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Original Research

A longitudinal study of COVID-19 disclosure stigma and COVID-19 testing hesitancy in the United States

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A R T I C L E I N F O

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A B S T R A C T

Objectives: This study examines the relationship between COVID-19 disclosure stigma and COVID-19 testing hesitancy and assesses their changes between November 2020 and 2021.
Study design: This was a longitudinal cohort.
Methods: A total of 355 participants completed four study waves between November 2020 and November 2021. Factor analyses and Cronbach's alpha assessed the factor structure and internal consistency of the COVID-19 Disclosure Stigma scale. Paired *t*-tests and McNemar's Chi-squared test assessed change between the study waves. Multivariable logistic regression models examined the relationship between COVID-19 disclosure stigma and testing hesitancy at four study waves.
Results: COVID-19 disclosure stigma declined significantly between the last study waves ($P = 0.030$). The greatest disclosure concern was reporting a positive test to close contacts (range: 19%–21%) followed by disclosure to friends (range: 10%–15%) and family (range: 4%–10%). Over the course of the four study waves, COVID-19 testing hesitancy when symptomatic ranged from 23% to 30%. Older age, female gender, and having received a COVID-19 vaccine were associated with decreased odds of testing hesitancy. Greater COVID-19 disclosure stigma and more conservative political ideology showed a consistent relationship with increased odds of COVID-19 testing hesitancy.
Conclusions: Study findings suggest that many people anticipate feeling stigmatized when disclosing positive test results, especially to close contacts. A substantial percentage of study participants reported hesitancy to be tested when symptomatic. This study identifies a need for interventions that normalize COVID-19 testing (e.g. engaging leaders with conservative followings), provide strategies for disclosing positive results, and allow anonymous notification of potential COVID-19 exposure.

Introduction

Testing for infection by SARS-CoV-2 (COVID-19 testing) is a critical tool for identifying and mitigating the spread of COVID-19. Initially, testing in the United States was highly limited in the months following the country's first confirmed case of COVID-19 in late January 2020.[1,2] The rate of testing increased dramatically in the first 8 months of the pandemic, from about 2 million tests per week in late April 2020 to approximately 2 million tests per day by late November 2020.[1] Starting in 2020, COVID-19 tests were available for free via programs offered by many health departments and purchase at many stores with pharmacies. Beginning in 2022, COVID-19 home test kits could be ordered from the US government at no cost. Even after the introduction of vaccinations for SARS-CoV-2, which effectively reduce cases of severe illness, COVID-19 testing remains an integral means of reducing the spread of the virus and helping to guide treatment.[3] For example, prompt testing of symptomatic individuals is critical, as COVID-19 antivirals are most effective when administered within the first few days.[4] Yet, although there has been a plethora of research focused on vaccine hesitancy, research on COVID-19 testing hesitancy has been limited. Understanding COVID-19 testing hesitancy and barriers to testing can inform COVID-19 prevention and pandemic control programs.

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Stigma is one such barrier to COVID-19 testing uptake. Stigma refers to a set of interrelated social processes, which differentiate persons characterized as 'normal' from the 'abnormal,' based on a given attribute and negative stereotypes.[5,6] It is common for stigma to be associated with infectious diseases, as it has been linked to HIV, hepatitis C, syphilis, tuberculosis, Ebola, and H1N1.[7] Stigma toward other pandemic diseases (e.g. HIV/AIDS) has been identified as a predictor of not testing.[8] In the context of COVID-19, stigma toward COVID-19 has manifested in different ways to disproportionately target a variety of sociodemographic groups, including persons of Asian descent,[9] people who are more likely to contract and spread COVID-19 (e.g. healthcare workers),[10] people of low socio-economic status engaged in essential work,[11] as well as people who have tested positive for COVID-19.[12]

In this article, we focus on the stigma associated with people who have tested positive for COVID-19. We view stigma as a multilevel construct that works along gradients of power, with stigma operating at the intrapersonal level by affecting one's self-perception as well as at the interpersonal level by shaping relationships.[13,14] During the COVID-19 pandemic, misinformation, as well as other social and structural processes, have facilitated the spread of stigmatization of people infected with COVID-19.[12] Misinformation has driven fear and anxiety over becoming infected, which, along with an individual's fear of infecting others, can lead to social exclusion or isolation. For example, a study of Jordanian adults found that perceived discrimination at work was associated with COVID-19 testing hesitancy.[15] Structural infection control measures, such as quarantine, physically exclude individuals and can further fuel stigma on an intrapersonal and interpersonal level.[16] Furthermore, terms used in the media and public discourse such as 'super spreader' and 'transmitting the virus' assign blame for infection to the individual.[16]

Disclosure is highly intertwined with stigma[17] and central to COVID-19 prevention and mitigation strategies. When a health condition is stigmatized, disclosure concern increases. Moreover, similar to stigma, disclosure can shape social relationships—disclosing an illness such as COVID-19 can significantly alter interpersonal relationships and support from their social network[17] as those infected may be viewed as careless for acquiring COVID-19 and endangering others through COVID-19 transmission. Given the importance of disclosing one's positive COVID-19 status in mitigating the spread of COVID-19, we focus specifically on individuals' comfort in disclosing positive results to close contacts. For testing to be effective, the contacts of people who test positive for COVID-19 need to be notified, tested, and isolate if they test positive. As many locales do not have contact tracing programs, personal disclosure is an important method for contacts to be notified of exposure and potential infections. In addition, where contact tracing is used, personal disclosure may be quicker than public health officials notifying contacts. In this study, we use novel items addressing three theory-informed and practice-relevant domains (i.e. friends, family, and other close contacts) to capture COVID-19 disclosure stigma.

Existing research on the relationship between COVID-19 testing and COVID-19 stigma in the United States is limited. One study by Earnshaw et al. assessed COVID-19 stigma and testing intentions early in the COVID-19 pandemic (April 2020) and identified a significant association between anticipated stigma and COVID-19 testing intentions.[18] In addition to looking only at a specific timepoint soon after the advent of the pandemic, the authors also note that their measure of testing (i.e. if participants would seek a test if one were to be 'ordered' by their doctor) may have resulted in an inflated likelihood of self-reported test-seeking; thus, they call for future work to focus on testing intention when symptomatic.[18] An additional limitation of the current body of literature on COVID-19 stigma is that COVID-19 is presented as a relatively fixed entity.[19,20] However, stigma, including stigma associated with testing positive for COVID-19, may have changed over time.[21] For example, the announcement of various celebrities and politicians who have tested positive for COVID-19 may impact perceptions of the disease and normalize diagnosis.[22] Moreover, increased access to home testing may have altered levels of COVID-19 stigma.[23] In addition, as vaccines are now readily available that greatly reduce the probability of severe COVID-19, hospitalization, and death, SARS-CoV-2 may not be perceived as so threatening, which may alter the level of stigma surrounding testing and of being infected. The present study, therefore, examines COVID-19 disclosure stigma within the continually changing dynamics of the COVID-19 pandemic by assessing it at multiple time points and examining the relationship between COVID-19 disclosure stigma and COVID-19 testing hesitancy over time. A subanalysis also includes vaccination status in models of vaccine hesitancy. It is important to look at vaccination status because those who are not vaccinated are at the highest risk of severe infection and should be quickly tested for potential treatment with antivirals.

Methods

Recruitment and sampling

This study used participants from the COVID-19 and Well-Being Study. The COVID-19 and Well-Being Study is an online longitudinal cohort study that began in March 2020 that aimed to examine individual-, social-, and societal-level fluctuations related to COVID-19 amid the rapidly changing landscape of the pandemic. Study periods occurred every few months and aimed to capture changes in COVID-19–related information, behaviors, and health status. Participants were initially recruited through Amazon's Mechanical Turk (MTurk), a platform that is frequently used by health researchers, as it allows for the study of real-time dynamics of large groups.[24] Study populations recruited through MTurk are not nationally representative but have been documented to perform better than other convenience samples on several key dimensions and have demonstrated good reliability.[25,26] The study protocols followed MTurk's best practices, including ensuring confidentiality, using unique completion codes, integrating attention checks throughout the survey, repeating study-specific qualification questions, and removing ineligible participants.[27,28] Eligibility for recruitment into the longitudinal cohort included being age 18 years or older, living in the United States, being able to speak and read English, having heard of the coronavirus or COVID-19, and providing written informed consent. To enhance reliability, eligible participants also had to pass attention and validity checks embedded in the survey.[29]

At baseline, 809 people were eligible for the study and asked to participate in each subsequent survey wave. This analysis uses survey waves when information on COVID-19 stigma was collected and includes survey waves 4 (November 2020), 5 (March 2021), 6 (June 2021), and 7 (November 2021). Participants were notified through the MTurk platform when a new survey was deployed. Participants received a reminder message to complete the survey approximately every 2 days during the survey window or until they completed the survey. To assess change over time, only participants who participated in all four waves were included in the present analysis. In total, 361 people participated in all four waves. Three participants were excluded from the present analysis due to missing data on the COVID-19 stigma questions or testing intentions. An additional three participants who did not identify as male or female were excluded due to small sample size, providing a final sample size of 355 participants. Participants were compensated $4.25 for completing each of the online surveys at waves 4, 5, 6, and 7, which is equivalent to approximately $12 per hour. The study protocols were approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

Measures

Three items assessed COVID-19 disclosure stigma. These items were designed to target disclosure stigma within the three interpersonal relationship domains of friends, family, and close contacts.

These three domains are frequently included in stigma-related scales seeking to measure secrecy and disclosure around stigmatized health conditions (e.g. mental illness,[30–32] HIV[33]). The three items were as follows: 'If I had a positive coronavirus test, I would feel very uncomfortable telling my friends,' 'If I had a positive coronavirus test, I would feel very uncomfortable telling my family,' and 'If I had a positive coronavirus test, I would feel very uncomfortable telling people that I had recently been in close contact with.' Although often the 'close contacts' domain may be asked about in other scales using terms such as 'community members' or 'coworkers,' we use the language of 'people that I had recently been in close contact with' to better align with COVID-19 prevention efforts and common COVID-19–related messaging. The participants responded on a 1- to 5-point Likert scale of 'strongly disagree,' 'disagree,' 'neither agree or disagree,' 'agree,' and 'strongly agree.' The sum of the three items at each study wave formed the stigma scale score (range: 5–15), with higher scores representing greater disclosure stigma.

