largest metropolis in India (after Mumbai, New Delhi, and Kolkata) with a population of 10.2 million. It is the most important urban center in the southeast coastal region of India, which has a typical subtropical, hot, humid, monsoon climate classified as Aw (tropical wet and dry) as per the Köppen climate classification. With mild and moderate winters and very hot summers, the average air temperature ranges from 21 to 35 °C (70–95 °F), and relative humidity varies from 45% to 95%.

The first COVID-19 case in Chennai was detected on March 9, 2020, and later, community transmission has taken place rapidly. The number of confirmed COVID-19 cases in 155 wards of Chennai megacity reported in this study was collected from the official website of Greater Chennai online database releases from May 15, 2020, to May 21, 2020. Ward-wise confirmed cases during this same period were also obtained from The News Minute coronavirus data repository.[6] The two data sets were compared to ensure consistency of COVID-19 incidences before executing the statistical analysis.

Because SES is a complex and multidimensional phenomenon, in the absence of individual data, which were not available at this pandemic situation, we developed well-recognized ecological (or contextual) measures of SES in the form of an index that represents area-based deprivation for 155 electoral wards (subcities) of Chennai megacity. Table S1 in the supplementary material summarizes the domains of selected widely used IMDs developed earlier, and most IMDs include income, employment, SES, education, housing quality, and ownership of goods or items.[7,8] The dimensions and indicators selected to devise an IMD for 155 electoral wards of Chennai megacity are slightly different from IMDs developed earlier because information on income is not available in the Census of India (see Table S1). The IMD is devised by using geographically weighted principal component analysis (GWPCA). GWPCA is now recognized as a very effective tool for detection of local non-stationary effects of variance in a data structure.[8] The local principal components (PCs) and local variance derived from GWPCA are suitable in devising the IMD.[8]

Mathematically, the local eigen decomposition of GWPCA transformation can be written in its algebraic expression as follows:

$$\mathrm{LVLT}\,(u, v) = \Sigma\,(u, v) = \mathrm{XT}\ W\,(u, v)\ X \tag{1}$$

where W (u,v) is a diagonal matrix obtained from optimal bandwidths (here adaptive) based on the 'bi-square' kernel weighting scheme. The detailed description of GWPCA is given in the appendix section. To reduce noise and locate important factors of the IMD, the first 3 PCs with eigenvalues higher than 1 (i.e., $\lambda i \geq 1$) were retained.

The GWPCA-derived dimension weights were computed by multiplying the squared component loads and the proportion of variance explained by the corresponding PC and summing up across PCs. Weights are therefore derived using Equation 2.

$$W_k = \sum_{k=1\ldots3} PC_{k,i}^2 \times \frac{\sqrt{\lambda_k}}{\sum_{j=1\ldots3}\sqrt{\lambda_j}} \tag{2}$$

where $W_k$ is the weight given to IMD dimension *i* (either poor housing condition, lack of HH amenities and services, low asset possession, poor availability of WaSH services, or gender disparity), $PC_{k,i}$ is the component load in the kth PC (column of L), k is the eigenvalue of the kth PC (in V), and j is the number of PCs retained (here 3). The initial IMD is developed as a weighted aggregation of component scores of 3 PCs. The initial IMD was standardized using the minimum-maximum normalization method to obtain the final IMD.

The hot spot analysis tool of ArcGIS 10.2 software (Getis-Ord Gi*) was used to explore the spatial clustering of COVID-19 incidences and high IMD values (mathematical expression given in the Supplementary Material). The distribution of COVID-19 cases in Chennai megacity was negative binomial because its variance was higher than the means (see Table S2). Therefore, we used Poisson regression (PR) and negative binomial regression (NBR) to analyze the impact of individual domains of the IMD on COVID-19 incidences in Chennai megacity (see Supplementary Material for details).

## Results

The descriptive analysis of COVID-19 incidences is reported in Table S2, in which it is shown that variability ($\sigma$=54.52) of COVID-19 incidences is higher than the mean ($\mu$ = 49.49) and that it is following the negative binomial distribution. The first three components with eigenvalues higher than 1 (i.e., $\lambda i \geq 1$) accounted for 80.7% of the total variance in the data, and the first component alone explained more than 47% variance in the data. The product of the proportion of local variance explained by three components and the component score was summed up to devise the initial IMD. The IMD score of 0 stands for the least deprived ward (ward no. 125) and 100 for the most deprived wards (ward no. 40).

Fig. 1e shows the spatial distribution of COVID-19 and IMD hot spots. Hot spot areas for both COVID-19 and the IMD were mainly located in the northern and central parts. This area is crowded with a higher concentration of slums; the majority of the HHs with poor housing conditions and lack of HH services are located in this zone of the megacity. Fig. 1f shows the correlation coefficient between the ward-level prevalence of COVID-19 per lakh population, and the IMD showed a high correlation ($R^2 = 0.755$, r = 0.86, $P < 0.001$). A total of 34 wards of 155 wards have shown a prevalence of COVID-19 per lakh population of 50 and more cases (see Table S3). It was observed that 21 such wards (61.7% of the total) belong to the high and very high IMD category.

Estimated coefficients and other test statistics from the PR and NBR models are presented in Table S4, and the highest variations (adjusted $R^2$: 72.2%) with the lowest BIC and AIC for the NBR model compared with the PR model suggest that the NBR model better explains the relationship between area deprivation and COVID-19 incidences in Chennai megacity. NBR with two-sided tests and $P$ <0.05 were considered statistically significant. The outcome of the PR and NBR models suggests that when all other variables were constant, according to NBR, the relative risk (RR) of COVID-19 incidences was 2.19 for the wards with high housing deprivation or, in other words, the wards with high housing deprivation having 119% higher probability (RR = $e^{0.786}$ = 2.19, 95% confidence interval [CI] = 1.98 to 2.40), compared with areas with low deprivation. Similarly, in the wards with poor availability of WaSH services, chances of having COVID-19 incidence were 90% higher than in the wards with good WaSH services (RR = $e^{0.642}$ = 1.90, 95% CI = 1.79 to 2.00). Spatial risks of COVID-19 were predominantly concentrated in the wards with a high IMD, which were mostly located in the northeastern parts of Chennai megacity.

## Discussion and conclusion

We formulated the IMD using multiple socio-economic indicators at the electoral ward level in Chennai megacity and examined the relationship between the IMD and COVID-19 incidences. The hot spot analysis indicates that the formulated IMD was significantly related to higher incidences of COVID-19 in areas with a higher IMD.

The critical matters of the study were the selection of domains and the method of index formulation. The selection of domains was based on the previous IMDs, data availability in the Indian context, and factors that directly or indirectly affect the transmission of COVID-19. The indicators of the IMD were drawn from

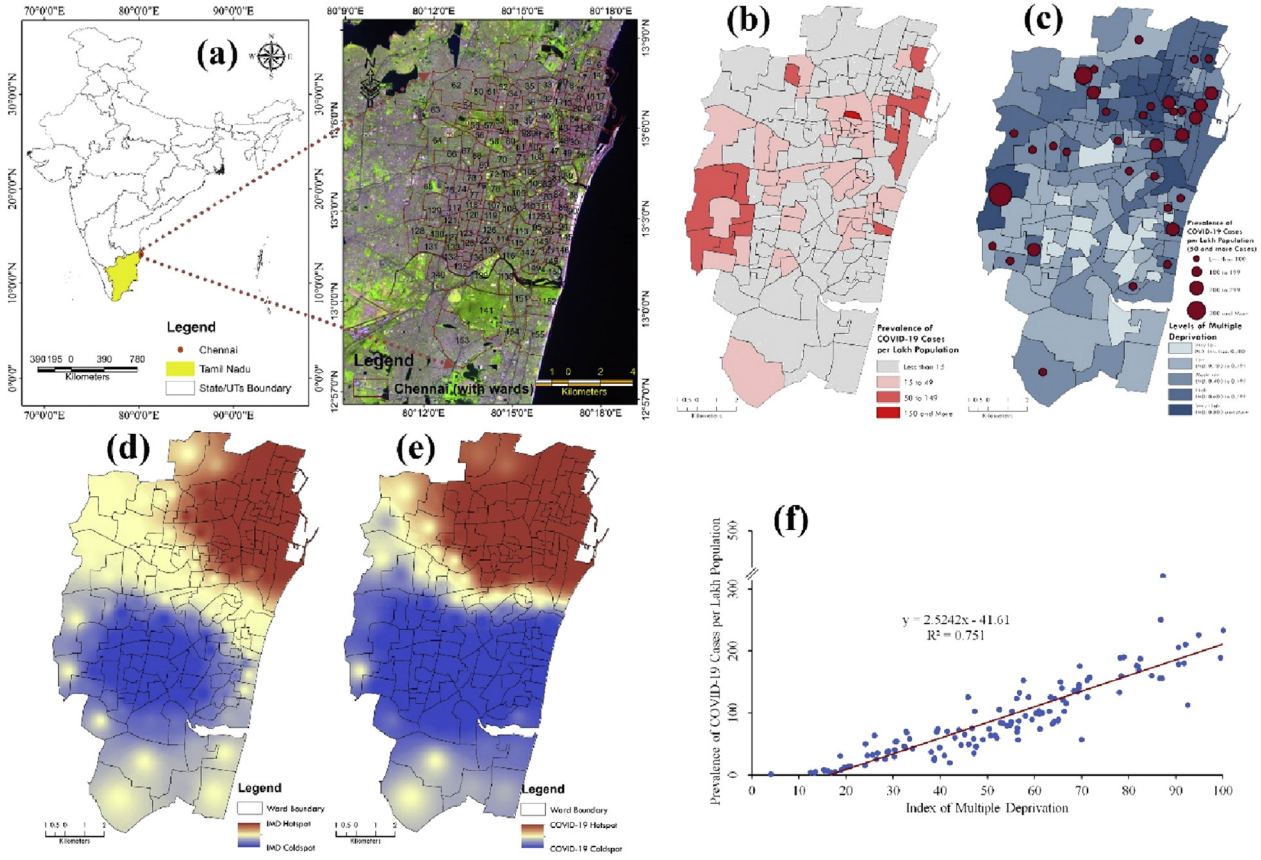


**Fig. 1.** (a) Study area; (b) ward-wise prevalence of COVID-19 incidences per 1,00,000 population; (c) distribution of wards with the prevalence of COVID-19 incidences of 50 and more cases per 1,00,000 population; (d) area deprivation hot spots and cold spots; (e) COVID-19 hot spots and cold spots; and (f) scatter plot showing the relationship between the IMD and prevalence of COVID-19 incidences per 1,00,000 population. COVID-19 = coronavirus disease 2019; IMD =Index of Multiple Deprivations.

the Census of India, the most reliable data source on SES in India. To formulate a composite index of SES deprivation, we used GWPCA, which is preferred over the currently widely used normal PCA. GWPCA as an emerging and promising tool[7] has a certain advantage over PCA such that it provides covariance structure, component scores, loadings, and explained variance for each electoral wards.[8] Therefore, we were able to devise the IMD by using the local component weights of IMD indicators, which was not possible in normal PCA.[8]

The regression results of this study support the findings of the earlier study that addressed the possible impact of SES on COVID-19 incidences.[9] To the best of our knowledge, this study was the first attempt on COVID-19 that quantitatively establishes the influence of area deprivation on COVID-19 incidences. The results of PR and NBR suggested that area deprivation has both positive and inverse associations with the incidences of COVID-19 in Chennai megacity. This further strengthens the findings of Ahmed et al.[10] that the socio-economic disadvantages and inequalities have a profound role in the spread of COVID-19. The findings of this study suggest that approaches to combat the COVID-19 pandemic must incorporate SES dynamics to develop a mitigation strategy.

In conclusion, this study formulated an IMD for area deprivation measures of SES disadvantage, and the index showed a substantial relation to COVID-19 incidences, especially for poor availability of WaSH services and poor housing conditions. This study highlights that the risks of COVID-19 tend to be higher in areas with low SES and that the northeastern part of Chennai megacity is predominantly high-risk areas. Although a more contextual discussion on IMD formulation is needed, the proposed index based on a common set of SES indicators may be readily applicable for research on the relationship between COVID-19 and SES deprivation. Our results can guide measures of COVID-19 control and prevention by considering spatial risks and area deprivation.