COVID-19 testing hesitancy was assessed by asking participants, 'If you had symptoms of coronavirus, how likely is it that you would get tested for coronavirus?' Responses included 'extremely unlikely,' 'unlikely,' 'neutral,' 'likely,' and 'extremely likely.' To assess COVID-19 testing hesitancy, a dichotomous variable was created to compare those not likely to get a COVID-19 test when symptomatic (responses of 'extremely unlikely,' 'unlikely,' and 'neutral') to those likely to be tested (responses of 'extremely likely' and 'likely'). Demographics were assessed at baseline data collection (March 2020), and variables included age, race/ethnicity, sex, family income, education, and political orientation. Age was assessed as a continuous variable. The respondents' race/ethnicity included 'White,' 'non-Hispanic Black,' 'Hispanic,' 'Asian,' 'Mixed,' or 'Other.' Due to small sample size, 'Hispanic,' 'Asian,' 'Mixed,' and 'Other' were collapsed into 'Other.' Sex of the respondents was based on their reported sex assigned at birth. Household income was dichotomized, based on the median, at 60,000 USD or less vs more than 60,000 USD per year. Education was also dichotomized based on the median, at some college degree or less vs bachelor's degree or higher. As the response to COVID-19 in the United States has become politically oriented, participants were also asked about their political orientation on a scale from 'very liberal,' 'liberal,' 'slightly liberal,' 'moderate,' 'slightly conservative,' 'conservative,' to 'very conservative,' with higher scores representing more conservative orientations. Two people did not identify their political ideology and were coded as moderate.

A supplementary analysis also adjusted for vaccination status. This analysis focused on waves 5, 6, and 7 because vaccines were not available at the time of prior survey waves. Vaccination status was assessed at each of these three waves and compared participants who had received at least one dose of a COVID-19 vaccine to participants who had received no doses. A second supplemental analysis assessed the independent effect of each of the COVID-19 disclosure stigma items on COVID-19 testing hesitancy.

Analyses

We used descriptive statistics to assess COVID-19 disclosure stigma and testing hesitancy when having symptoms of COVID-19 at each study wave. A factor analysis and Cronbach's alpha were used to assess the factor structure and internal consistency of the COVID-19 Disclosure Stigma scale. Paired *t*-tests assessed change in mean COVID-19 disclosure stigma, and McNemar's Chi-squared test assessed change in COVID-19 testing hesitancy between study waves.

Unadjusted logistic regression models examined the relationship between COVID-19 disclosure stigma and testing hesitancy at each study wave. To assess the independent association between COVID-19 disclosure stigma and testing hesitancy, multivariable models for each of the four study waves were analyzed, adjusting for demographic variables. In the logistic regression models, COVID-19 disclosure stigma was converted to a z-score. A first supplemental analysis used multivariable logistic regression models to examine the relationship between COVID-19 disclosure stigma and hesitancy, adjusting for demographics as well as COVID-19 vaccination status. The second supplementary analysis examined each COVID-19 disclosure stigma item separately to assess the independent effect of each measure using bivariate and multivariable models. All analyses were performed using STATA 17 (StataCorp).[34]

Results

Table 1 shows the demographic characteristics of the study population. The mean age of study participants was 42.22 years (SD 11.94). About half of the sample (55.49%) was female, and 82.82% were White. The political ideology of participants was diverse, with 51.27% identifying as liberal, 22.25% as moderate, and 26.48% as conservative. More than half (59.72%) of participants had received a bachelor's degree or higher, and 47.04% reported a household income >$60,000. At wave 5, 13.52% of participants reported receiving at least one dose of the COVID-19 vaccine. This increased to 69.86% at wave 6 and 77.18% at wave 7.

Across the four study waves, participants reported the greatest disclosure stigma in reporting a positive test to close contacts (Fig. 1, 21.13% in wave 4–19.15% in wave 7) followed by disclosure stigma around telling friends (14.93% in wave 4–10.70% in wave 7). The least disclosure stigma was in reporting positive results to family (9.58% in wave 4–4.23% in wave 7). The COVID-19 Disclosure Stigma Scale indicated a one factor structure at each study wave and high internal consistency (α wave 4 = 0.85; α wave 5 = 0.82; α wave 6 = 0.79; α wave 7 = 0.80; Table 2). Scores on the COVID-19 Disclosure Stigma Scale did not significantly change between

Table 1
Demographics (N = 355).

Variable	N (%) or mean (SD)
Age, mean (SD)	42.22 (11.94)
Sex	
Male	158 (44.51%)
Female	197 (55.49%)
Race	
White	294 (82.82%)
Black	21 (5.92%)
Other	40 (11.27%)
Education	
Some college or less	143 (40.28%)
Bachelor degree or higher	212 (59.72%)
Income	
$60K or less	188 (52.96%)
>$60K	167 (47.04%)
Political orientation,[a] mean (SD)	3.42 (1.75)
Received COVID-19 vaccine, Wave 5	48 (13.52)
Received COVID-19 vaccine, Wave 6	248 (69.86)
Received COVID-19 vaccine, Wave 7	274 (77.18)

[a] Political orientation: (1) very liberal, (2) liberal, (3) slightly liberal, (4) moderate, (5) slightly conservative, (6) conservative, and (7) very conservative.

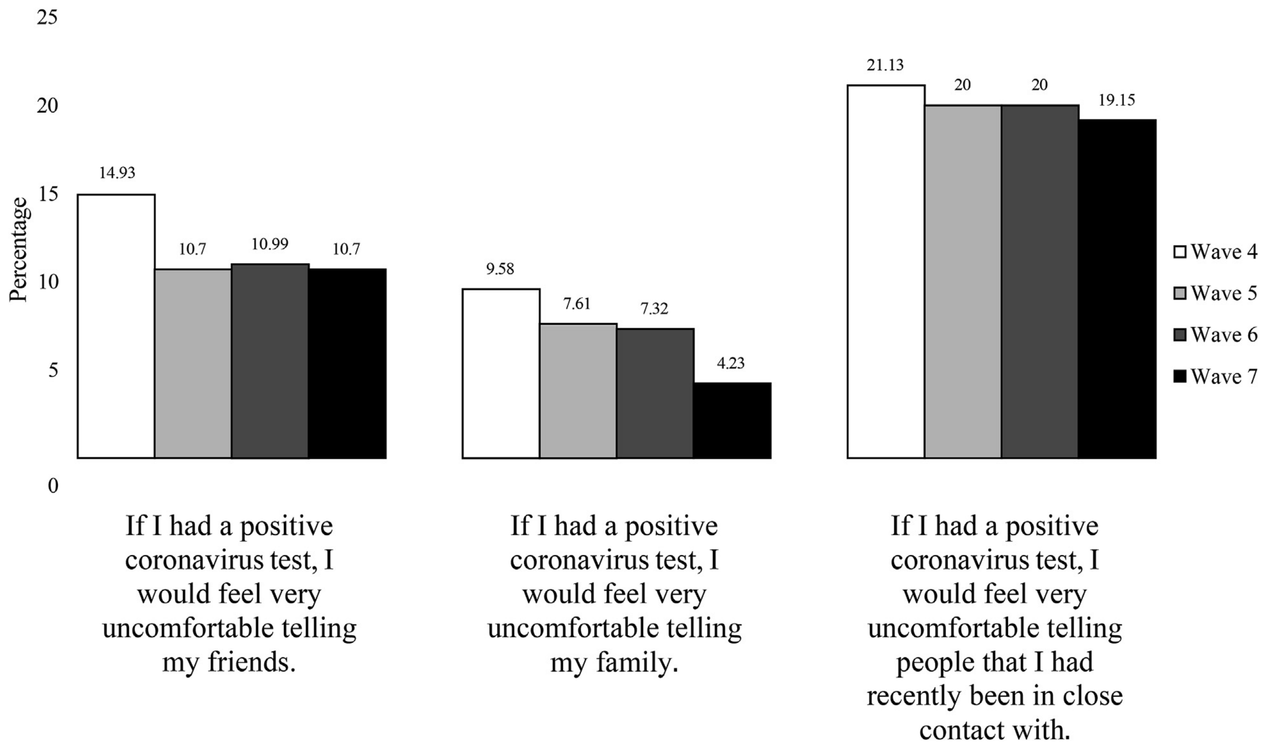

Fig. 1. Frequency of endorsing COVID-19 disclosure stigma items across study waves.

wave 4 and 5, nor between wave 5 and wave 6 (Fig. 2). However, there was a significant decline in COVID-19 disclosure stigma between waves 6 and 7 ($P = 0.030$).

Over the four study waves, COVID-19 testing hesitancy when symptomatic ranged from 23.10% to 29.58% (Fig. 3). A statistically significant increase in COVID-19 testing hesitancy was evident between waves 5 and 6 ($P = 0.044$) followed by a significant decrease between waves 6 and 7 ($P = 0.005$).

In the logistic regression models (Table 3), older age was associated with decreased odds of COVID-19 testing hesitancy in unadjusted waves 5, 6, and 7 models, and these relationships remained significant in each of the adjusted models. Women had decreased COVID-19 testing hesitancy odds compared with males in wave 6 only. Participants reporting a more conservative political ideology had increased odds of COVID-19 testing hesitancy in both the unadjusted and adjusted models for waves 4, 5, and 6. For wave 7, the relationship between political ideology and testing hesitancy was only significant in the adjusted models. Higher COVID-19 stigma showed a consistent relationship with increased odds of COVID-19 testing hesitancy. This relationship was significant in all unadjusted models as well as in the multivariable models for waves 5, 6, and 7.