## Author statements

*Ethical approval*

None sought.

*Funding*

None declared.

*Competing interests*

None declared.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.06.011.

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Public Health 185 (2020) 243–245

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# Not all worries were created equal: the case of COVID-19 anxiety

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ARTICLE INFO

*Article history:*
Received 25 May 2020
Received in revised form
11 June 2020
Accepted 15 June 2020
Available online 22 June 2020

*Keywords:*
COVID-19
Anxiety
STAI
Optimism bias
Prominence effect

ABSTRACT

*Objectives:* The objective of this study was to investigate possible differences in COVID-19–related anxiety based on previous theories in social psychology.
*Study design:* Cross-sectional online questionnaire delivered via the crowdworking platform.
*Methods:* Four-hundred and seven (120 men and 287 women) adults (aged >18 years) from the United Kingdom answered the State-Trait Anxiety Inventory 'in light of the COVID-19 situation', followed by three health and three financial anxiety items.
*Results:* Our findings imply that women are more anxious than men, people are more anxious about others than about themselves, their anxiety about relatives is higher than about strangers, and anxiety about health is higher than about financial issues.
*Conclusions:* We suggest that these preliminary findings should be further investigated to help policy-makers improve both their treatment of pandemic-related anxiety and their messages.


## Introduction

In just a few months, COVID-19 had spread to most countries. Thus far, millions have been infected, hundreds of thousands killed, and billions suffer the economic consequences. Indeed, the World Health Organization announced a global emergency.[1] Not surprisingly, many suffer from COVID-19–related anxiety,[2] as has been documented using new psychological measures.[3] Current research indicates that coronavirus-related anxiety resembles situational anxiety, in that it may be related to more severe health consequences such as alcohol/drug coping, negative religious coping, extreme hopelessness, and suicidal ideation.[4] Thus, scientists should investigate the different components of COVID-19–related anxiety and help policymakers improve treatment and adjust their measures (including guidelines and messages) accordingly.

We build on previous theories in psychology to investigate four possible differences in COVID-19–related anxiety. First, women's scores on both explicit and implicit anxiety measures are generally higher than those of men.[5] This implies that women may be more susceptible to stressful situations, and consequently, men and women should possibly be treated and addressed differently. Second, a robust finding in psychology is the optimism bias: people perceive themselves as less likely than others to suffer from misfortunes such as car accidents or illness.[6] This 'it won't happen to me' approach can be problematic when it comes to people's adherence to authorities' health guidelines. Third, research has shown that people are more anxious about their significant others' risk in comparison with both their own (optimism bias)[7] and that of strangers (due to greater psychological distance).[8] Finally, research has shown that health matters are perceived as more salient and consequently influence judgments more than financial issues (i.e. the prominence effect).[9]

## The current research

Participants (120 men and 287 women, all adults aged older than 18 years) were recruited through a crowdworking platform ('Prolific') and were paid to answer an online questionnaire.

### *General anxiety*

To measure the state of anxiety, we used the state items of the widely used State-Trait Anxiety Inventory (STAI).[10] These 20 items measure anxiety by aggregating the results of all the items into one index. Items include statements such as 'I feel nervous' and 'I feel calm,' which participants rated on a scale of 1 ('Not at all') to 4

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https://doi.org/10.1016/j.puhe.2020.06.032
0033-3506/

('Very much so'); the higher the total score, the more generally anxious the participant may be. Here, they were asked to rate the statements 'in light of the COVID-19 situation'.

*Specific anxiety*

To measure health- and economic-specific anxiety, participants rated the degree to which they experienced each type of anxiety in light of COVID-19 across six items: two self-focused, two relative-focused, and two country-focused (i.e. strangers) items. The statements were designed based on the STAI to maintain consistency and, as such, were rated using the same scale. Examples include 'Please rate the degree to which you experience anxiety regarding each of the following: my financial state (self-focused economic); the state of my relatives' health (relative-focused health).' The sequence of all 26 anxiety items (general and specific) was randomized.

## Results

*Men vs. Women*

Independent-samples t-tests compared anxiety measures between men and women (descriptive statistics for all variables can be found in Table 1). There was a significant difference in STAI index scores between men and women, $t(405) = -6.65$, $P < 0.001$. This pattern repeated itself in health-related anxiety regarding the self ($t(405) = -2.64$, $P = 0.008$), close relatives ($t(405) = -4.56$, $P < 0.001$), and strangers ($t(405) = -5.75$, $P < 0.001$). The same pattern was found for economic anxiety regarding close relatives ($t(405) = -2.14$, $P = 0.033$) and strangers ($t(405) = -2.32$, $P = 0.021$). Interestingly, men and women did not differ significantly in economic anxiety regarding the self ($t(405) = -1.01$, $P =$ ns). These results suggest that women do indeed report greater anxiety than men, even in times of a global pandemic.

*Self vs. others*

Paired-samples t-tests compared the health and economic anxiety measures between the self and others – relatives and countrymen (i.e. strangers). There was a significant difference between self-focused health-related anxiety and both relative- and stranger-focused anxiety: $t(406) = -17.65$, $P < 0.001$ and $t(406) = -10.67$, $P < 0.001$, respectively. This pattern repeated itself when comparing self-focused economic anxiety and both relative- and stranger-focused anxiety: $t(406) = -4.11$, $P < 0.001$ and $t(406) = -6.52$, $P < 0.001$, respectively. Specifically, these results suggest that individuals worry about the economic and health status of others more than about their own (i.e. the optimism bias).

**Table 1**
Means of general and specific anxiety measures across sexes.

| | STAI[a] | Health[b] | | | Economic[b] | | |
|---|---|---|---|---|---|---|---|
| | | Self | Relatives | Strangers | Self | Relatives | Strangers |
| Women | 54.64 | 2.49 | 3.40 | 3.16 | 2.37 | 2.61 | 2.79 |
| | (11.40) | (1.02) | (0.76) | (0.77) | (1.06) | (1.02) | (0.88) |
| Men | 46.32 | 2.20 | 3.01 | 2.67 | 2.25 | 2.38 | 2.56 |
| | (11.72) | (0.99) | (0.87) | (0.83) | (1.03) | (1.01) | (0.96) |
| Overall | 52.18 | 2.41 | 3.29 | 3.02 | 2.33 | 2.54 | 2.72 |
| | (12.09) | (1.02) | (0.81) | (0.82) | (1.05) | (1.02) | (0.91) |

Note: standard deviations appear in parentheses. STAI, State-Trait Anxiety Inventory.
[a] On an aggregate scale ranging from 20 to 80, composed of 20 items.
[b] On a scale of 1 ('Not at all') to 4 ('Very much so').

Importantly, because we conducted multiple comparisons, we applied Bonferroni-adjusted significance tests for pairwise comparisons for the previous and all subsequent analyses and achieved statistical significance of $P < 0.05$.

*Close relatives vs. strangers*

Paired-samples t-tests were conducted to compare relative-focused and stranger-focused (i.e. 'your country') health and economic anxiety. There was a significant difference between relative-focused health anxiety and stranger-focused health anxiety, $t(406) = 5.87$, $P < 0.001$, which supports the psychological distance hypothesis. Interestingly, this pattern was reversed in economic anxiety: relative-focused anxiety was smaller than stranger-focused anxiety, $t(406) = -3.04$, $P = 0.002$. A possible explanation may be that relatives may rely on the financial state of the participant for supporting them, but they do not rely on the state of the participant's health for medical support.

*Health vs. economic anxiety*

Paired-samples t-tests were conducted to compare self-, relative-, and stranger-focused anxiety measures between health and economic items. There was a significant difference between relative-focused health anxiety and relative-focused economic anxiety, $t(405) = 13.51$, $P < 0.001$. This pattern repeated itself in stranger-focused measures ($t(406) = 6.11$, $P < 0.001$) but was not significant in self-focused measures ($t(406) = 1.24$, $P = 0.215$). In other words, these results suggest that individuals experience greater health anxiety than economic anxiety when it regards others. In contrast, they worry about their own health and economic status to the same degree. These results may be due to optimism bias, which causes individuals to be overly optimistic about themselves across domains.

## Conclusion

The current research explored the differential levels of anxiety reported amid the COVID-19 pandemic. Our findings imply that women are more anxious than men, people are more anxious about others than about themselves, their anxiety about relatives is higher than about strangers, and anxiety about health is higher than about financial issues.

We suggest that these preliminary findings should be further investigated to help policymakers improve both their treatment of pandemic-related anxiety and their messages and guidelines (e.g. emphasize the risk to relatives more than to the self).

## Author statements

*Ethical approval*

This study received the institution's ethical committee approval for this research.

*Funding*

None declared.

*Competing interests*

None declared.

*Data availability statement*

The data that support the findings of this study are openly available at https://osf.io/tch7j/?view_only=dbd592545607427c967b8bfd9a1b65d8.

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Public Health 185 (2020) 15–17

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# Overview of rapid mitigating strategies in Singapore during the COVID-19 pandemic

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ARTICLE INFO

*Article history:*
Received 6 May 2020
Received in revised form
11 May 2020
Accepted 12 May 2020
Available online 22 May 2020

*Keywords:*
Covid-19
Pandemic
Mitigating strategies
Rapid response

ABSTRACT

This article describes the rapid mitigation strategies in addressing the rising number of coronavirus disease 2019 (COVID-19) cases in Singapore. Learning from the severe acute respiratory syndrome experience in 2003, early preparation started in January 2020 when Wuhan was declared as the epicentre of the epidemic. The government had constructed a three-pronged approach which includes travel, healthcare and community measures to curb the spread of COVID-19.



Singapore confirmed its first coronavirus disease 2019 (COVID-19) case on January 22, 2020. At the time of writing, the cumulative number of cases in Singapore had exceeded 22,000. This article describes the preparations and rapid mitigation strategies in addressing the rocketing number of COVID-19 cases in the country (see Fig. 1).

## Travel-related measures

Learning from the painful severe acute respiratory syndrome (SARS) experience in 2003, early preparation started in January 2020 when Wuhan city was declared as the epidemic epicentre. Border control measures were placed as early as January 2 when the Ministry of Health (MOH) issued a health advisory and implemented temperature screening for passengers arriving from Wuhan. This was gradually tightened with restrictions extended to Hubei province and then mainland China in conjunction with declaration of the outbreak as a 'Public Health Emergency of International Concern' on January 30. On Singapore's end, the public was advised successively against outbound travel to Hubei, China and subsequently Daego and Cheongdo counties in South Korea as cases in these regions multiplied. Expatriation of Singaporeans from Wuhan was carried out with stringent quarantine and severe acute respiratory syndrome coronavirus 2 testing measures.[1]

Bilateral agreements were also made with the Malaysian government in February to align screening protocols at land borders. A joint field epidemiology training network to share surveillance data was activated. This had led to identification of the first international cluster in Singapore resulting from a global business conference. Stricter travel controls in Singapore and worldwide were imperative as early studies had confirmed that the mean $R_0$ for COVID-19 is around 3.28.[2]

By early March, travel restrictions were extended to Iran, South Korea, Japan, Italy, Spain, France, Germany and the United Kingdom. These restrictions were implemented before the World Health Organization announced COVID-19 as a 'pandemic' on March 11. Further enhancement took place when Stay-Home-Notice (SHN) was issued to all overseas travellers on March 20. All travel restrictions and 'isolation' orders were capped at the standard 14 days based on the COVID-19 incubation period.

## Healthcare and hospital measures

At the healthcare level, the MOH and National Centre for Infectious Diseases jointly developed guidelines on management of case suspects, which were disseminated to hospitals, physicians and laboratories in January.[3] After the first confirmed case, contact

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https://doi.org/10.1016/j.puhe.2020.05.015
0033-3506/

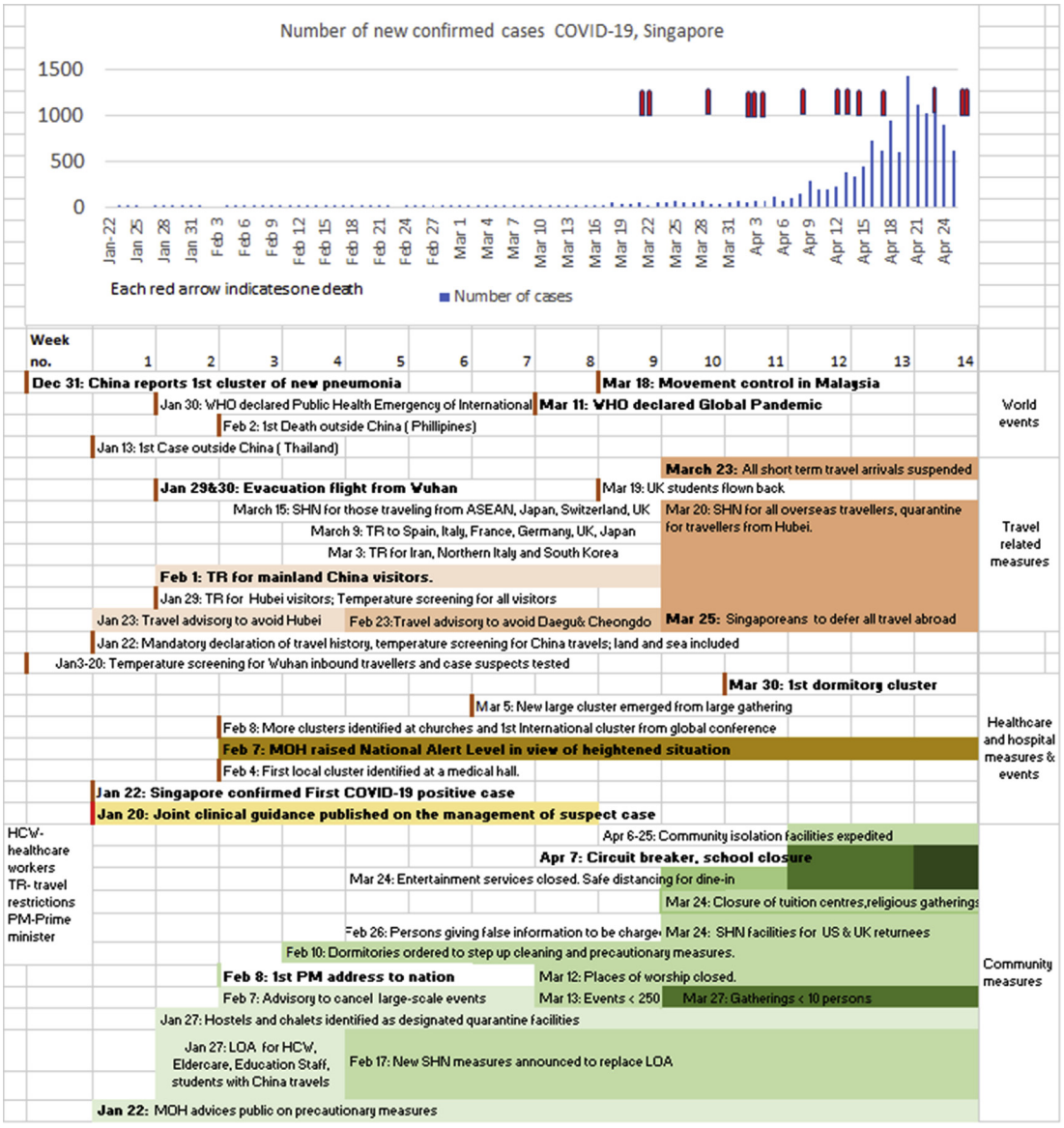


**Fig. 1.** Timeline of events and measures taken at various levels. COVID-19 = coronavirus disease 2019; WHO = World Health Organization; SHN = Stay-Home-Notice; MOH = Ministry of Health; LOA = leave of absence.

tracing yielded two more positive cases in Singapore, while Malaysia had their first three cases from Singapore's index case. Vigorous contact tracings were conducted through activity mapping, analytic tools, surveillance footages, door-to-door enquiries with the help of the Singapore Police Force and smartphone application (TraceTogether).[4] Coupled with the antibody laboratory tests developed by Duke-NUS Medical School, the link between Singapore's two largest COVID-19 clusters in February was uncovered.[5]

Fever surveillance among healthcare workers was implemented, in which all healthcare workers, including clinical and non-clinical employees, were to report temperature twice daily. Employees having a temperature of 37.5 °C and higher would be required to seek immediate medical attention and not report to work. This strategy was used to identify potentially infected healthcare workers early during the SARS outbreak in 2003.[6]

## Community measures

At the community level, the MOH raised public awareness on the importance of personal hygiene, handwashing, wearing of masks, civic mindedness and health-seeking behaviours. Timely dissemination of reliable information to the public was proven effective in the previous SARS outbreak to dissipate anxieties.[7] When the national alert level was raised to the second highest level, the government regularly updated the public on precautionary measures, containment efforts and assurance of national supplies.

As early as February 17, stricter SHN has replaced leave of absence (LOA). SHN law enforcement requires residents and long-term pass holders travelling from high-risk places to stay home mandatorily at all times, monitor their health and use contactless delivery for their food and daily essentials. Previously, persons on

LOA were able to briefly leave their residential properties for food, groceries and 'important personal matters'. Revocation of permanent resident status, cancellation of work passes, fines and jail sentences were among the outcomes of those breaching the laws.

Closure of places commenced from places of worship to entertainment services and tuition centres. Business continuity plans for companies kicked off with staggering of work hours at workplaces. Food and beverage industries were advised to comply with safe distancing measures. As part of crowd-limiting measures, fixed seats in eateries, buses and trains were marked as not to be occupied. Fines were imposed for failure in abiding by safe distancing—serving as a reminder and deterrent to the public.

As the number of cases rose rapidly, reciprocating measures were implemented promptly. The announcement of the circuit breaker (partial lockdown with elevated safe distancing measures and movement restriction in public and private places) on April 4 suspended non-essential services and led to school closures. This endeavour corresponded to lockdowns and movement restrictions in many other countries.[8] As the measure did not show satisfying results in the initial two weeks, a four-week extension of this order was announced on April 21 along with tighter community measures such as closure of more work premises and controlled access to crowded places.

Singapore saw the number of confirmed COVID-19 cases surge in early April 2020 after the identification of several foreign worker dormitory clusters. These workers were housed in mega-dormitories with a capacity of up to 13,000 occupants, where they lived in close proximity and shared communal facilities. They also gathered in large groups at workplaces and public spaces during rest days. The high-density living between the 180,000 workers meant that they were always at risk of promoting transmissions. A special taskforce was formed to curb the spread in dormitories and to ensure the workers' well-being. The taskforce locked down dormitories with infection clusters, isolated those symptomatic and moved some of the workers to new accommodations. Strict hygiene measures, sanitization and safe distancing measures were adopted. Medical support was deployed to these dormitories for early and extensive testing, isolation and treatment.

Several quarantine and isolation facilities have been repurposed as early as January to contain the ever-increasing number of cases, but these facilities were inadequate. Many public venues worldwide have been converted to isolation facilities for patients with mild to moderate COVID-19 as the demand exceeded hospitals' surge capacity.[9] Resorts and convention centres (with a combined capacity of more than 10,000 at the time of writing) have been converted to house stable patients with mild symptoms of COVID-19. The healthcare workforce has also been deployed to these community facilities. As the number of COVID-19 cases continues to rise, the government has been working relentlessly on another makeshift facility at a shipping terminal with the capacity for 15,000 patients and will be sourcing other avenues, including cruise ships.

With the current circuit breaker in place, the highest number of cases per day was 1426. Ever since the peak, the mean number of cases dropped to 681 at the time of writing. Local community cases and cases among foreign workers in dormitories peaked at 116 and 1371, respectively, per day and dropped to an average of 9 and 658 cases, respectively, per day.[10]

While some would debate on the tardiness of certain measures being implemented, we opined that careful and thoughtful planning with successive rapid executions has been carried out to balance the profound impact of the socio-economic activities and the healthcare system.

## Author statements

### *Ethical approval*

None required.

### *Funding*

Any opinions, findings, conclusions or recommendations expressed in this material are those of the authors and do not reflect the views of the Ministry of Health or the SingHealth Institution.

### *Competing interests*

None declared.

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Public Health 185 (2020) 338–340

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# Patients' attitudes towards cost feedback to doctors to prevent unnecessary testing: a qualitative focus group study

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ARTICLE INFO

*Article history:*
Received 21 March 2020
Received in revised form
13 June 2020
Accepted 15 June 2020
Available online 26 July 2020

*Keywords:*
Hospital care
Unnecessary tests
Healthcare costs
Patient attitudes
Focus groups

ABSTRACT

*Objectives:* There is a need to improve efficiency in healthcare delivery without compromising quality of care. One approach is the development and evaluation of behavioural strategies to reduce unnecessary use of common tests. However, there is an absence of evidence on patient attitudes to the use of such approaches in the delivery of care. Our objective was to explore patient acceptability of a nudge-type intervention that aimed to modify blood test requests by hospital doctors.
*Study design:* Single-centre qualitative study.
*Methods:* The financial costs of common blood tests were presented to hospital doctors on results reports for 1 year at a hospital. Focus group discussions were conducted with recent inpatients at the hospital using a semi-structured question schedule. Discussions were transcribed and analysed using qualitative content analysis to identify and prioritise common themes explaining attitudes to the intervention approach.
*Results:* Three focus groups involving 17 participants were conducted. Patients were generally apprehensive about the provision of blood test cost feedback to doctors. Attitudes were organised around themes representing beliefs about blood tests, the impact on doctors and their autonomy, and beliefs about unnecessary testing. Patients thought that blood tests were important, powerful and inexpensive, and cost information could place doctors under additional pressure.
*Conclusion:* The findings identify predominantly positive beliefs about testing and negative attitudes to the use of financial costs in the decision-making of hospital doctors. Public discussion and education about the possible overuse of common tests may allow more resources to be allocated to evidence-based healthcare, by reducing the perception that such strategies to improve healthcare efficiency negatively impact on quality of care.


There is a need to improve efficiency and reduce waste in healthcare delivery.[1] A significant proportion of medical testing is estimated to be unnecessary, leading to patient harms and wasted resources.[2] We have previously demonstrated that presenting financial costs of tests to requesting hospital physicians can reduce demand for tests.[3] This is an example of a cheap and easily implemented behavioural strategy that can reduce unnecessary testing without restricting freedom of choice in individual doctors.

It is important to understand patients' views on the use of cost information to influence doctors' decisions about the care they provide. Patients could be apprehensive of attaching prices to individual tests, which may be a barrier to adoption and scaling up of this approach in the NHS. Awareness of attempts to limit diagnostic testing may evoke concerns about quality of care and reduce patient satisfaction, however there is an absence of evidence about patients' perspective. We conducted a single-centre qualitative study to explore this.