In the first supplemental analysis (Supplemental Table 1), multivariable models also adjusted for COVID-19 vaccination status at waves 5, 6, and 7. COVID-19 disclosure stigma remained significant and independent predictor of vaccination hesitancy at each of the analyzed waves (wave 5: adjusted odds ratio [aOR] = 1.37, 95% confidence interval [CI] = 1.07, 1.74; wave 6: aOR = 1.49, 95% CI = 1.15, 1.95; wave 7: aOR = 1.12, 95% CI = 1.02–1.24).

Participants who had received at least one dose of the COVID-19 vaccine were significantly less likely to report testing hesitancy when symptomatic at wave 6 (aOR: 0.25, 95% CI: 0.15–0.44) and wave 7 (aOR:0.24, 95% CI: 0.13–0.45), but this relationship was not statistically significant in the wave 5 multivariable model.

The findings from analyzing the COVID-19 disclosure items separately (Supplemental Table 2) show that individual items performed differently across study waves. COVID-19 disclosure to friends was significantly associated with COVID-19 testing

Table 2
Factor structure of COVID-19 Disclosure Stigma scale.

COVID-19 Disclosure Stigma Scale Items	Study wave 4		Study wave 5		Study wave 6		Study wave 7	
	Eigen-value	Factor loading	Eigen-value	Factor loading	Eigen-value	Factor loading	Eigen-value	Factor loading
If I had a positive coronavirus test, I would feel very uncomfortable telling my friends.	1.90	0.80	1.67	0.75	1.57	0.73	1.65	0.79
If I had a positive coronavirus test, I would feel very uncomfortable telling my family.	−0.10	0.83	−0.14	0.76	−0.13	0.75	−0.11	0.73
If I had a positive coronavirus test, I would feel very uncomfortable telling people that I had recently been in close contact with.	−0.15	0.74	−0.16	0.74	−0.17	0.69	−0.18	0.70
Cronbach Alpha	$\alpha = 0.85$		$\alpha = 0.82$		$\alpha = 0.79$		$\alpha = 0.80$	

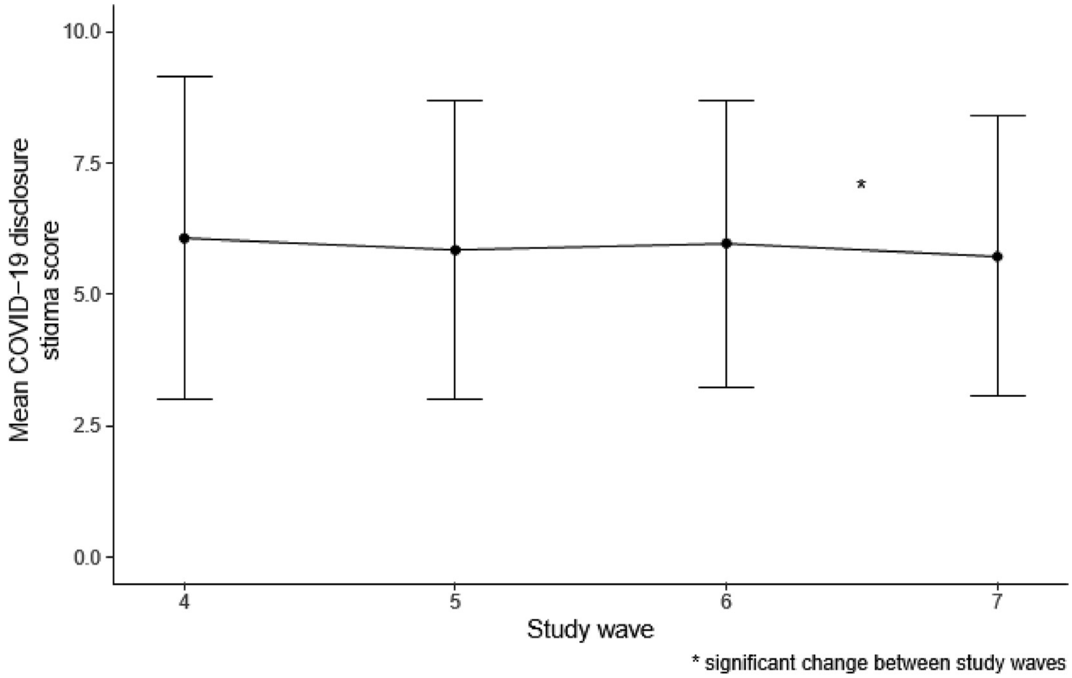

Fig. 2. Mean COVID-19 disclosure stigma scores by survey wave.

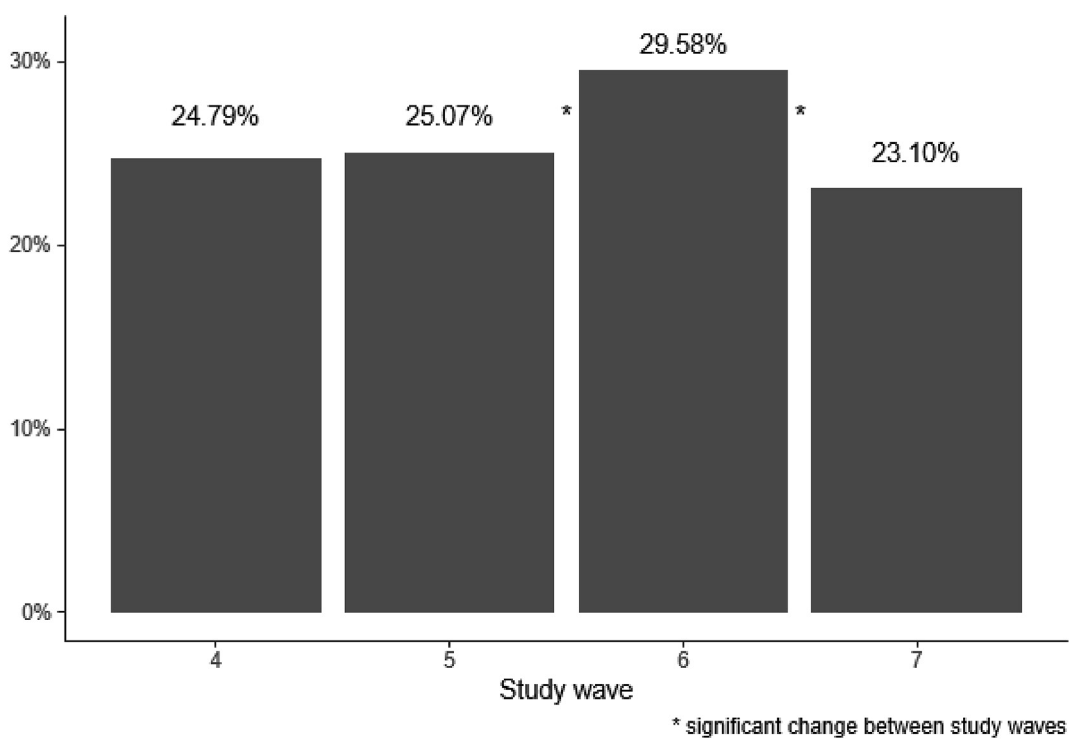

Fig. 3. COVID-19 testing hesitancy by survey wave.

hesitancy in unadjusted models across study waves but did not retain significance in adjusted models. Both COVID-19 disclosure stigma to family and to close contacts were significant in unadjusted models in two waves, and each retained significance in one of the waves. The lack of significance for individual items in the adjusted model can be explained by the high correlations among the COVID-19 disclosure stigma items (wave 4 $r = 0.62–0.73$; wave 5 $r = 0.59–0.62$; wave 6 $r = 0.54–0.61$, wave 7 $r = 0.53–0.64$).

Discussion

This study has identified that within this study population, COVID-19 disclosure stigma is prevalent among US adults and is

Table 3
Unadjusted and adjusted logistic models of COVID-19 testing hesitancy.

Variable	COVID-19 testing hesitancy—wave 4		COVID-19 testing hesitancy—wave 5		COVID-19 testing hesitancy—wave 6		COVID-19 testing hesitancy—wave 7	
	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)	OR (95% CI)	aOR (95% CI)
Age	0.98 (0.95, 1.00)	**0.98 (0.95, 1.00)**	**0.98 (0.96, 1.00)**	**0.97 (0.95, 1.00)**	**0.97 (0.95, 0.99)**	**0.97 (0.95, 1.00)**	**0.96 (0.94, 0.99)**	**0.97 (0.94, 0.99)**
Sex (ref: male)	0.84 (0.52, 1.36)	0.95 (0.57, 1.58)	0.68 (0.42, 1.10)	0.77 (0.46, 1.28)	**0.51 (0.32, 0.81)**	**0.55 (0.34, 0.90)**	0.75 (0.46, 1.23)	0.85 (0.50, 1.43)
Race (ref: white)								
Black	1.63 (0.63, 4.20)	1.52 (0.57, 4.06)	0.73 (0.24, 2.23)	0.68 (0.21, 2.18)	1.27 (0.50, 3.26)	1.23 (0.46, 3.32)	1.53 (0.57, 4.10)	1.49 (0.53, 4.17)
Other	1.40 (0.67, 2.89)	1.27 (0.59, 2.77)	1.48 (0.73, 3.03)	1.50 (0.69, 3.25)	1.53 (0.77, 3.04)	1.41 (0.66, 2.98)	**2.29 (1.14, 4.61)**	2.03 (0.96, 4.28)
Education (ref: some college or less)	0.85 (0.52, 1.39)	0.99 (0.58, 1.71)	0.88 (0.54, 1.42)	0.81 (0.47, 1.41)	0.86 (0.54, 1.37)	0.79 (0.47, 1.34)	0.94 (0.57, 1.55)	0.93 (0.53, 1.62)
Income (ref: $60,000 or less)	0.63 (0.39, 1.04)	**0.53 (0.30, 0.91)**	1.14 (0.70, 1.84)	1.01 (0.58, 1.74)	1.09 (0.69, 1.72)	1.03 (0.61, 1.74)	0.80 (0.48, 1.31)	0.77 (0.44, 1.34)
Political orientation	**1.20 (1.05, 1.38)**	**1.28 (1.10, 1.49)**	**1.31 (1.14, 1.51)**	**1.35 (1.16, 1.57)**	**1.27 (1.11, 1.45)**	**1.33 (1.14, 1.53)**	1.10 (0.96, 1.27)	**1.17 (1.00, 1.37)**
COVID-19 Stigma—wave 4	**1.29 (1.02, 1.64)**	1.23 (0.96, 1.58)	–	–	–	–	–	–
COVID-19 Stigma—wave 5	–	–	**1.42 (1.13, 1.79)**	**1.37 (1.07, 1.74)**	–	–	–	–
COVID-19 Stigma—wave 6	–	–	–	–	**1.46 (1.15, 1.85)**	**1.45 (1.13, 1.87)**	–	–
COVID-19 Stigma—wave 7	–	–	–	–	–	–	**1.43 (1.09, 1.87)**	**1.38 (1.04, 1.83)**

aOR, adjusted odds ratio; CI, confidence interval.
Bold values represent *P*-value ≤0.05.

associated with COVID-19 testing hesitancy. These results echo findings from Earnshaw et al. who cross-sectionally identified a relationship between stigma and COVID-19 testing in April 2020 before vaccine availability.[18] The focus of this study on COVID-19 disclosure stigma specifically, as well as the replication of the relationship between COVID-19 disclosure stigma and testing hesitancy across multiple time points, provides additional validation of the results. Study findings highlight that public health interventions should focus on reducing COVID-19 disclosure stigma, as COVID-19 testing and disclosure of testing results to close contacts and peers is imperative to mitigate the pandemic.

The significant reduction in COVID-19 disclosure stigma between study waves 6 and 7 (between June and November of 2021) suggests that people may be more willing to disclose a positive COVID-19 test as the pandemic continues. The ongoing trend in COVID-19 disclosure stigma should be monitored, and factors associated with the change identified throughout the pandemic. For example, since the first at-home rapid test was approved by the Food and Drug Administration in November 2020, at least 15 more at-home tests have been approved. This increased accessibility is useful for reducing viral transmission[35] and may have made testing positive for COVID-19 less stigmatizing.

This study also illustrated that participants felt the least comfortable disclosing a positive test result to close contacts, with approximately 20% of participants reporting this concern across all study waves (Fig. 1). This finding suggests that public health interventions should provide conversational tools and strategies to aid individuals in disclosing a positive COVID-19 diagnosis to close contacts. Public health communication programs can also help normalize positive diagnoses and the process of disclosing a positive test to peers by highlighting celebrities or political figures who have tested positive and providing conversation starters and communication strategies to aid individuals in disclosing their positive results to peers.

Anonymity around one's disclosure of a positive result could also mitigate stigma and testing hesitancy. Contact tracing provides a potentially anonymous way to notify contacts of COVID-19, but it is not available in many locations, and traditional models of contact tracing may be less effective with highly contagious strains. Hence, it is still imperative to encourage person-to-person disclosure, especially to households and close network members. Innovative technologies, such as websites, apps, or texting services, have been created by public health entities to anonymously notify a contact of exposure without revealing the identity of the person with the positive test. One such example is TellYourContacts.org, which allows you to send an anonymous text or email to someone with whom you have recently been in close contact. The program also provides templates for those who may not know what to say to their close contacts.[36]

Another key finding from this study was that approximately 25% of participants reported that they would not be tested for COVID-19 if they experienced symptoms, identifying that COVID-19 testing hesitancy is a critical public health concern. Although COVID-19 disclosure stigma was a strong and consistent predictor of testing hesitancy, age and political orientation were also associated with testing intention. Older age was associated with a decreased odds of COVID-19 hesitancy. This association could be due to greater concern about COVID-19 among older populations, a finding identified by Niño et al.[37] Individuals identifying with a greater conservative political ideology were more likely to report COVID-19 testing hesitancy if symptomatic. This finding may be due, in part, to perceived social pressure to downplay the seriousness of COVID-19. Vaccine hesitancy may also be higher among more conservative individuals due to misinformation propagated by conservative news sources and political leaders;[38,39] these same news sources leaders could be engaged in efforts to normalize testing and disclosure.

In later study waves, COVID-19 vaccination status was found to be significantly associated with testing hesitancy. The finding that individuals who have not been vaccinated are also more hesitant to be tested if symptomatic is alarming. Testing for early detection is essential for unvaccinated individuals because they are more likely to develop severe symptoms if they contract COVID-19, and anti-viral medications for COVID-19 are most effective if administered soon after infection.[4] Future research should assess barriers to testing for unvaccinated individuals. It may be that these individuals would be more willing to be tested with at-home test kits rather than at public testing facilities. This study also identified a significant increase in COVID-19 testing hesitancy between wave 5 (March 2021) and wave 6 (June 2021) and a decrease between waves 6 (June 2021) and 7 (November 2021). This finding aligns with testing uptake trends in the United States.[40] The decrease and increase could be associated with lower and higher rates of COVID-19, respectively, during this period. Further research is needed to understand better the factors associated with these trends. For example, sex was only associated with COVID-19 vaccine hesitancy at wave 6, with females reporting significantly reduced vaccine hesitancy compared to males. As COVID-19 positivity rates were experiencing a downward trend at this time, it may be that females' compared with males' testing intention is less sensitive to changing rate of community spread.

The present study is one of the first to assess COVID-19 testing hesitancy and COVID-19 disclosure stigma. Future studies should examine additional drivers of these two underexamined constructs. To expand on the present study, researchers should examine barriers to disclosure and how to make it a more normative behavior. Future research should also examine groups at greater risk of experiencing COVID-19 disclosure stigma as well as intervention strategies to mitigate it. For example, research suggests that stigma related to COVID-19 disproportionately impacts racial/ethnic minoritized groups in the United States.[41]

Study limitations should be noted. The online MTurk sample may not be generalizable to all US adults, although samples from MTurk have been found to outperform other convenience samples.[26] This study is not representative of Hispanic and Asian US residents, which are populations that have been uniquely affected by poor COVID-19 outcomes and discrimination, respectively. Furthermore, this study assessed testing intention rather than testing uptake, and intentions may not reflect behaviors when someone is actually symptomatic. Future studies should assess the outcome of acquiring testing when symptomatic as well as examine delays in COVID-19 testing due to disclosure stigma. Qualitative studies are needed to better understand domains of COVID-19 disclosure stigma and can aid in the development of measurement tools. Future studies should assess barriers and facilitators to COVID-19 testing. Underlying health status, insurance status, living conditions, and local COVID-19 rates may be associated with willingness to get tested for COVID-19 when symptomatic and warrant further examination. Factors associated with COVID-19 stigma also warrant additional research. For example, there may be an interaction between COVID-19 stigma and political party.

The dynamics of the ongoing COVID-19 pandemic depend on the emergence of new variants as well as the rapid identification, intervention, and disclosure of positive cases. Although trends in testing hesitancy are declining, approximately one-quarter of respondents reported hesitancy to be tested when symptomatic—particularly people with more conservative political ideology and those with greater COVID-19 disclosure stigma. These findings suggest that current methods of COVID-19 case monitoring are likely not capturing many positive cases, as a substantial portion of US residents are hesitant to be tested when symptomatic. To keep case counts contained and limited, intervention efforts must focus on reducing testing hesitancy and increasing willingness to disclose positive results to peers. Public health interventions that provide strategies for increasing the disclosure of positive results and facilitating anonymous disclosure are needed.

Author statements

Ethical approval

This study was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

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Competing interests

The 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.2022.08.003.

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Original Research

An investigation of factors affecting changes in health behaviours during the COVID-19 pandemic in a UK population–based cohort study

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ABSTRACT

Objectives: The COVID-19 pandemic has led to changes in behaviours, which may have different health effects in population subgroups. We investigated whether within-individual changes in health behaviours from before to during the pandemic differ by socio-economic deprivation, age or sex.
Study design: Prospective cohort study.
Methods: Participants were recruited from the existing UK Fenland cohort study with measurements of health behaviours twice prepandemic (2005 to February 2020) and three times during the pandemic (July 2020 to April 2021). Health behaviours included daily servings of fruit and vegetables, units of alcohol consumed per week, smoking status, sleep duration and total and domain-specific physical activity energy expenditure. Sociodemographic information (English indices of multiple deprivation, education, occupation and ethnicity) and COVID-19 antibody status were also collected. Participants were grouped into three categories based on their English indices of multiple deprivation score: most, middle and least deprived.
Results: Participants were included if they had completed at least one measurement during the pandemic and one prepandemic ($n = 3212$). Fruit and vegetable consumption, total physical activity energy expenditure and smoking prevalence decreased during the pandemic compared with prepandemic, whereas average sleep duration increased and alcohol consumption did not change. Decreases in fruit and vegetable intake and physical activity energy expenditure were most pronounced in the most deprived group compared with the least deprived group and were greater in women than men.
Conclusions: Socio-economic inequalities in health behaviours have worsened during the pandemic. As the country emerges from the COVID-19 pandemic, strategies to reduce health inequalities need to be put at the forefront of recovery plans.

Introduction

The COVID-19 pandemic has given rise to unprecedented restrictions on people's lives and has resulted in more than 380 million confirmed cases and 5.6 million deaths worldwide[1] as of January 2022. The pandemic has had differential health, social and economic effects on different groups in society.[2] As with most patterns of disease, the most deprived groups in the United Kingdom were affected particularly by the pandemic. Direct effects included higher risk of avoidable death from COVID-19 for those aged <75 years, which was substantially greater for those living in the most deprived areas of England compared with those in the least deprived areas during 2020.[3,4] This pattern was also reported in other countries, for example, in the United States where people living in a more deprived area had a higher risk of COVID-19 hospitalisation.[5]

In addition to the differential direct effects that the virus itself had on health, there were also a range of indirect effects of both the pandemic and the associated non-pharmaceutical interventions that were likely to impact groups in society differentially. For example, those from more deprived groups were more likely to experience loss of income and unemployment during the pandemic

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compared with less deprived groups and were therefore more likely to feel the associated negative impact that loss of income has on health behaviours, health and well-being.[2] A systematic review including 87 studies reported that health behaviours including poor diet, alcohol consumption and physical inactivity had been exacerbated in the first year of the pandemic.[6] However, a high proportion of the studies were cross-sectional, and the review did not assess how these health behaviours differed between socio-economic groups or with deprivation measures.