An intervention had been implemented at a busy teaching hospital in England in February 2017, displaying phlebotomy and

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https://doi.org/10.1016/j.puhe.2020.06.023

**Table 1**
Results of qualitative content analysis.

| Coding category | Representative quotes and frequency of participants expressing view | |
|---|---|---|
| **Theme 1: Beliefs about blood tests** | | |
| Blood tests are an important and valuable tool | Blood tests are essential and they're becoming more essential, and I think they're becoming much more central in understanding the body's function and the body's health. I have no doubt at all that blood tests are absolutely important. Really important. (FG2R3, man, 81)* | 16 |
| | I think a blood test gives a lot of information on the performance of different parts of the body. […] My concern would be if it put the doctor off from doing the blood test that he would have done otherwise, with the risk that they miss something. (FG3R5, man, 75) | |
| Blood testing saves money | I think it's a cost saving in the end, because without those more people would be going longer before they receive treatment for something, and the longer you wait the more invasive and the more difficult the treatment and the more treatment that you need. (FG1R5, woman, 49) | 9 |
| | I would have thought it saves the NHS money. If you're given a blood test for whatever and it comes back negative, then you know you don't have to do anything more. (FG1R2, man, 76) | |
| Blood tests inform how I understand and feel about my health | There's blood tests that I would like them to do more often because they would inform how I feel. It's really important to understand the treatment you're going through. (FG1R6, woman, 61) | 8 |
| | I know it's expensive, but if it's a negative result then it's nice to know. It gives a bit of reassurance to the patient, and that in itself is good for their positive mindset and therefore makes them feel better. (FG2R4, man, 35) | |
| **Theme 2: Impact on doctors and their autonomy** | | |
| Doctors know when to do a test | For me personally it wouldn't make a difference, I trust their judgement to say what's best really. (FG3R4, man, 32) | 11 |
| Doctors should not think about costs | When I am being treated I do not want my doctor thinking of budget, I want my doctor thinking wholly of what is in my best interest. (FG1R5, woman, 49) | 7 |
| | You can't start interfering with a doctor's clinical views in the interests of economy. But if you can persuade them, if you're having a blood test or some other test just for the sake of it, then that should be discouraged. (FG3R2, man, 75) | |
| Costs place additional pressure on doctors | I think they're under enough pressure anyway so why should they be made to feel guilty if they think someone needs a blood test? I wouldn't like them to see the price, then they feel pressured. (FG1R1, woman, 37) | 6 |
| **Theme 3: Beliefs about unnecessary testing** | | |
| Doctors do unnecessary tests | When I was in hospital I was in for two weeks and I'm sure I had blood test nearly every day. For what reason? I don't think I needed them every day. I was having them a lot and I just think is this really necessary? (FG2R2, woman, 27) | 10 |
| | Sometimes I feel doctors do it just to pass the time a little to keep the patient there, to keep the patient happy. Whereas sometimes the blood tests aren't necessarily done for a reason. (FG1R4, woman, 27) | |
| Cost savings should be made in other areas | I do feel that the blood tests should be left alone, but there's an awful lot of other administration costs that could really be cut back on. (FG2R3, man, 81) | 11 |

* Participant ID, gender, age (years).

laboratory costs, and the total annual spend on the test by the hospital, on the results reports of three common blood tests (full blood count, urea and electrolyte and liver function tests). A 12 month controlled evaluation found the intervention was associated with a 3% reduction in demand for full blood count tests, a 2% reduction in urea and electrolyte tests and no change in liver function tests.[4]

An invitation pack was sent to a random sample of adults who had been inpatients at the same hospital during the previous two years and had opted in to a patient research panel. Focus groups took place at the hospital, facilitated using a semi-structured question schedule, including a brief outline of the intervention that stated that it did not restrict a doctor from ordering a test (see online supplement). Groups were audio and video recorded. Participants were given a £40 multi-store gift card and reimbursed travel costs.

Recordings were transcribed and analysed with NVivo software using qualitative content analysis, a method for systematically describing the meaning of qualitative data.[5] The final coding frame, including example quotes and frequencies of participants in each category, form the results of the analysis.

A sample of 397 patients were invited, 28 (7%) responded and 17 gave informed consent and participated. Three focus groups were held in October 2018 with a mean duration of 70 min and a participant range of 5–6. Participants were aged 27–81 years (mean 57) and 11 (65%) were men.

Ten participants expressed negative attitudes towards cost feedback for doctors, four expressed positive attitudes and three expressed mixed attitudes. Two groups contained a combination of negative/positive/mixed attitudes whilst only negative attitudes were reported in the other group. Findings are described below and representative quotes from each coding frame category are shown in Table 1.

**Theme 1.** *Beliefs about blood tests.* Participants viewed blood tests as an important and valuable tool in screening for and diagnosing disease. Some described personal experiences that caused them to feel that they owed their health to having had a blood test. This contributed to a fear that things could be missed if fewer tests were done. Participants believed that the cost of a blood test was small, that blood testing saves money through earlier diagnosis and that such tests 'prove their worth'.

**Theme 2.** *Impact on doctors and their autonomy.* Participants trusted the judgement of doctors about whether or not a test is needed. Most felt that doctors should not know about costs and should only consider what is in the patient's best interests. Cost information was seen to place additional pressure on doctors, to whom they were empathetic about the pressures experienced in

their work. In contrast, some participants felt that cost feedback could be useful in reducing unnecessary tests.

**Theme 3.** *Beliefs about unnecessary testing.* There was an awareness that doctors sometimes order unnecessary tests, including a view that the demand for tests was often driven by the patient. Older adults appeared more concerned about test costs than younger participants. However, there was resistance to the use of costs in decision-making and a feeling that other areas of the NHS should be targeted for cost savings, including management, administration, procurement and overuse of services by patients.

There was agreement in one of the groups that older adults are less concerned than others about cost feedback to doctors because they may be old enough to remember a time before the NHS existed, they 'like to know what things cost', are more likely to have received health treatment and may be more anxious about being a burden to doctors.

Although there were differing views expressed, the group interaction involved no direct conflict, with participants' views grounded strongly in their own experiences of the health service. As all participants were recent hospital inpatients and several described their conditions or treatment, this created a dynamic of tolerance and respect for each other's views. Consensus was evident on some points, such as the value of blood tests and the small perceived cost of a blood test.

The findings highlight attitudes and beliefs that should be addressed in order to improve the acceptability to patients of interventions that provide transparent financial cost information to doctors about common diagnostic tests. We found an awareness of the possibility of unnecessary testing but a preference for cost savings in other areas of healthcare. Blood tests were viewed as a powerful, inexpensive and cost-effective tool that reassured and informed patients. There was a fear that fewer tests could mean things were missed, often based on personal stories. This is consistent with reported attitudes in primary care, where patients regard blood tests as a useful screening instrument that fulfils a need for objective validation of what is happening inside their bodies, reinforced by the social environment and the media.[6,7] Stories of unnecessary testing may be needed to aid understanding in patients.[8] Older adults were more concerned about test costs than younger participants, highlighting possible generational differences in attitudes towards the role of the NHS.

The judgement of doctors was highly trusted and most participants felt that costs should not be a factor in testing decisions in the NHS. There is limited research into patient views on this topic in publicly funded health systems but a program to reduce overuse in a hospital in Canada reported it had been important to prioritise harm reduction over cost-containment because the latter does not resonate with clinicians or patients.[9] A focus group study in the USA to examine the willingness of patients to consider and discuss costs with clinicians found a preference for the best care regardless of cost, with individualistic attitudes expressed in contrast to the concerns about the impact on doctors we observed.[10] Our patients repeatedly described the pressures that doctors work under and the additional burden that cost feedback could place on them. This indicates that the use of cost feedback in decision-making could undermine trust in the doctor-patient relationship. A greater emphasis on shared decision-making may help to prevent cost feedback damaging patient satisfaction and perceived quality of care.

In conclusion, patients were generally apprehensive about the provision of cost feedback to doctors. Discussion and patient education about overuse of tests may increase acceptability of the use of cost feedback to improve efficiency and reduce waste in healthcare delivery.

## Author statements

### *Ethical approval*

The study was approved by Wales Research Ethics Committee 7, ref. 17/WA/0393.

### *Funding*

This work was supported by the Health Foundation Behavioural Insights Research Programme, ref. 7600.

### *Competing interests*

All authors have no conflicts of interest to declare.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.06.023.

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Public Health 185 (2020) 18

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Letter to the Editor

# Protecting health workers' mental health during COVID-19

As health systems globally are overwhelmed by coronavirus disease 2019 (COVID-19), health workers 'must be protected'[1] as 'every country's most valuable resource.'[2] This must go beyond access to effective personal protective equipment. Measures to support the enormous psychological burden faced by frontline health workers worldwide are urgently needed.

The global surge in demand for health care is placing health workers under severe pressure, including frustration, exhaustion, difficult triage decisions and traumatic patient outcomes, exacerbated by physical distancing measures and isolation. In addition, the high risk of infection, inadequate protection from contamination and illness and death in their medical colleagues places their mental health under significant threat and is compounded by concerns of transmitting infection within their households.

The psychological effects of COVID-19 among health workers in Wuhan, where the novel coronavirus emerged, include stress, anxiety, depression, insomnia, denial, anger and fear,[3] with similar reports from those in Italy, Spain and New York, where health systems have been overwhelmed with COVID-19. This is consistent with the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak[4] and should therefore be expected across health settings worldwide during the current pandemic.

Psychological distress can directly impede health workers' ability to provide safe, timely and effective care, while also having lasting impacts on their mental health.[7] It is therefore of paramount importance that their psychological well-being is safeguarded, particularly in low- and middle-income countries, where stigma and discrimination associated with mental health and gaps in mental health services prevent timely help-seeking and favourable outcomes.[5]

Health systems should heed the advice of the World Health Organization (WHO) in safeguarding the mental health of their frontline health workers[6] and take lessons from those ahead of them in the pandemic's evolution. The Second Xiangya Hospital in China, for example, provided a psychological intervention plan to support frontline health workers during the outbreak.[7] This included group activities, a psychological assistance hotline and online courses for dealing with stress, along with staff training, practical assistance and protected time for in-person counselling. In Wuhan, local government addressed mental health problems by recognising health workers with COVID-19 infection as having work-related injuries and redeploying staff from less pressurised provinces to reduce workload in overwhelmed hospitals.[3]

The global health response to COVID-19 must be that every country urgently provides multifaceted psychological safeguarding of the mental health of their frontline health workers, learning from previous epidemics and the experience of affected countries, to protect healthcare providers' effectiveness, secure their longevity and recognise their value as indispensable resources.

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12 May 2020
Available online 30 May 2020

https://doi.org/10.1016/j.puhe.2020.05.044

Public Health 185 (2020) 21–25

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Readability of online patient education material for the novel coronavirus disease (COVID-19): a cross-sectional health literacy study

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ARTICLE INFO

*Article history:*
Received 6 April 2020
Received in revised form
20 May 2020
Accepted 20 May 2020
Available online 30 May 2020

*Keywords:*
Coronavirus
COVID-19
Readability
Google
Internet

ABSTRACT

*Objectives:* The internet has become one of the most important resources for the general population when searching for healthcare information. However, the information available is not always suitable for all readers because of its difficult readability. We sought to assess the readability of online information regarding the novel coronavirus disease (COVID-19) and establish whether they follow the patient educational information reading level recommendations.
*Study design:* This is a cross-sectional study.
*Methods:* We searched five key terms on Google and the first 30 results from each of the searches were considered for analysis. Five validated readability tests were utilized to establish the reading level for each article.
*Results:* Of the 150 gathered articles, 61 met the inclusion criteria and were evaluated. None (0%) of the articles met the recommended 5th to 6th grade reading level (of an 11-12-year-old). The mean readability scores were Flesch Reading Ease 44.14, Flesch-Kincaid Grade Level 12.04, Gunning-Fog Index 14.27, Simple Measure of Gobbledygook SMOG Index 10.71, and Coleman-Liau Index 12.69.
*Conclusions:* Online educational articles on COVID-19 provide information too difficult to read for the general population. The readability of articles regarding COVID-19 and other diseases needs to improve so that the general population may understand health information better and may respond adequately to protect themselves and limit the spread of infection.


## Introduction

The internet has grown to become one of the most popular resources for people in finding health information.[1] In the United States, up to 80% of all adult internet users have looked online to find information about several health issues.[2] 70% of health seekers express that the information that they have found has influenced them in their decision-making regarding the treatment of their disease.[3] Although the information is readily accessible, it's utility may be variable depending on the readability of the information. The mean reading level of adults in the United States has been estimated to be equivalent to that of a 13- to 14-year old.[4] Taking this into account, the American Medical Association (AMA) and United States Department of Health and Human Services (USDHHS) have recommended that patient educational information should not exceed the reading level of an 11- to 12-year old.[5] However, numerous studies have shown that the reading difficulty of health articles online is much higher than recommended.[6–8] To date, no readability analysis has been performed regarding the novel coronavirus disease (COVID-19).

COVID-19 has resulted in thousands of deaths worldwide and has resulted in more fatalities than the previous two coronavirus epidemics combined (i.e. SARS and MERS). As of March 11, 2020, the outbreak was recognized by the World Health Organization (WHO) as a pandemic.[9] Thus, proper public education becomes critical so that patients may prevent and contain the infection. Because the internet is often the first source of information regarding health care for patients, it is critical to evaluate the readability level of the information.[10] In this study, we sought to assess the readability of online information regarding COVID-19.