The aim of this study was to investigate changes in health behaviours during the pandemic compared with before the pandemic and whether these changes were influenced by deprivation. The health behaviours of interest were self-reported fruit and vegetable consumption, alcohol consumption, smoking status, sleep duration, and physical activity (PA) energy expenditure. Data were collected prospectively in participants of the Fenland cohort study, the United Kingdom, at five different time points over 2005–2021 using the same measurement instruments. The first two time points were before the pandemic, and the other three were during the pandemic. Specifically, we aimed to investigate whether health behaviours differed between before the pandemic and during the COVID-19 pandemic by deprivation group.

Methods

Study design

The Fenland cohort study was established in 2005; participants were recruited from general practice sampling frames in Cambridgeshire (http://www.mrc-epid.cam.ac.uk/research/studies/fenland-study/; n ~ 46,000). All participants were invited to Phase 1 (P1), Phase 2 (P2) and then to the Fenland COVID-19 substudy. A total of 12,435 people took part in P1 of the study (P1: 2005–2015) and 7795 in P2 of the study (P2: 2014–2020). P2 clinical visits were stopped at the start of the COVID-19 pandemic, and P2 ended early. A substudy of the Fenland cohort, the Fenland COVID-19 study was conducted remotely. Participants were recruited between July and October 2020 and followed up at three time points over a period of 6 months from enrolment date to April 2021 (C0, C3 and C6).[7] For the present study, participants were included if they had (1) taken part in the Fenland COVID-19 study, (2) had diet and PA data from at least the first time point during the pandemic (C0) (3) and had data from at least one prepandemic time point (P1 and/or P2).

Ethics and patient and participant involvement

Ethics approvals for Phases 1 and 2 were obtained from Cambridge East Research Ethics committee on 11 May 2004 and 5 July 2014, respectively. Written informed consent was obtained from all participants, and participants were made aware that they were able to request to leave the study at any point. For the Fenland COVID-19 substudy, ethical approval was obtained from South West Cornwall and Plymouth Research Ethics committee on 30 June 2020. Consent for the Fenland COVID-19 substudy was completed online. The Fenland cohort participant panel was involved in the planning, conducting and reporting of the Fenland COVID-19 study as part of patient and public involvement.

Setting and participants

Participants born between 1950 and 1975 were originally recruited from general practice registers, a population-based sampling frame across Cambridgeshire, United Kingdom. Inclusion and exclusion criteria have been described.[7] As part of the Fenland COVID-19 substudy, participants who were known to be still alive and had not withdrawn previously from the study, who had a valid email or telephone number, were approached via phone call, email or text message (n = 11,469) and asked whether they would like to participate. There was no specific exclusion criterion for the substudy.

Deprivation

The English indices for multiple deprivation 2019 (IMD) were derived from participants' current address available at the start of the Fenland COVID-19 study.[8] IMD measures relative levels of area deprivation among the 32,844 Lower Layer Super Output Area (LSOAs) in England and is calculated based on seven domains of deprivation, which includes income, employment, health deprivation and disability, education and skills training, crime, barriers to housing and services and living environment.[8]

Participants were grouped into three categories based on national IMD tertiles whereby Group 1 (most deprived) included IMD ranks from 1 to 10,947, Group 2 (middle) included IMD ranks from 10,948 to 21,896, and Group 3 (least deprived) included ranks from 21,897 to 32,844.

Outcome variables

Five different health behaviours were investigated; fruit and vegetable consumption, alcohol consumption, smoking status, sleep duration and PA measured using the same measurement instruments at all the five study time points.

Diet

Habitual dietary patterns over the previous 4 weeks were obtained using a validated food frequency questionnaire.[9] Individuals were asked how frequently they consumed servings of specific fruit or vegetables: never or less than once a month, 1–3 times per month, once a week, 2–4 times per week, 5–6 times per week, once a day, 2–3 times per day, 4–5 times per day, or 6 or more times per day. For computational purposes, we used the midpoint of food frequencies reported in ranges and 0 for people reporting ‘never or less than once a month’. Total daily reported servings of fruit and vegetables were calculated by adding the number of reported servings of different types of fruit and vegetables consumed. Adequate fruit or vegetable consumption was categorised as consuming 5 or more servings of fruit or vegetables a day based on National Health Service (NHS) recommendations.[10]

Participants reported frequency of intake of different types of alcohol, which was converted into units of alcohol; a small glass of wine (125 mL) was defined containing 1.36 units of alcohol, a half pint (192 mL) of beer, lager or cider as 1.4 units, a small glass (50 mL) of port, sherry, vermouth or liqueur as 0.8 units, and a single measure of spirits (23 mL) as 0.9 units of alcohol. Total units of alcohol consumed per week were then calculated by adding the number of units of different types of alcoholic beverages consumed per week. Excessive alcohol consumption was categorised as consuming 14 or more units of alcohol per week based on NHS recommendations.[10]

Smoking status

At P1, P2 and C0, participants were asked whether they currently smoked, had smoked in the past or had never smoked.

Time spent sleeping

Reported sleep duration was ascertained by asking participants to record the average time that they went to bed and woke up over the last 4 weeks on weekdays and on weekends, and a weighted average per day was calculated.[11] This question was only introduced halfway through Phase 1, and therefore, data are not available on all participants at Phase 1.

Physical activity

Recent PA over the previous 4 weeks was determined using the validated Recent Physical Activity Questionnaire (RPAQ).[12] The RPAQ is a self-completion questionnaire designed to assess physical activity in four domains: at home, at work, commuting and during leisure time over the previous 4 weeks. RPAQ has been validated against doubly labelled water and accelerometry for the assessment of physical activity energy expenditure (PAEE) in adults. The electronic web-based version of RPAQ was used for this study. Reported frequency and duration were used to compute time spent in specific activities, which was multiplied by energy costs of each activity taken from the reported metabolic equivalent of tasks from the physical activity compendium[13] to calculate activity-specific PAEE, which were summated by domain and across all domains as total PAEE. If reported time spent in activities was >18 h (assuming 6 h sleep), all reported durations of activity were scaled back to 18 h. PAEE was expressed in KJ/kg/day.

Baseline characteristics

Age at Phase 1 of the study was used in analyses, and four categories were used in subgroup analyses (30–40, 40–50, 50–60 and 60+ years). Highest educational attainment was classified using international standards[14] (lower secondary education, upper secondary education or postsecondary non-tertiary education and Bachelor's degree or equivalent level), and ethnicity and occupation were self-reported during Phase 1 of the study. The degree level category included having a university degree, and no differentiation was made for those with further degree qualifications (such as Master's or PhD). Self-reported ethnicity was reported in 17 categories. As most participants identified as ‘White’, ethnicity was categorised as ‘White’ and ‘not White’. Self-reported occupation was categorised into three occupation groups:[15] Group 1, routine manual and service, semi-routine and technical; Group 2, middle or junior managers, clerical and intermediate; Group 3, traditional professional, modern professional and senior managers.[16]

Height in centimetres and weight in kilograms were measured by a trained member of the study team at P1 and P2, and weight was also self-reported at C0 in those participants who had access to weighing scales at home. Body mass index (BMI) (weight in kilogram/height in square metres) was calculated; overweight (including obese participants) was defined as BMI $\geq$25 kg/m^2, and obesity was defined as $\geq$30 kg/m^2. BMI at C0 was calculated using height measured from P2. To ascertain whether participants had been exposed to the SARS-CoV-2 virus before and during the Fenland COVID-19 substudy period, participants completed remote blood sample collections at three time points (C0, C3 and C6). Participants collected blood from their upper arm or thigh using self-administered OneDraw devices and the dried blood spot samples were posted back to the MRC Epidemiology Laboratory, University of Cambridge, UK. The samples were analysed for SARS-CoV-2 immunoglobulin G antibodies using commercial enzyme-linked immunosorbent assay.[7] The study focussed on seropositivity. Therefore, all negative results and borderline results were classed as not seropositive.

Statistical analysis and data handling

Statistical analysis was performed using Stata version 14 (Statacorp LLC, Texas, USA).[17] Skewed variables were summarised using median and interquartile range, normally distributed variables using mean and standard deviation (SD) and categorical variables with *n* (%).

Analyses at each time point

To test for associations between IMD groupings 1 and 3 and each outcome variable, a Wilcoxon rank-sum test was used, and Chi-squared test was used for categorical variables. To test for a trend across IMD grouping, (1-3) non-parametric rank tests were used.

Assessing the effect of the pandemic overall and within subgroups

A two-level random intercepts linear (for all outcomes except smoking) or logistic (for smoking) regression model was used to investigate whether health behaviours differed between during pandemic (at least C0 time point, and C3 and/or C6 if completed) and prepandemic (P1 and/or P2) time points. The model was adjusted for age at Phase 1, time to follow-up from Phase 1, season (spring/summer/autumn/winter) and sex. Continuous outcomes were log transformed to address non-normality of the residuals. The pandemic effect was reported as a ratio of geometric means (RGM) of the outcome (>1 implies an increase, <1 implies a decrease) comparing during vs. prepandemic, overall and stratified by (1) IMD group,(2) gender and (3) age group (30–40, 40–50, 50–60 and 60+ years). The interaction with each of these variables was tested by including the relevant parameters in the model and applying a Wald test.

Sensitivity analysis

To assess the effect of using occupation as an individual marker of deprivation rather than IMD, which is a group level marker, analyses were repeated using the three occupation groups as the exposure variable instead of IMD group.

To assess the impact of COVID-19 infection on changes in health behaviour, the analyses were repeated after removing participants who were seropositive for COVID-19 at any of the three time points measured during the pandemic (C0, C3 or C6).

Role of the funding source

The funders were not involved in the study design, collection analysis or interpretation of the data in the writing of the report or the decision to submit the paper for publication.

Results

Of the 12,435 participants originally recruited in the Fenland cohort, 11,469 participants were contactable and invited to take part in the COVID-19 substudy, of whom 4031 (35%) consented to participate. This analysis included 3231 (80%) participants who had completed both a food frequency questionnaire and RPAQ questionnaire at C0 (Fig. 1 and Supplementary Fig. 1). Those participants included in this analysis were compared with participants originally recruited in the Fenland cohort who did not take part in the COVID-19 substudy and were not included in the analysis ($n = 3231$ vs. $n = 9204$). A higher proportion of those in the analysis group were women than Fenland cohort participants not in the analysis (57.5% vs. 52.5%); they were also older (mean [SD]: 49.3 [7.3] vs. 48.3 [7.6]), more likely to be in the highest occupation group (traditional professional, modern professional, or higher managerial; 65.6% vs. 48.8%), have a Bachelor's degree or equivalent (47.8% vs. 32.1%) and less likely to be in the most deprived IMD group (15.7% vs. 26.2%).

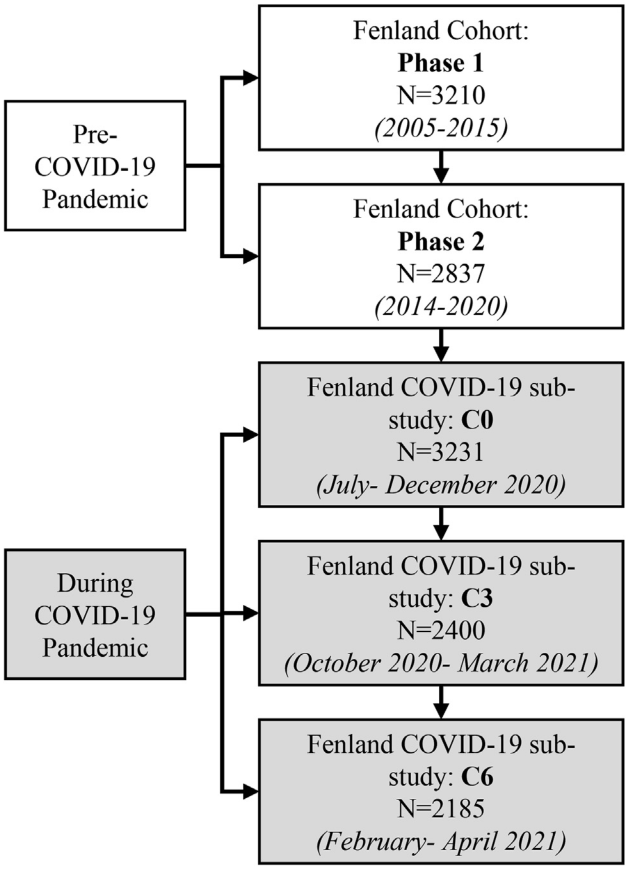

Fig. 1. Participant flow diagram. Participants were included in the present study if they had completed health behaviour questionnaires at C0 (Fenland COVID-19 sub-study, baseline), $n = 3231$. The flowchart indicates the number of participants who were included from the prepandemic time points (Phase 1: $n = 3210$ and Phase 2: $n = 2837$, shaded white) and during the pandemic (baseline C0: $n = 3231$, C3: $n = 2400$ and C6: $n = 2185$, shaded grey), and the dates during which the health behaviours were measured.

Baseline characteristics

Of the 3231 participants included, 58% were women, and 98% of participants were White (Table 1). At Phase 1 (P1: baseline), participants had a mean (SD) age of 49.3 (7.3) years, 48% had a Bachelor's degree or equivalent, and 66% reported traditional professional, modern professional or higher managerial as their occupation (Group 3). At baseline, 16% of participants were in the most deprived IMD group, 35% in the middle deprived group and 49% in the least deprived group. When stratifying by IMD group, participants in the most deprived group (Group 1) were on average 4 kg heavier than those in the least IMD deprived group and were more likely to be overweight (65% vs 52%) or obese (24% vs 15%) than those in the least IMD deprived group ($P < 0.0001$ for all). The mean time interval from P1 to the first time point during the pandemic (C0) was 9.8 years (SD 2.3), range (5.5–15.7 years). The mean time interval was higher in the most deprived IMD group compared with the middle and least deprived groups (most deprived: 10.2 years [SD 2.3], middle: 9.6 years [SD 2.3], 9.9 years [SD 2.3] and least deprived: 9.9 years [SD 2.3], respectively, $P < 0.001$).

At baseline, participants in the most deprived IMD group ate fewer portions of fruit and vegetables per day, consumed fewer units of alcohol per week and were more likely to smoke compared with the least deprived IMD group (Health behaviours in Table 1). At baseline, the average reported sleep duration and total PA was similar across IMD groups, although the most deprived IMD group expended more PA at work and home and less PA during leisure time compared with the least deprived IMD group.

Change in health behaviours before and during the COVID-19 pandemic

Fruit and vegetable consumption was estimated to have decreased by 12% during the pandemic compared with before the pandemic (RGM: 0.88 [95% confidence interval: 0.87–0.90]; $P < 0.0001$). In relation to the primary hypothesis, this decrease was greatest in the most deprived IMD group (RGM: 0.86 [0.82–0.91]; P interaction = 0.02), and in women (RGM: 0.86 [0.84–0.88]; P interaction < 0.0001). Fruit and vegetable intake decreased among all age groups but more so in the youngest (those aged 30–40 years at P1: baseline) and oldest (60+ years) age groups (P interaction = 0.05; Fig. 2A, Supplementary Table 1).

Reported alcohol consumption did not differ significantly overall before compared with during the pandemic. However, men tended to report an increase in alcohol consumption, and women tended to report a decrease (P interaction = 0.03), and those in the youngest age group (30–40 years at P1: baseline) reported a 9% increase in alcohol consumption during the pandemic compared with before the pandemic (RGM: 1.09 [0.98–1.21]; P interaction = 0.007).

The average sleep duration increased overall by 3% during the pandemic compared with before the pandemic (RGM: 1.03 [1.02–1.03]; $P < 0.0001$). Sleep duration increased more so in men (P interaction < 0.0001) but did not differ significantly by IMD or age group.

Total PAEE decreased overall by 17% (RGM: 0.83 [0.81–0.86], $P < 0.0001$). In relation to the primary hypothesis, this decrease was greatest in the most and middle deprived IMD groups (RGM: 0.81 [0.73–0.90] and 0.81 [0.77–0.86], P interaction = 0.04), in women (RGM: 0.80 [0.77–0.84]; P interaction < 0.0001) and in the over 60 s (RGM: 0.76 [0.65–0.91]; P interaction = 0.13).

Smoking decreased during the pandemic (odds ratio [95% confidence interval]: 0.45 [0.22–0.92]; $P = 0.03$) compared with before the pandemic. Because of the small number of participants who smoked (3.6% during the pandemic), it was not possible to perform stratified analyses for this outcome of the primary hypothesis.

Participants who worked at each time point

The percentage of participants who reported they were working at the different time points decreased from 92% at baseline (P1) to 60% by C6 (Supplementary Table 3). This decrease was similar among the three IMD groups. This did not distinguish between those who continued to work in their workplace and those who were working from home.

Sensitivity analysis: occupation

The use of occupation group in place of IMD in the multilevel mixed-effects generalised linear model was very similar in terms of the interpretation of the results with the exception of two minor differences in the statistical significance of interaction terms in the models for change in total PAEE (Supplementary Table 2). The biggest difference was for a model investigating domain-specific PAEE at home, for which there was a highly statistical interaction between occupational grouping and the term for the pandemic ($P < 0.0001$), which was not evident at all in a model for the same outcome exploring the potential interaction between IMD and the pandemic ($P = 0.99$). The direction of the interaction was that

Table 1
Characteristics of participants of the Fenland Study at Phase 1 ($n = 3231$) by indices for multiple deprivation category (1: most deprived [$n = 508$, 16%], 2: middle [$n = 1132$, 35%], 3: least deprived [$n = 1591$, 49%]).