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https://doi.org/10.1016/j.puhe.2020.05.041
0033-3506/

## Methods

### Search strategy

On March 13, 2020, the Google search engine was used to search for the following five key terms: "Coronavirus," "COVID-2019," "SARS CoV-2," "2019-nCoV," and "What is the coronavirus". $7.39 \times 10^9$, $4.59 \times 10^9$, $1.43 \times 10^8$, $1.02 \times 10^8$, and $5.08 \times 10^9$ search results were identified for each search, respectively. The first 30 results per key term were evaluated because 90% of internet users do not look past this number.[11]

### Inclusion and exclusion criteria

A total of 150 search results were considered for the readability analysis. Articles not in English, duplicates, newspaper articles (because they contained mostly political updates), biomedical journal articles, non–open-access articles (behind a paywall), and statistical websites were excluded.

### Readability assessment

All articles were restructured into plain text and all irrelevant material was deleted, such as figures, their legends, images, and references. The analysis was performed using five readability formulas: Flesch Reading Ease (FRE), Flesch-Kincaid Grade Level (FKGL), Gunning-Fog Index (GFI), Simple Measure of Gobbledygook (SMOG) Index, and Coleman-Liau Index (CLI).

The FRE and the FKGL are different formulas that use the average sentence length in words and average syllables per 100 words for the assessment.[12]

GFI uses the average sentence length and the number of words containing three or more syllables for the calculations. Polysyllabic words are excluded, including proper nouns, a combination of easy words (including hyphenated words), and polysyllable verbs whose third syllable is "es" or "ed".[13]

SMOG Index is calculated by counting every polysyllabic word (containing three or more syllables) in sections containing 10 sentences each placed in the beginning, in the middle, and at the end of the text in question.[14] In contrast to the other readability formulas, CLI does not take the number of syllables into account. Instead, it makes the assessment based on the average number of letters and sentences per 100 words.[15]

The FRE score determines the reading ease based on a scale from 0 to 100, where a lower score indicates a higher difficulty (0–30 is very difficult, 30–50 is difficult, 50–60 is fairly difficult, 60–70 is standard, 70–80 is fairly easy, 80–90 is easy, 90–100 is very easy).[12] The other four formulas, however, use a scale based on the educational level needed to understand the text. A score less than 6 is regarded as 6th grade reading level (11-12 years), a score of 7 as 7th grade reading level (12-13 years), a score of 8 as 8th grade (13-14 years), 9 as high school freshman (14-15 years), 10 as high school sophomore (15-16 years), 11 as high school junior (16-17 years), 12 as high school senior (17-18 years), 13 as college freshman (18-19 years), 14 as college sophomore (19-20 years), 15 as college junior (20-21 years), 16 as college senior (21-22 years), and 17 or above is regarded as college graduate (someone over the age of 22 years).

## Results

Of the 150 articles, 61 were analyzed as they met the inclusion criteria. The mean reading level of the articles was equivalent to a high school senior/college freshman (17 to 18 year olds) ($12.4 \pm 2.1$). The minimum score was 8.8, whereas the maximum score was 20.1. According to the mean FRE score, the articles are considered difficult to read ($44 \pm 11.5$). In Table 1, the mean scores of the readability formulas are presented. Table 2 shows the distribution of the scores.

All articles were of at least a high school sophomore grade level (15-16 years old). According to the FRE, 91.8% of the articles were found difficult to read. On the FKGL scale, 78.68% of the articles had a readability index of a high school senior grade (17- to 18-year olds). Similarly, on GFI, SMOG, and CLI, the percentage of articles that were above the readability index of a high school senior (17- to 18-year olds) were 98.36%, 62.29%, and 88.52%, respectively.

Table 3 displays that the information provided from websites related to governments, hospitals and health organizations (such as WHO) are also not following the recommendations for educational material. All of the medical articles were written beyond the recommended 5th- to 6th-grade level (11- to 12-year olds).[16]

Fig. 1 shows a comparison between the overall readability, government health organization readability, and hospital readability.

## Discussion

### Readability analysis

We found that online information about COVID-19 is too difficult for the general population to read and comprehend. None of the articles met the 5th- to 6th-grade reading level (11- to 12-year olds) recommended by the AMA and the USDHHS.[5,16] Most articles (84%) were designated as too difficult to read, which makes it tough for the public to acquire understandable information regarding COVID-19. To reduce the spread of infection and, thus, reduce the burden on a country's healthcare system, a country's population needs access to understandable information online. We urge prominent organizations such as the WHO and the Centers for Disease Control and Prevention to make their online information friendlier to the general public. Easy readability of relevant medical information empowers individuals to take the right steps to protect themselves. This may reduce panic and anxiety especially in the midst of a pandemic. Our findings are novel because our article is the first to do a readability analysis on COVID-19. Morever, we conducted our readability analysis on COVID-19 during the pandemic itself to provide a contemporary and relevant view of the problem.

### Context

Medical terminology is an essential factor affecting the readability of a text. Even if the person's educational level is high, long sentences and unfamiliar words can make the text challenging to read. If they are not accustomed to medical literature, misunderstanding and misinformation may occur and the patient may stop researching basic medical care. Therefore, information aiming to educate patients should be clear and understandable. A 2018 systematic review analyzing 157 readability studies found that the readability level of online health articles is incomprehensible for the public.[8]

### Limitations

This study is limited by the constraints of a cross-sectional study. Because the material available on the internet is constantly increasing, the results of our study will only reflect what information was present for the public at this point in time. However, our study brings awareness to the problem; this may influence hospitals and government organizations to reduce the reading difficulty on their websites. Morevoer, this readability study is

**Table 1**
Mean score for individual formulas used in the readability assessment of the websites.

| Readability formula | Mean score | Standard deviation |
|---|---|---|
| Flesch Reading Ease (FRE) | 44.14 | 11.46 |
| Flesch-Kincaid Grade Level (FKGL) | 12.04 | 2.67 |
| Gunning-Fog Index (GFI) | 14.27 | 2.84 |
| Simple Measure of Gobbledygook (SMOG) Index | 10.71 | 1.96 |
| Coleman-Liau Index (CLI) | 12.69 | 1.86 |

**Table 2**
Distribution of scores within each individual formula.

| Readability formula | Score | Number of websites |
|---|---|---|
| Flesch Reading Ease (FRE) | Easy (80–100) | 0 |
| | Average (60–79) | 5 |
| | Difficult (0–59) | 56 |
| Flesch-Kincaid Grade Level (FKGL) | Below 6 | 0 |
| | 6–10 | 13 |
| | Above 10 | 48 |
| Gunning-Fog Index (GFI) | Below 6 | 0 |
| | 6–10 | 1 |
| | Above 10 | 60 |
| Simple Measure of Gobbledygook (SMOG) Index | Below 6 | 0 |
| | 6–10 | 23 |
| | Above 10 | 38 |
| Coleman-Liau Index (CLI) | Below 6 | 0 |
| | 6–10 | 7 |
| | Above 10 | 54 |

**Table 3**
Mean readability score of websites related to governments, hospitals/clinics, or health institutions/organizations.

| Readability formula | Mean score | Standard deviation |
|---|---|---|
| Flesch Reading Ease (FRE) | 47.82 | 12.76 |
| Flesch-Kincaid Grade Level (FKGL) | 11.51 | 3.06 |
| Gunning-Fog Index (GFI) | 13.57 | 3.10 |
| Simple Measure of Gobbledygook (SMOG) Index | 10.17 | 2.16 |
| Coleman-Liau Index (CLI) | 12.65 | 1.82 |

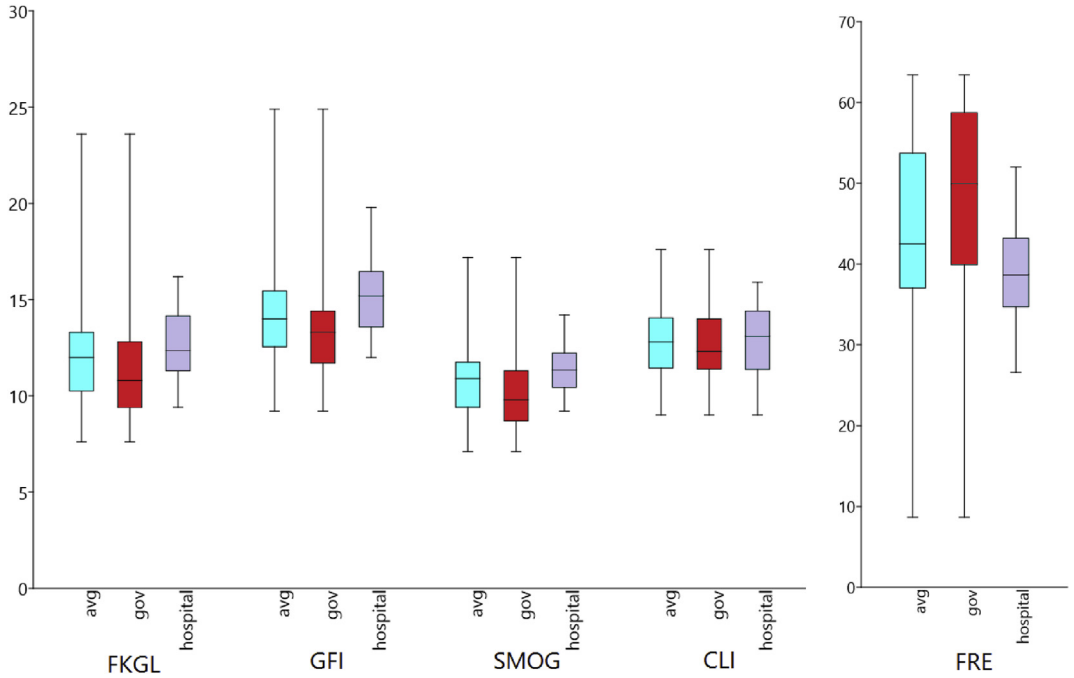


**Fig. 1.** The mean score for each of the readability formulas used in the assessment of the overall readability (colored blue), government health organizations readability (colored red) and hospital readability (colored purple). Abbreviations: avg, average; gov, government health organizations; FKGL, Flesch-Kincaid Grade Level; FRE, Flesch Reading Ease; GFI, Gunning-Fog Index; GFS, Gunning-Fog Score; CLI, Coleman-Liau Index; SMOG, Simple Measure of Gobbledygook.

based on text only. Infographics and videos—which may often enhance the understanding of a text—were removed to perform the analysis. This was another limitation of this study.

### *Future directions*

Previous studies have shown that the quality of health information online is biased, misleading, and poor.[17,18] Thus, although we assessed the readability of COVID-19 health articles, the quality of these articles still needs to be evaluated. In addition, because YouTube has become a major source of patient information, the quality of information on this platform also needs to be assessed.[19–22] The role and effectiveness of online medical resources concerning telemedicine may also be explored.[23]

We encourage websites to display COVID-19 infographics and videos as they may be a more friendly way of providing information to the public. Moreover, infographics are easy to potentially share on social media and may help spread the health information about the disease.

### *Public health implications*

Considering Europe is now the epicenter of COVID-19 pandemic, it becomes critical that government sites such as ecdc.europa.eu (European Centre for Disease Prevention and Control) publish advisories in simple understandable terms. Studies show that these articles play a critical role in recommending health safety guidelines, reduce the burden on the healthcare system, and help healthcare workers prioritize managing the disease effectively.[24–27] An analysis of the 1918 influenza pandemic showed that early implementation of certain interventions (e.g. isolation policies, mask ordinances, and bans on public gatherings) reduced influenza transmission.[26] We assert that for these interventions to be effective, the public needs access to understandable online health information so that personal measures to contain and prevent the disease may be taken (e.g. by washing heads frequently, practicing respiratory hygiene, and seeking medical care early). Low health literacy has been associated with nonadherence to treatment plans and medical regimens, poor patient self-care, high healthcare costs, and increased risk of hospitalization and mortality.[28] Thus we hope that this article serves as a "call to action" for health authorities to provide more comprehensible reading material online.

### *Conclusion*

Online information regarding COVID-19 is too difficult to read and understand as designated by the AMA and the USDHHS.[5] This includes websites run by governments and health institutions such as the WHO. Because the internet now is one of our most popular sources of information, it is critical that people are provided with understandable information. Health articles too difficult to understand may cause misinformation to spread, public panic due to a lack of accessible information, and a greater burden on a country's healthcare system.

## Author statements

### *Ethical approval*

No ethical approval was required as all the data analyzed were publicly available.

### *Funding*

None reported.

### *Competing interests*

None reported.

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Public Health 185 (2020) 47

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Letter to the Editor

# Re: 'Non-COVID-19 visits to emergency departments during the pandemic: the impact of fear'

The COVID-19 pandemic, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is an incredible stress test for emergency departments (EDs) worldwide. Not only should EDs be prepared for increasing COVID-19–related patient volumes, they should also preserve sufficient capacity for the 'usual' emergencies. Similar to the experiences in our own centers, Mantica et al.[1] observed a steep decline of non–COVID-19 ED visits in two northern Italian hospitals. When the daily COVID-19 mortality rates in Italy peaked, the number of ED visits reached its lowest point. The authors focus on the fear by patients to contract the virus in hospitals, which may have resulted in reduced ED utilization for low urgent complaints and a tendency to postpone specialist consultation. Although we agree that the impact of fear on hospital resource utilization during this pandemic is an important concern, we would like to provide some additional insights.

A few reports exist about reduced ED utilization during the first weeks of the pandemic.[2–4] Although fear may have its share and many patients with low urgent complaints likely postponed physician consultation, the (indirect) effects of lockdowns, social distancing, and improved personal hygiene should not be overlooked. First, lockdown was associated with a reduction of workplace and traffic accidents in France and Spain.[2,3] Second, schools are well-known vectors of infectious disease transmission, which makes it likely that school closures have reduced the burden of 'regular', non–COVID-19, infections.[5] Improved hand hygiene in the community may have had similar effects. Third, hospitals canceled elective surgeries, likely causing reduced ED visits for postoperative complications. Finally, a decrease in physical efforts by patients and improved air quality may be associated with reduced access for cardiovascular emergencies.[2,6]

Nevertheless, fear likely contributed to reduced ED utilization,[7,8] and it has indeed been reported that patients delayed seeking emergency care because of COVID-19 fear.[4,9] Therefore, it is vital that the public is properly informed about the safe hospital environment and the low risk to contract SARS-CoV-2. However, one should keep in mind that there is more than fear that keeps the patients away.

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23 May 2020
Available online 6 June 2020

https://doi.org/10.1016/j.puhe.2020.05.063

Public Health 185 (2020) 312–317

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# Spousal alcohol consumption and female hypertension status: evidence from Nepal

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ARTICLE INFO

*Article history:*
Received 2 December 2019
Received in revised form
6 April 2020
Accepted 25 May 2020
Available online 24 July 2020

*Keywords:*
Blood pressure
Hypertension risk
Alcohol
Household environment
Nepal

ABSTRACT

*Objective:* Psychosocial factors, such as environmental stressors, can increase the risk of hypertension. This study examines the role of the household environment in hypertension outcomes by assessing the link between female hypertension status and spousal alcohol consumption in Nepal.

*Study design:* This is a cross-sectional study.

*Methods:* We used the 2016 Nepal Demographic and Health Survey to assess differences in hypertension outcomes in women aged 15 to 49 years whose husbands drink alcohol and in those whose husbands do not. We estimated a multinomial logistic model to obtain adjusted differences in the likelihood of being hypertensive between the two groups. We also examined several socio-economic conditions across the two groups to discuss various aspects of the association.

*Results:* After controlling for anthropometric and various sociodemographic attributes, we find that women whose husbands drink alcohol were 2.5 percentage points (95% confidence interval [CI]: −0.31, 5.31) more likely to be hypertensive than women whose husbands do not. They were also more likely to experience food insecurity, to experience spousal violence, and to consume tobacco products. Among women whose husbands became intoxicated ('got drunk') very often, the likelihood of being hypertensive was 4.0 percentage points (95% CI: −0.26, 7.67) higher than among women whose husbands do not drink alcohol.

*Conclusion:* Women whose husbands consume alcohol have an elevated risk of being hypertensive, illustrating the association between hypertension and the household environment. The findings document the added hypertension burden in socially vulnerable population groups and can inform initiatives to reduce alcohol consumption in Nepal.



## Introduction

Hypertension has a complex etiology, which includes genetic, behavioral, and environmental factors. Among the latter, a number of psychosocial factors have been discussed as risk factors for hypertension.[1–3] These include occupational stress,[4–7] stressful social environment and social isolation,[2,8] neighborhood characteristics,[9,10] marital stress,[11] low socio-economic status,[12] household food insecurity,[13,14] domestic and intimate partner violence,[15] and racial discrimination.[16,17] These studies further imply that the intensity and duration of exposure to acute or chronic stressors can be linked to sustained elevation of blood pressure (BP), higher incidence of hypertension, or delayed BP recovery. The present study offers new evidence on the role of the household environment in hypertension by assessing the link between female hypertension status and spousal alcohol consumption in Nepal, a low-income country in South Asia.

Alcohol consumption, a risk factor for hypertension, liver cirrhosis, cancer, and cardiovascular diseases,[18–21] is a significant public health concern in Nepal. Alcoholic beverages constitute 5.6% of the average household per capita food expenditure in Nepal.[22] The prevalence of alcohol consumption is estimated to be 28% among adult males (aged 15 to 69 years) in Nepal, and 18% of the alcohol consumers are daily drinkers.[23] Among the male current drinkers, 11% are heavy drinkers, and the mean number of standard drinks per drinking occasion is 4.7.[23] There is, however, a large difference in alcohol consumption between men and women in Nepal, where only 1.5% of women but 21% of men drink alcohol.[24]

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https://doi.org/10.1016/j.puhe.2020.05.049

Given the role of alcohol consumption in promoting adverse psychosocial family environment,[25] the adverse consequences of Nepal's alcohol consumption rate on women's health are more likely to be driven by spousal consumption than by personal alcohol use. Examining the added health burden from spousal alcohol consumption can inform initiatives to reduce alcohol consumption in Nepal.

Almost one in every five adults in Nepal is estimated to have hypertension.[26] The prevalence is 15.2% for women aged 15 to 69 years and 21.8% for men of the same age-group.[27] A rise in hypertension-related complications has strained Nepal's healthcare system, revealing an unmet need for hypertension prevention and control.[28] In the context of Nepal's growing hypertension burden, understanding the psychosocial risk factors for hypertension within the household could inform and motivate hypertension interventions targeted at vulnerable groups.

## Methods

We analyzed data from the 2016 Nepal Demographic and Health Survey (2016 DHS), a multistage stratified national sample survey. The 2016 DHS contains several modules on individual and household characteristics, BP, and domestic violence. In the BP module, female respondents (aged 15+ years) were asked about hypertension history and had their systolic BP (SBP) and diastolic BP (DBP) measured. In the domestic violence module, ever-married women (aged 15 to 49 years) were asked about husbands' alcohol consumption. We used information from these two modules, as well as data on individual and household characteristics, to assess the relationship between husbands' alcohol consumption and wives' hypertension status.

The BP module provides SBP and DBP measures of 6396 women aged 15 to 49 years, whereas the domestic violence module reports husbands' alcohol consumption for 3825 of the female respondents, resulting in 3778 observations for analysis. The respondent's hypertension status comprises three categories—normal, prehypertensive, and hypertensive, determined by the SBP and DBP measures and self-reported antihypertensive medication intake. Normal BP status is defined as SBP <120 mmHg and DBP <80 mmHg; prehypertensive status is defined as SBP between 120 and 139 mmHg and/or DBP between 80 and 89 mmHg; and hypertensive status is defined as SBP $\geq$140 mmHg and/or DBP $\geq$90 mmHg and/or an individual taking antihypertensive medication at the time of the survey.[27]

We first observed how the likelihood of each hypertension status of women aged 15 to 49 years differs among women whose husbands consume and do not consume alcohol. These differences were obtained using complex survey weights, but not accounting for individual specific anthropometric and sociodemographic attributes. We then estimated the following multinomial logistic model to obtain adjusted differences: (see Equation (1))

$$P(H_i = s|alcohol, \boldsymbol{X}) = \frac{\exp(\beta_{0s} + \gamma_s\, alcohol_i + \mathbf{x}_i'\boldsymbol{\beta}_{js} + Province_i)}{1 + \sum_{k=1}^{2}\exp\left(\beta_{0k} + \gamma_k\, alcohol_i + \mathbf{x}_i'\boldsymbol{\beta}_{jk} + Province_i\right)} \quad (1)$$

where $H_i$ denotes respondent $i$'s hypertension status (normal, prehypertensive, or hypertensive; with normal being the base category) and $alcohol_i$ is a binary variable indicating alcohol consumption of respondent $i$'s husband. $X_i$ is a vector of sociodemographic and anthropometric attributes including the respondents' age (in 5-year groups), education, wealth index quintiles, body mass index (BMI), ethnicity, household size, and urban or rural residence. Province fixed effects are denoted by $Province_i$. The subscripts $j$ and $k$ refer to the $j$th control variable and $k$th hypertension category, respectively. Complex survey weights were used to estimate the logistic model in Equation (1). The average marginal effect of husbands' alcohol consumption was then estimated for each mutually exclusive hypertension category. The average marginal effects were multiplied by 100 to obtain adjusted differences in hypertension status between women whose husbands consume alcohol and those whose husbands do not. The adjusted differences in the likelihood of being hypertensive were further analyzed by age-group, wealth index quintile, nutritional status, and educational attainment.

To examine the role of husbands' alcohol consumption intensity, we re-estimated Equation (1) replacing $alcohol_i$ with a set of dummy variables indicating the frequency of 'getting drunk.' This set of variables indicates the following consumption levels: does not drink (base category), 'never gets drunk,' 'gets drunk sometimes,' and 'gets drunk very often.' Finally, we explored possible channels of the association between husbands' alcohol consumption and wives' hypertension status by examining differences in socio-economic conditions such as household food security, spousal violence, and tobacco use across women whose husbands consume alcohol and those whose husbands do not. The empirical analysis was conducted using Stata 13.1 software.

## Results

The estimated likelihood of being hypertensive in our sample of Nepalese women was 12.8%. Of the 3778 women in the sample, 44.3% reported that their husbands consume alcohol. The baseline characteristics of women by spousal alcohol consumption are presented in Table 1. Incidence of spousal alcohol consumption is higher for women with no education and women at lower wealth quintiles.

There is a 4.5 percentage point gap in hypertension prevalence between wives of alcohol-consuming husbands and those of husbands not consuming alcohol. After controlling for anthropometric and sociodemographic attributes, the hypertension prevalence gap between the two group was 2.5 percentage points (Table 2).

Table 3 reports the gap in hypertension prevalence between women whose husbands consume alcohol and those whose husbands do not, stratified by individual characteristics. For the younger cohorts (age 15 to 29 years), we did not observe statistically significant differences in hypertension by spousal alcohol use.