Characteristics	All ($n = 3231$)	IMD category 1: most deprived	IMD category 2: middle	IMD category 3: least deprived	Test for trend[a], *P*-value
Age (y), mean (SD)	49.3 (7.3)	49.2 (7.3)	49.4 (7.2)	49.2 (7.3)	0.68
Sex, *n* (%)					
Female	1858 (57.5)	286 (56.3)	651 (57.5)	921 (57.9)	0.49
Male	1373 (42.5)	222 (43.7)	481 (42.5)	670 (42.1)	
Occupation, *n* (%)					
Technical, semi-routine and routine	478 (15.3)	136 (27.4)	187 (16.9)	155 (10.1)	0.0001
Lower managerial and intermediate occupations	597 (19.1)	113 (22.8)	218 (19.8)	266 (17.4)	
Traditional and modern professional and higher managerial	2054 (65.6)	247 (49.8)	697 (63.3)	1110 (72.5)	
Education[a], *n* (%)					
Bachelor's degree or equivalent	1501 (47.8)	126 (26.1)	495 (44.3)	880 (56.3)	0.0001
Upper secondary/non-tertiary education	1351 (43.0)	281 (58.3)	489 (44.7)	581 (37.2)	0.0001
Lower secondary	288 (9.2)	75 (15.6)	110 (10.1)	103 (6.6)	0.0001
Ethnicity, *n* (%)					
White	3071 (97.9)	493 (99.4)	1079 (97.5)	1499 (97.9)	0.05
Not White	64 (2.1)	3 (0.6)	28 (2.5)	33 (2.1)	
Anthropometry					
Weight (kg), mean (SD)	76.8 (15.7)	79.8 (17.6)	76.9 (15.4)	75.7 (15.1)	0.0001
Height (cm), mean (SD)	170.5 (9.2)	169.9 (9.2)	170.5 (9.2)	170.7 (9.3)	0.09
BMI (kg/m^2), mean (SD)	26.3 (4.6)	27.5 (4.9)	26.4 (4.6)	25.9 (4.4)	0.0001
≥BMI 25 kg/m^2[a], *n* (Y%)	1808 (55.9)	331 (65.2)	646 (57.1)	831 (52.3)	0.0001
≥BMI 30 kg/m^2[a], *n* (Y%)	563 (17.4)	122 (24.0)	205 (18.1)	236 (14.8)	0.0001
Health behaviours					
Fruit and vegetable (servings/day), median (IQR)	7.4 (5.4–10.1)	7.1 (5.1–10.1)	7.6 (5.4–10.1)	7.5 (5.5–9.9)	0.07
Alcohol consumption (units/week), median (IQR)	5.5 (1.4–10.3)	4.8 (0.7–8.9)	4.9 (1.3–9.5)	5.9 (2.0–11.8)	0.0001
Current smoker, *n* (%)	238 (12.6)	53 (16.4)	94 (13.8)	91 (10.4)	0.0001
Ever smoker, *n* (%)	1365 (42.4)	244 (48.1)	498 (44.1)	625 (39.5)	0.0001
Sleep (hours/day), median (IQR)	8.0 (7.5–8.5)	8.0 (7.5–8.5)	8.0 (7.5–8.4)	8.0 (7.6–8.5)	0.53
Total PAEE (kJ/kg/day), median (IQR)	26.6 (19.1–37.5)	26.8 (18.5–38.3)	26.2 (18.9–37.4)	26.7 (19.4–37.4)	0.8
PAEE at work (kJ/kg/day), median (IQR)	12.5 (9.2–16.4)	13.3 (10.5–18.1)	12.6 (9.2–16.5)	12.4 (9.0–15.2)	0.0001
PAEE at home (kJ/kg/day), median (IQR)	2.6 (0.85–6.4)	2.9 (0.77–7.5)	2.6 (0.85–6.5)	2.6 (0.89–6.2)	0.6
PAEE at leisure (kJ/kg/day), median (IQR)	7.2 (2.9–13.6)	6.1 (1.9–11.9)	7.1 (2.6–13.5)	7.5 (3.3–14.1)	0.06
PAEE during commute (kJ/kg/day), median (IQR)	1.0 (0.34–3.1)	0.81 (0.27–1.8)	1.0 (0.34–2.9)	1.0 (0.41–3.1)	0.05

BMI, body mass index (kg/m^2); IMD, English indices for multiple deprivation 2019; IQR, interquartile range; PAEE, physical activity energy expenditure; SD, standard deviation.
[a] Education level available for 3140 participants.

particularly among those reporting lower managerial and intermediate-level occupations, there was a statistically significant reduction in activity at home during the pandemic, which was not seen in other occupational groups.

Sensitivity analysis: COVID-19 seropositivity

Overall, 14% of participants were seropositive for COVID-19 antibodies at one or more of the three time points during the early waves of the pandemic from July 2020 to April 2021. This percentage did not differ significantly by IMD (IMD Group 1: 14% vs Group 3: 13%; $P < 0.47$). Excluding participants who were seropositive for COVID-19 antibodies at C0, C3 or C6 ($n = 428$) made little difference to the models for change in health behaviour pre- and post-pandemic (Supplementary Fig. 2A–C).

Discussion

Main findings

Our study confirmed the primary hypothesis that observed inequalities in some health behaviours further increased during the pandemic; fruit and vegetable consumption and total PAEE declined more so in the most deprived group compared with the least deprived group during the pandemic relative to prepandemic health behaviours. The average sleep duration increased during the pandemic, but this did not differ by deprivation group.

Socio-economic inequalities in health behaviours existed before the pandemic in this population-based cohort study in which participants from more deprived areas were more likely to be smokers and to report eating fewer portions of fruit and vegetables. Overall, obesity prevalence was 1.6-fold higher in the participants from the most deprived areas (24%) compared with those from the least deprived areas (15%).

We found that changes in health behaviours during the pandemic differed by gender and age. Women reported a greater decrease in fruit and vegetable consumption and total PAEE compared with men, and the decline in total PAEE was most pronounced in those aged > 60 years; this finding is in line with other studies that have reported a greater decrease in self-reported PA in older age groups during the pandemic.[18,19] We did not have information on the types of work people were doing and whether this was from home or in the workplace, which could have impacted their total PAEE. However, we did find that activity from commuting was higher in the most deprived group during the pandemic (Supplementary Table 1), which suggests that they were more likely to be in the workplace than working at home.

Limitations and strengths of the study

This study was embedded in an existing prospective cohort and had repeated data on health behaviours from before the COVID-19 pandemic as well as during the pandemic using the same measurement tools at all time points. This study design therefore diminished recall or measurement bias and allowed for direct comparison of health behaviours across the five time points. Other published studies assessing change in health behaviours in relation to the pandemic have not collected prepandemic data prospectively

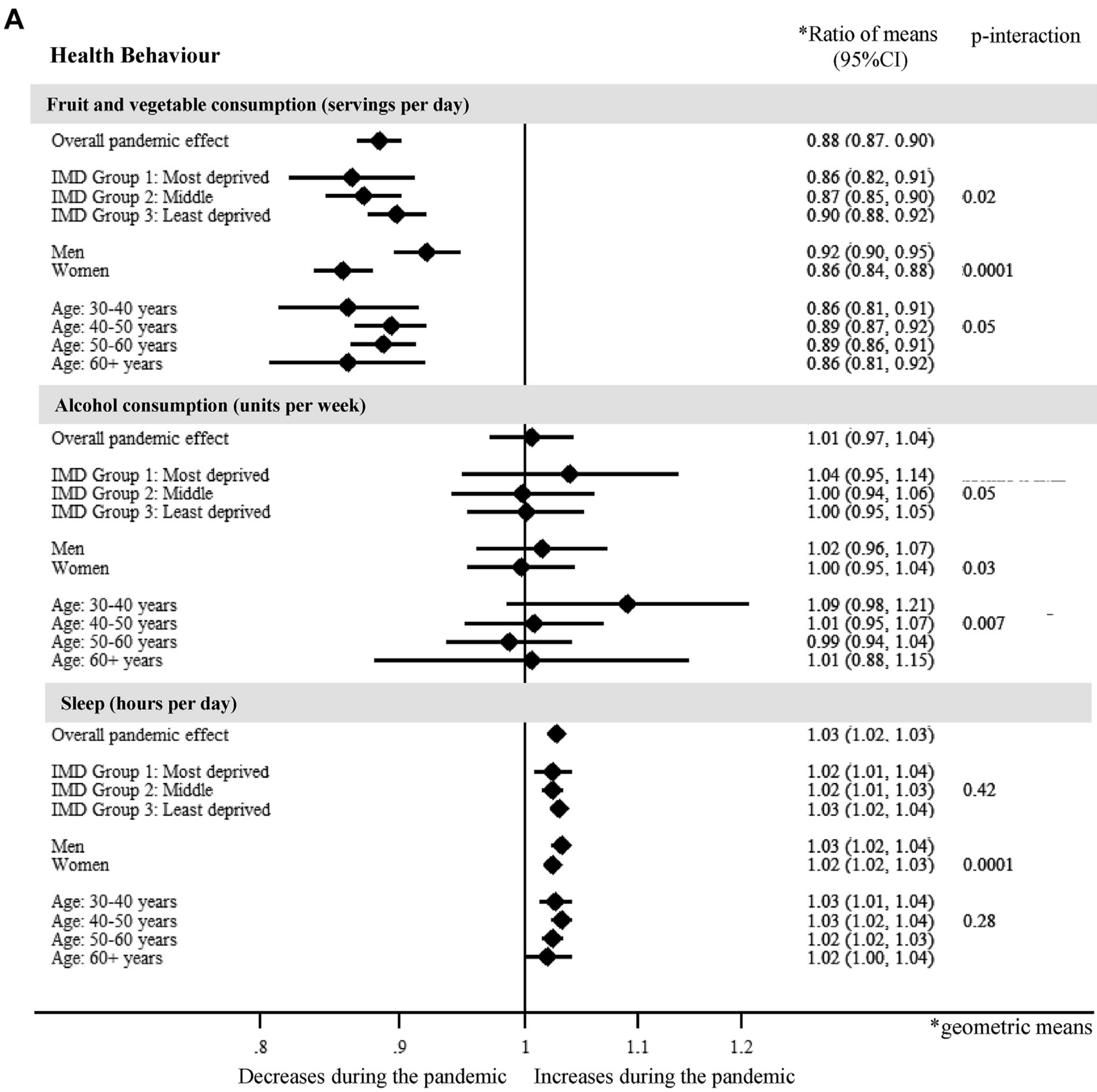

Fig. 2. (A–C) Effect of the pandemic on health behaviours, overall and within subgroups. The effect of the pandemic (during vs. pre) is presented as the ratio of geometric means (95% confidence intervals). A ratio <1 indicates that the health behaviour declined during the pandemic compared with before the pandemic, and a ratio >1 indicates that the health behaviour increased during the pandemic compared with before the pandemic. A ratio of 1 indicates no difference.

and therefore had to rely on participant recall of prior behaviour, which is open to bias.[18,20–31]

Other strengths of this study were the availability of two time measurement time points prepandemic. Models were adjusted for age at Phase 1 and time to follow-up from Phase 1, thus allowing consideration of the rate of change of health behaviours with age under normal circumstances. We also considered the effect of seasonality by adjusting for the season at each time point in the analyses, unlike other studies.[20,21] It is well established that certain health behaviours differ by season, for example, reported fruit and vegetable consumption is known to be lower in the winter. As Phases 1 and 2 of the cohort study recruited participants across several complete years, we were able to account for the effect of the season when assessing changes in health behaviour. This would otherwise have been an issue as the three measurements during the pandemic were largely taken in the autumn and winter months.