**Table 1**
Baseline characteristics of women by spousal alcohol consumption.

| Baseline characteristics | All women (%) | Women whose husbands do not consume alcohol (%) | Women whose husbands consume alcohol (%) |
|---|---|---|---|
| **Age-group (years)** | | | |
| 15 to 19 | 6.41 (5.41, 7.41) | 7.94 (6.41, 9.48) | 4.48 (3.31, 5.65) |
| 20 to 24 | 16.79 (15.27, 18.31) | 17.73 (15.52, 19.95) | 15.61 (13.40, 17.81) |
| 25 to 29 | 18.80 (17.16, 20.44) | 19.01 (16.60, 21.42) | 18.54 (16.45, 20.63) |
| 30 to 34 | 18.27 (16.67, 19.86) | 17.24 (14.94, 19.54) | 19.56 (17.43, 21.68) |
| 35 to 39 | 16.61 (15.02, 18.20) | 17.11 (14.63, 19.59) | 15.98 (13.93, 18.03) |
| 40 to 44 | 13.60 (12.16, 15.03) | 12.11 (10.24, 13.99) | 15.46 (13.32, 17.61) |
| 45 to 49 | 9.52 (8.21, 10.84) | 8.85 (7.02, 10.67) | 10.38 (8.61, 12.14) |
| **Education** | | | |
| No education | 41.81 (39.14, 44.49) | 39.12 (35.52, 42.72) | 45.20 (41.99, 48.41) |
| Primary | 18.73 (16.68, 20.79) | 17.63 (15.09, 20.18) | 20.12 (17.15, 23.09) |
| Secondary | 28.11 (25.95, 30.26) | 29.67 (26.84, 32.50) | 26.14 (23.26, 29.02) |
| Higher | 11.35 (9.51, 13.18) | 13.57 (10.81, 16.33) | 8.54 (6.83, 10.26) |
| **Wealth index quintile** | | | |
| Lowest | 17.62 (15.23, 20.00) | 13.98 (11.62, 16.35) | 22.19 (18.93, 25.45) |
| Second | 19.98 (17.93, 22.03) | 18.65 (16.37, 20.93) | 21.66 (18.93, 24.38) |
| Middle | 21.21 (19.30, 23.13) | 22.42 (19.99, 24.84) | 19.70 (17.17, 22.23) |
| Fourth | 21.51 (19.21, 23.80) | 23.37 (20.44, 26.31) | 19.16 (16.33, 21.99) |
| Highest | 19.68 (16.79, 22.57) | 21.57 (18.19, 24.96) | 17.30 (14.05, 20.55) |
| **Nutritional status (BMI in kg/m$^2$)** | | | |
| Normal (BMI = 18.5–24.9) | 59.67 (57.30, 62.05) | 59.76 (56.67, 62.85) | 59.56 (56.28, 62.84) |
| Underweight (BMI<18.5) | 13.68 (12.03, 15.33) | 14.78 (12.57, 17.00) | 12.30 (10.32, 14.27) |
| Overweight (BMI = 25.0–29.9) | 20.75 (18.92, 22.59) | 20.03 (17.74, 22.32) | 21.66 (18.98, 24.34) |
| Obese (BMI ≥30) | 5.90 (4.73, 7.06) | 5.43 (3.88, 6.98) | 6.48 (4.80, 8.17) |
| **Household size** | | | |
| 2 or less | 8.33 (7.29, 9.36) | 8.02 (6.76, 9.28) | 8.72 (7.14, 10.31) |
| 3 to 4 | 35.75 (33.52, 37.98) | 33.31 (30.78, 35.84) | 38.83 (35.78, 41.88) |
| 5 to 6 | 31.17 (29.01, 33.34) | 30.06 (27.33, 32.79) | 32.58 (29.87, 35.28) |
| 7 or more | 24.75 (22.76, 26.73) | 28.62 (25.79, 31.44) | 19.87 (17.41, 22.34) |
| **Residence** | | | |
| Urban | 60.03 (55.36, 64.69) | 60.01 (54.60, 65.42) | 60.05 (55.09, 65.02) |
| Rural | 39.97 (35.31, 44.64) | 39.99 (34.58, 45.40) | 39.95 (34.98, 44.91) |
| Observations | 3778 | 1991 | 1787 |

BMI = body mass index.
Estimates were obtained using complex survey weights; 95% confidence intervals are in parentheses. The column total within each category (e.g. age-group) is 100%.

For older age cohorts (aged 30 to 49 years), the gap was statistically significant and gradually increased with age. For instance, the likelihoods of being hypertensive were 2.0 and 4.8 percentage points higher for women in the age-groups 30 to 34 and 45 to 49 years whose husbands consume alcohol, than for women of the corresponding age cohorts and whose husbands do not consume alcohol. A gap of around 2.5 percentage points prevailed across all five wealth index quintiles and across all four educational attainment categories. The gap was found to be higher for respondents with obesity and overweight respondents and relatively lower for underweight and normal-weight categories.

Of the 44.3% women who report husbands' alcohol consumption, 27.7% reported that their husbands never get drunk, 17.1% reported that their husbands get drunk sometimes, and 55.2% reported that their husbands get drunk very often. Table 3 compares wives' likelihood of being hypertensive with husbands' frequency of getting drunk. Women whose husbands 'get drunk very often' were at higher risk of being hypertensive than wives whose husbands do not drink alcohol. We did not find statistically significant differences for women whose husbands 'never get drunk' or 'get drunk sometimes' (Table 4).

Fig. 1 illustrates differences in household food security, spousal violence, and tobacco use between the two groups of women. Women with alcohol-consuming husbands were more likely to belong in a household that suffers from food insecurity. They were also more likely to be a victim of physical, sexual, and emotional spousal violence than women whose husbands do not consume alcohol. Finally, wives whose husbands consume alcohol were more likely to consume tobacco products, which is an added risk factor for elevated BP.

**Table 2**
Hypertension status among women aged 15–49 years by husbands' alcohol consumption.

| Blood pressure status | Hypertension status of women whose husbands do not consume alcohol (%) | Differences in hypertension status between women whose husbands consume alcohol and women whose husbands do not consume alcohol (percentage points) | |
|---|---|---|---|
| | | Unadjusted difference | Adjusted difference |
| Normal | 64.84 (61.80, 67.88) | −4.08 (-8.35, 0.19); $P = 0.061$ | −0.24 (-4.51, 4.04) |
| Prehypertensive | 24.30 (21.64, 26.96) | −0.39 (-3.85, 3.06) | −2.27 (-5.86, 1.32) |
| Hypertensive | 10.86 (9.22, 12.51) | 4.47 (1.68, 7.27); $P = 0.002$ | 2.50 (-0.31, 5.31); $P = 0.081$ |

BMI = body mass index.
Estimates were obtained using complex survey weights. The adjusted differences are average marginal effects (multiplied by 100) estimated from multinomial logistic regressions. Regressions reporting adjusted differences control for respondents' age-group, education, wealth index quintile, BMI, ethnicity, household size, and urban or rural residence and include province fixed effects; 95% confidence intervals are in parentheses.

**Table 3**
Comparison of hypertension prevalence among women by sociodemographic and anthropometric characteristics and husbands' alcohol consumption status.

| Sociodemographic and anthropometric characteristics | Hypertensive status of women whose husbands do not consume alcohol (%) | Differences in hypertensive status between women whose husbands consume alcohol and women whose husbands do not consume alcohol (percentage points) | |
|---|---|---|---|
| | | Unadjusted difference | Adjusted difference |
| **By age-group (years)** | | | |
| 15 to 19 | 2.89 (-0.38, 6.16) | −2.68 (-6.01, 0.66) | 0.70 (-0.40, 1.79) |
| 20 to 24 | 4.82 (1.86, 7.78) | −0.73 (-5.09, 3.63) | 1.15 (-0.36, 2.66) |
| 25 to 29 | 4.25 (2.27, 6.22) | 5.46 (1.28, 9.65); $P = 0.011$ | 1.51 (-0.37, 3.40) |
| 30 to 34 | 10.63 (6.33, 14.93) | −0.93 (-6.53, 4.67) | 2.02 (-0.21, 4.24); $P = 0.075$ |
| 35 to 39 | 16.56 (12.06, 21.07) | 5.43 (-2.27, 13.12) | 3.49 (-0.47, 7.44); $P = 0.084$ |
| 40 to 44 | 15.59 (10.10, 21.09) | 11.30 (1.32, 21.27); $P = 0.027$ | 4.00 (-0.47, 8.47); $P = 0.079$ |
| 45 to 49 | 27.32 (18.49, 36.14) | 4.68 (-6.88, 16.24) | 4.83 (-0.31, 9.96); $P = 0.065$ |
| **By wealth index quintile** | | | |
| Lowest | 9.48 (5.21, 13.74) | 2.08 (-3.69, 7.85) | 2.44 (-0.20, 5.08); $P = 0.070$ |
| Second | 11.24 (7.32, 15.16) | 5.48 (-0.90, 11.85); $P = 0.092$ | 2.91 (-0.33, 6.15); $P = 0.078$ |
| Middle | 7.57 (4.95, 10.20) | 5.76 (0.70, 10.82); $P = 0.026$ | 2.50 (-0.30, 5.30); $P = 0.080$ |
| Fourth | 10.00 (6.28, 13.72) | 1.81 (-4.55, 8.17) | 2.20 (-0.35, 4.76); $P = 0.090$ |
| Highest | 15.80 (11.84, 19.75) | 8.85 (0.48, 17.22); $P = 0.038$ | 2.47 (-0.45, 5.39); $P = 0.098$ |
| **By nutritional status (BMI in kg/m$^2$)** | | | |
| Normal (BMI = 18.5–24.9) | 8.39 (6.26, 10.52) | 2.88 (-0.28, 6.05); $P = 0.074$ | 2.18 (-0.33, 4.68); $P = 0.088$ |
| Underweight (BMI <18.5) | 3.82 (0.90, 6.73) | −1.06 (-4.79, 2.67) | 0.94 (-0.30, 2.18) |
| Overweight (BMI = 25.0–29.9) | 18.39 (13.80, 22.99) | 8.78 (2.09, 15.46); $P = 0.010$ | 3.59 (-0.46, 7.64); $P = 0.082$ |
| Obese (BMI≥30) | 29.48 (16.92, 42.03) | 7.48 (-10.34, 25.31) | 4.53 (-0.18, 9.25); $P = 0.059$ |
| **By education** | | | |
| No education | 13.02 (10.06, 15.99) | 2.27 (-2.04, 6.59) | 2.34 (-0.32, 5.01); $P = 0.085$ |
| Primary | 8.07 (4.85, 11.28) | 11.63 (4.94, 18.32); $P = 0.001$ | 2.59 (-0.40, 5.59); $P = 0.090$ |
| Secondary | 9.87 (7.04, 12.70) | 1.26 (-2.96, 5.49) | 2.54 (-0.21, 5.29) $P = 0.070$ |
| Higher | 10.44 (5.57, 15.32) | 7.68 (-1.58, 16.93) | 2.93 (-0.49, 6.36); $P = 0.093$ |

BMI = body mass index.
Estimates were obtained using complex survey weights. The adjusted differences are average marginal effects (multiplied by 100) at respective values of socio-economic status estimated from multinomial logistic regressions. The control variables in the adjusted difference estimation include age-group, education, wealth index quintile, BMI, ethnicity, household size, urban or rural residence, and province fixed effects; 95% confidence intervals are in parentheses.

## Discussion

This study investigates the role of spousal alcohol consumption in hypertension outcomes among women of reproductive age in a low-income South Asian country, Nepal. We find that women whose husbands consume alcohol were at significantly higher risk of being hypertensive than women whose husbands do not consume alcohol; however, the statistical significance of the effect size is relatively weak. We also find that this risk further increases with higher levels of husbands' alcohol consumption, measured by the frequency of 'getting drunk.'

Earlier studies have found that husbands' smoking is associated with wives' hypertension status.[29] However, unlike the direct health effects of passive smoking, the relationship between husbands' alcohol consumption and wives' hypertension is more likely to be realized through a psychosocial mechanism. It has been suggested that spouses of individuals with hypertension have higher odds of having hypertension owing to shared circumstances such as common living environment and lifestyle habits.[30] To our knowledge, the present study is the first to flag an association between husbands' alcohol consumption and wives' hypertension condition using a national sample survey.

Although our analysis does not explain the exact mechanism through which this association may occur, plausible explanations include household circumstances related to chronic stress or nutrition. Chronic or persistent stress is a known risk factor for hypertension.[2] Spousal violence or inmate partner violence against women has a direct link to psychological trauma or stress, which could contribute to hypertension and other cardiovascular diseases.[15,31] In the 2016 DHS data, we observe that wives whose husbands drink alcohol had higher risk of experiencing physical, sexual, and emotional spousal abuse, underscoring the relevance of this factor as a link between women's hypertension and spousal drinking. We further find that women whose husbands get drunk very often were at higher risk of being hypertensive than women whose husbands get drunk sometimes or never get drunk. It has been reported that almost three-fourths of the women whose husbands get drunk very often are victims of spousal violence.[27]

**Table 4**
Differences in hypertension status among women aged 15–49 years by husbands' level of alcohol consumption.

| Frequency of getting drunk | Unadjusted difference | Adjusted difference |
|---|---|---|
| Never gets drunk | 2.24 (-1.73, 6.21) | 1.22 (-2.44, 4.88) |
| Gets drunk sometimes | 2.85 (-1.81, 7.51) | 0.67 (-3.82, 5.17) |
| Gets drunk very often | 6.06 (2.06, 10.06); $P = 0.003$ | 3.96 (-0.26, 7.67); $P = 0.036$ |

BMI = body mass index.
Estimates were obtained using complex survey weights. 'Does not drink alcohol' is the base case for level of alcohol consumption; and the differences refer to differences between certain alcohol consumption level groups (e.g. never, sometimes, often) and the base case. The control variables in the adjusted difference estimation include age-group, education, wealth index quintile, BMI, ethnicity, household size, urban or rural residence, and province fixed effects; 95% confidence intervals are in parentheses.

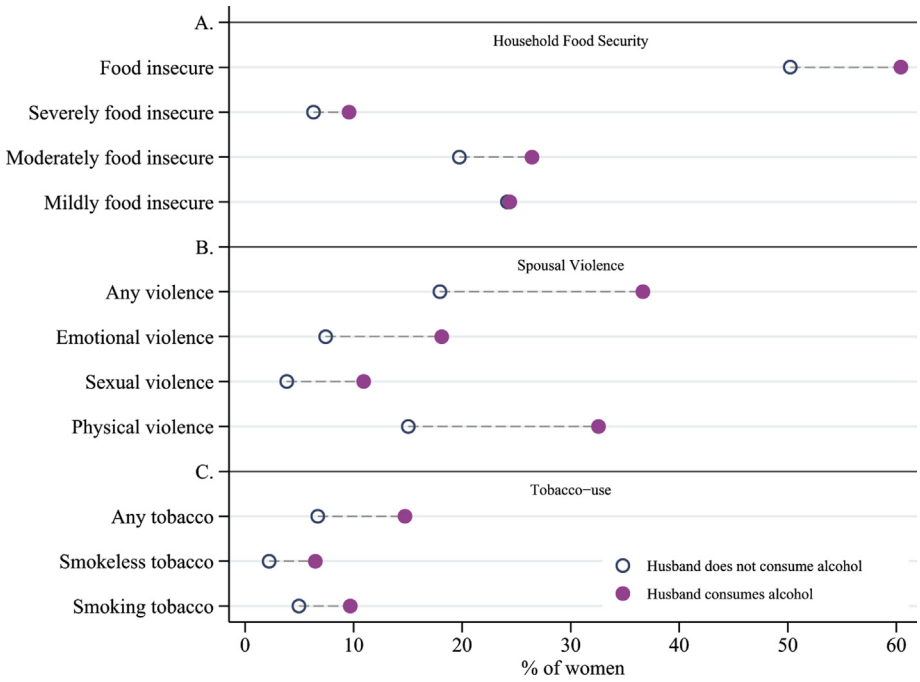


**Fig. 1.** Differences in wives' selected socio-economic conditions by husbands' alcohol consumption. Each pair of solid dots in the horizontal axis, corresponding to the socio-economic conditions in the vertical axis, represents the likelihood of an event (expressed in percentage of women). The differences (percentage points) in likelihood of certain socio-economic conditions between women whose husbands consume alcohol and those whose husbands do not are presented by the dashed line connecting the two markers.

This is consistent with the indication that spousal violence against women could be one of the possible mechanisms to trigger a positive association between husbands' alcohol consumption and wives' hypertension status.

Husbands' alcohol consumption may result in reduced spending on other household commodities by reducing the money available after expenditure on alcohol. This could impact a household's dietary and other health needs and might contribute to added stress among women managing the household with limited means. Analyzing the differences in food consumption between alcohol-consuming and non–alcohol-consuming households will enhance our understanding of this issue, which can be explored in future research.

Several studies have documented a link between food insecurity and hypertension.[32,33] Consistent with this literature, our study estimates that women whose husbands drink alcohol were more likely to be in a household that is food insecure. Women in food-insecure households may have unhealthy diets (e.g. insufficient fruits and vegetables) and often receive less than a fair share of the intrahousehold food allocation.[34] This may lead to adverse health conditions, indirectly affecting women's hypertension status.

The study is subject to several limitations. As a cross-sectional analysis, it does not allow inference of causal effects, and the findings document associations only. The study does not shed light on the precise mechanisms for the association between husbands' alcohol consumption and wives' hypertension status. Omitted variables can obscure the estimated relationship. For example, the consumption of tobacco and alcohol products is correlated with raised BP.[18] While our models control for tobacco use among women, the 2016 DHS does not report women's alcohol consumption. However, the bias from omitting personal alcohol use as a determinant of hypertension in women is minimized by the very low rate of alcohol use among women in Nepal. The DHS does not provide clinical diagnosis of hypertension—rather, it reports the occurrence of elevated BP at the time of the survey.[27] Despite the limitations, the association reported in this study has public health implications and informs the discussion of policies to address hypertension and harmful alcohol use in Nepal. Thus far, alcohol has been considered as a risk factor of hypertension for alcohol-consuming individuals.[35] By showing that spousal drinking might also play a role, this article highlights the importance of the household environment in hypertension risk among women.

## Author statements

*Acknowledgements*

The authors are grateful to Deliana Kostova for her comments and suggestions.

*Ethical approval*

The study used publicly available secondary data and thus is not subject to ethical approval.

*Funding*

None declared.

*Competing interests*

None declared.

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Public Health 185 (2020) 91–92

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Short Communication

# TB infection and BCG vaccination: are we protected from COVID-19?

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ARTICLE INFO

*Article history:*
Received 17 April 2020
Received in revised form
20 May 2020
Accepted 20 May 2020
Available online 30 May 2020

ABSTRACT

*Objectives:* The incidence of emerging coronavirus disease 2019 (COVID-19) disease is variable across the different parts of the world. Apart from travel patterns, other factors determining this difference may include host immune response. The aim of this study was to assess the effect of tuberculosis (TB) endemicity and Bacille Calmette-Guerin (BCG) coverage on COVID-19.
*Study design:* This was a cross-sectional study.
*Methods:* We reviewed available data regarding TB incidence, BCG coverage (as per the World Health Organization), and COVID-19 incidence of 174 countries. We divided the countries into four cohorts depending on annual TB incidence and BCG coverage.
*Results:* Countries with high TB incidence had lower COVID-19 than countries with low TB incidence. Similarly, countries with high BCG coverage had lower incidence of COVID-19, suggesting some protective mechanisms in TB-endemic areas. However, the ecological differences and different testing strategies between countries could not be accounted for in this analysis.
*Conclusion:* Higher TB incidence and BCG coverage were found to be associated with lesser incidence of COVID-19. This outcome paves the way for further research into pathogenesis and immune response in COVID-19.


The coronavirus disease 2019 (COVID-19) pandemic has affected countries across the globe but in a differential manner. Apart from traveling patterns, probable hypotheses postulated for the same have been temperature differences and the presence of Bacille Calmette-Guerin (BCG) vaccination in the immunization schedule of various countries.[1,2] Because BCG vaccination is commonly practiced in countries with higher tuberculosis (TB) burden, an apparent confounding factor for the same would be the presence of latent TB infection in the community. It is imperative to differentiate whether the decreased SARS-CoV-2 infection is related to BCG vaccination or latent TB, as it might give an insight regarding the pathogenesis of the disease. In this study, we evaluated the relationship of BCG coverage and TB incidence of 174 countries affected, with their COVID-19 incidence and case fatality rate (CFR).

This was a retrospective cross-sectional study and population data of all the countries affected by COVID-19 (174 countries), the number of cases, and the deaths due to COVID-19 as on 1st April 2020 were sorted from online platforms.[3–5] The TB incidence data were obtained from the world TB registry as available on the World Health Organization (WHO) website (after prior permission).[4] The data were managed and analyzed using Stata 14.0 statistical software. We stratified the countries based on TB incidence (low/high, low defined as <50 cases per 100,000 population) as well as BCG coverage (low/high, low defined as ≤60% coverage as per the WHO, or BCG not part of the immunization schedule of the country). A comparison of the distribution of quantitative variables between two categories of population density and TB incidence were made using the Wilcoxon rank-sum test.

As of 1 April 2020, the USA had a maximum reported COVID-19 cases (n = 163,199), while Libya, Papua New Guinea, Syria, Timor-Leste, Sierra Leone, and Saint Vincent and Grenada had the least (n = 1). Maximum deaths occurred in Italy (n = 12,430), while 62 countries reported no mortality. After stratifying the countries into four groups, i.e., low TB/low BCG (group 1), low TB/high BCG (group 2), high TB/low BCG (group 3), and high TB/high BCG (group 4), COVID incidence (per 100,000 population) and CFR (per 100 population) were analyzed. The median incidence (per 100,000

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https://doi.org/10.1016/j.puhe.2020.05.042
0033-3506/

**Table 1**
COVID-19 incidence (per 100,000 population) and case fatality rate (per 100 population) in relation to annual TB incidence (per 100,000 population) and BCG coverage of the country.

| Characteristic | Group 1 (low TB incidence, low BCG coverage) N = 38 | Group 2 (low TB incidence, high BCG coverage) N = 60 | Group 3 (high TB incidence, low BCG coverage) N = 5 | Group 4 (high TB incidence, high BCG coverage) N = 71 | *P*-value |
|---|---|---|---|---|---|
| COVID-19 incidence (per 100,000) | 46.60 (1.36–749.06) | 4.30 (0.005–132.51) | 0.04 (0.02–17.61) | 0.43 (0.01–85.46) | <0.001 |
| COVID-19 case fatality rate (per 100) | 1.42 (0–11.7) | 1.43 (0–25.0) | 0 (0–28.5) | 0 (0–33.3) | 0.09 |

Data are represented in terms of median (range).
Data were taken from the World Health Organization website, Global Tuberculosis Report, and https://www.worldometers.info/coronavirus.
BCG, Bacille Calmette-Guerin; COVID-19, coronavirus disease 2019; TB, tuberculosis.

population) of COVID-19 was 46.6 in group 1, 4.3 in group 2, 0.04 in group 3, and 0.43 in group 4, with a significant difference ($P < 0.05$) among all the groups except group 3 and group 4 ($P = 0.1$) Table 1. The median CFR was 1.42 in group 1, 1.43 in group 2, and 0 in group 3 and group 4, without any significant difference between the groups.

Our analysis demonstrated that high-TB-burden countries had a lower incidence of COVID-19, irrespective of the BCG vaccine status of the country. On the other hand, in low-TB-burden countries, BCG vaccine might confer protection against COVID-19. This probable relationship between TB and COVID-19 may be explained by cross-immunity between *Mycobacterium* species and COVID-19, which may be conferred by either latent or previous TB infection or BCG vaccination. Various vaccines including the BCG can produce positive non-specific immune effects leading to enhanced response against other non-mycobacterial pathogens such as the vaccinia virus. Another possible explanation is that COVID-19 and TB share the common Th1 immune pathway, and it seems plausible that latent TB infection or a past TB infection could lead to a better immune response to SARS-CoV-2.[6,7] As mentioned earlier, BCG vaccination for COVID-19 may have a protective role in low-TB-burden countries, thus suggesting a role of BCG vaccination as prophylaxis to individuals at high risk of COVID-19 and its complications in these countries. A clinical trial with this intent is already underway (https://clinicaltrials.gov/ct2/show/NCT04327206). This analysis has several limitations as the countries are in different stages of the disease, and it may be premature to infer the effect of TB endemicity on COVID-19 incidence. Second, the administrative strategies to prevent transmission of infection also vary significantly between countries. Some countries have resorted to aggressive testing and abandoning all social get-togethers, while others have not. It might have affected the exact incidence of disease, thus affecting our study outcomes. The number of countries in group 3 was low; thus, finding the BCG effect in high-TB-burden countries is not possible. We were also not able to account for the ecological differences between the countries while analyzing these data sets. The countries vary in the form of the age structure of the population, economic status, social practices between various subpopulations, and hygiene practices. All these factors may contribute to the variable occurrence of COVID-19. The United Kingdom (UK) has reported a significant proportion of deaths due to COVID-19 in minority populations such as blacks and Asians, which are more likely to have received BCG vaccination or had a history of previous TB, but the data on their duration of stay in the UK have also not been analyzed so far. Another issue is that the protection provided by BCG vaccine may also wane with age and thus predisposing the elderly population to a higher risk of disease. Finally, it is crucial to understand that these data only provide a correlation rather than a causal association, suggesting the need for prospective evaluation.

We conclude that there might be an association of low BCG coverage and low TB incidence with poor outcomes in COVID-19. Future research into the pathogenesis of COVID-19 may further improve our understanding of TB and COVID-19 relationship.

## Author statements

### *Ethical approval*

Ethical approval was not deemed necessary as this was an analysis of publically available data. WHO data was used after obtaining prior permission.

### *Funding*

None declared.

### *Competing interests*

None declared.

### *Authors' contribution*

All the authors have contributed equally.

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