The study was able to compare the results using both a group level indicator of deprivation (IMD), a multifaceted marker of area deprivation that considers income, employment, education, health, crime, housing and living environment and an individual marker of socio-economic status, namely, occupation. Sensitivity analysis indicated that the two measurements of social inequalities produced broadly similar results, with the exception of total PAEE, largely due to the domain-specific PAEE at home, where there were distinct differences between men and women. This is in line with previous studies that have shown that IMD concordance with occupation type is reasonable.[32]

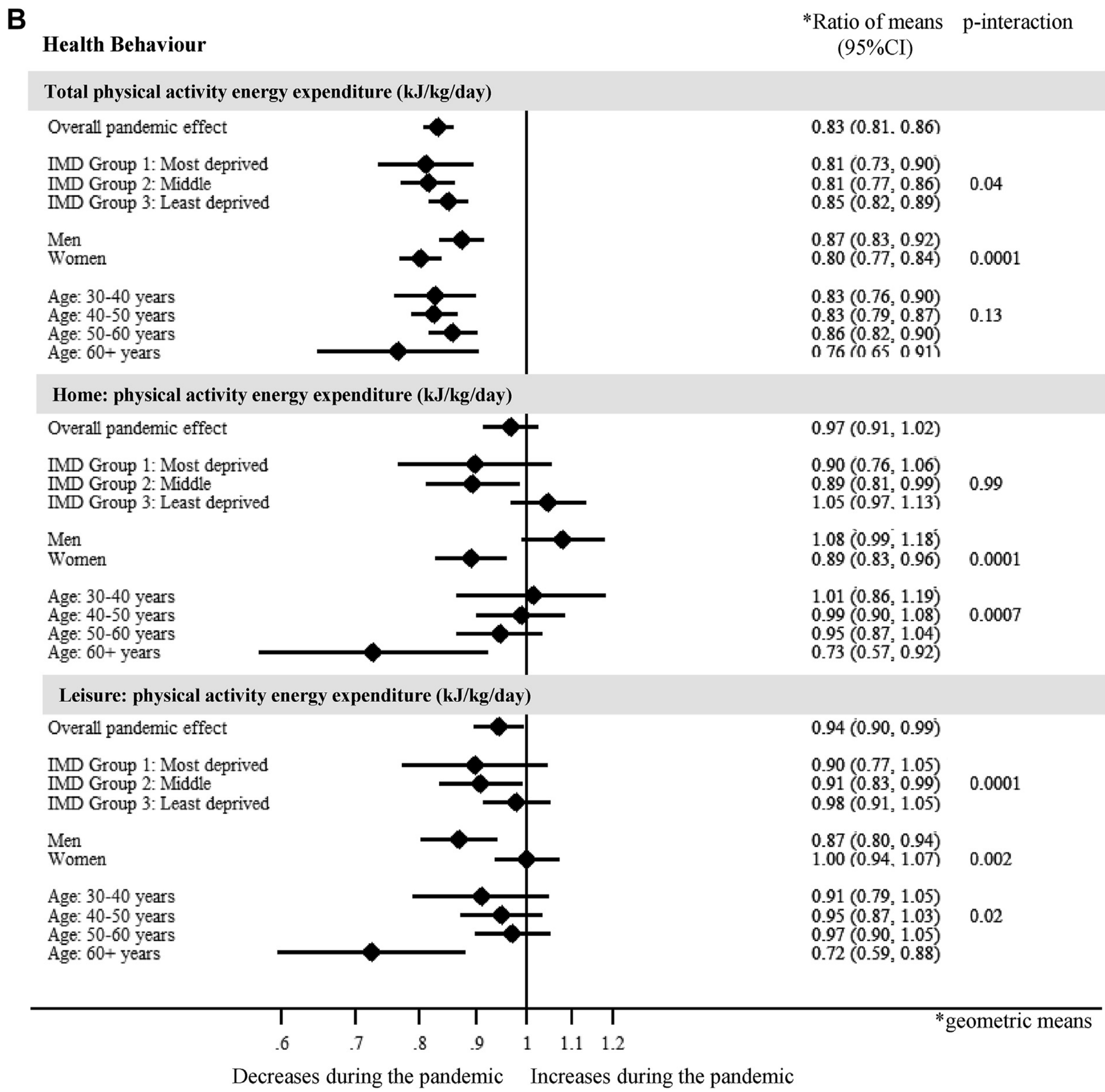

Fig. 2. (*continued*)

A limitation of this study was that recruitment was undertaken via telephone and email, which may exclude some population groups who do not have access to a telephone or email. This study was conducted in an established and well-characterised cohort, which provided information on socio-demographic characteristics of all participants so that differences could be investigated between those who were included in this study of prepandemic and during pandemic health behaviours and those who did not participate. Those who consented to take part in the study were less likely to come from deprived areas and more likely to have a higher education level and be in the highest occupation group. This cohort study recruited from across Cambridgeshire, where there is low ethnic diversity in the study population, which reflects the low ethnic diversity of the region; we were unable to comment on ethnic differences and changes in health behaviours as a result of the pandemic. In addition, the time from baseline to follow-up was slightly longer in the most deprived group compared with the least deprived group; however, time to follow-up was adjusted for as a covariate in the statistical models.

Implications of the study and future research

Previous studies have shown that health behaviours in adults are often mirrored in their children,[33] so it is likely that the change in health behaviours seen in adults in this study could affect other family members too and not only their own personal health. Therefore, the effect of the pandemic on health behaviour may extend beyond the population subgroup that we studied here. Whether those effects are temporary or long-lasting remains to be determined.

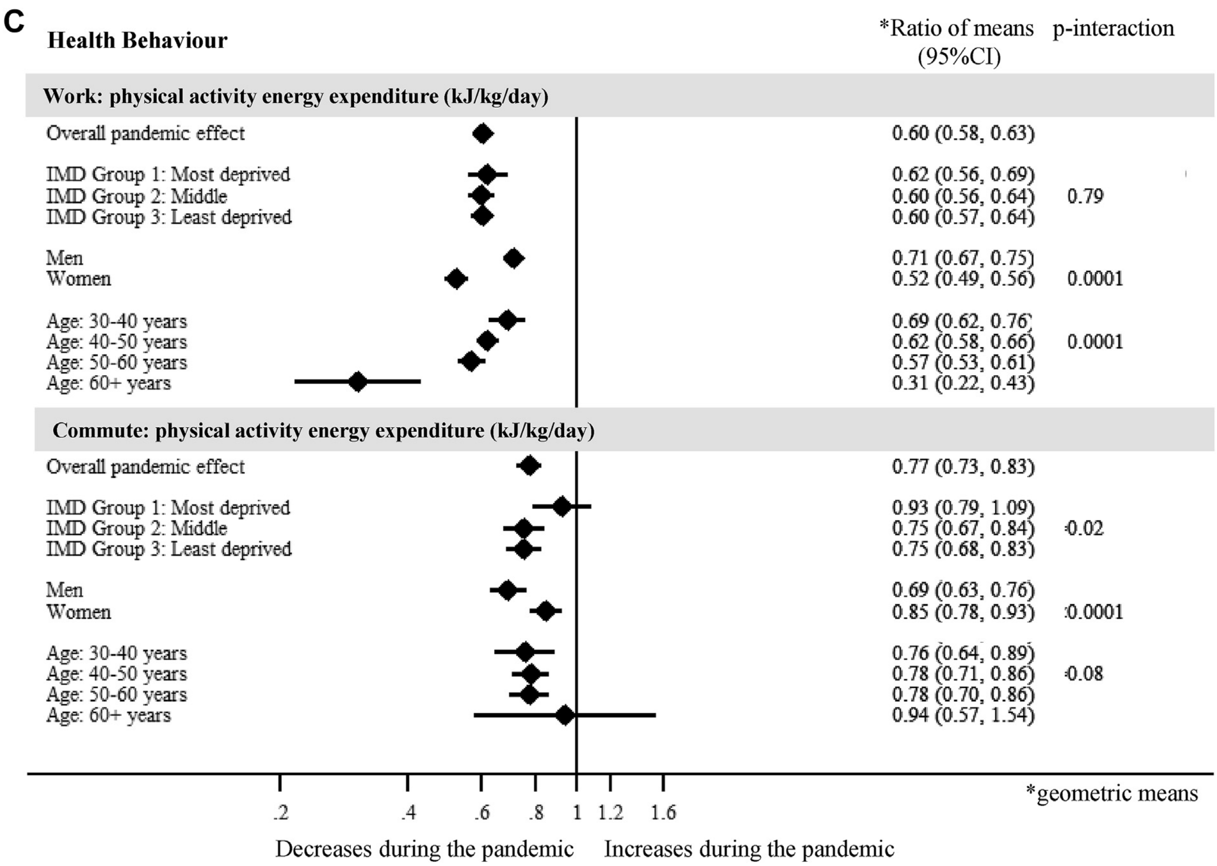

Fig. 2. (*continued*)

The study suggests that strategies to reduce health inequalities need to be at the forefront of local and national government recovery plans, not just in continued support for disadvantaged groups during the pandemic, like enhanced access to fresh fruit and vegetables, for example, but also through more long-term approaches, which seek to make systematic efforts to reduce inequalities.

Conclusions

The study has shown that socio-economic inequalities in health behaviours, particularly fruit and vegetable consumption and total PAEE, have worsened during the pandemic. As the country emerges from the COVID-19 pandemic, strategies to reduce inequalities need to be put at the forefront of recovery plans.

Author statements

Ethical approval

Ethics approvals for Phases 1 and 2 were obtained from Cambridge East Research Ethics committee on 11 May 2004 and 5 July 2014, respectively. Written informed consent was obtained from all participants, and participants were made aware that they were able to request to leave the study at any point. For the Fenland COVID-19 substudy, ethical approval was obtained from South West Cornwall and Plymouth Research Ethics committee on 30 June 2020. Consent for the Fenland COVID-19 substudy was completed online. The Fenland cohort participant panel was involved in the planning, conducting and reporting of the Fenland COVID-19 study as part of patient and public involvement.

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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.2022.08.005.

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Original Research

Comparing public knowledge around value of hand and respiratory hygiene, vaccination, and pre- and post-national COVID-19 lockdown in England

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A R T I C L E I N F O

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A B S T R A C T

Objectives: The COVID-19 pandemic spotlighted the importance of infection prevention and control (IPC) measures. Existing literature focuses on healthcare professionals, whereas this article explores changes in public knowledge of IPC, where knowledge is comparably sparse.
Study design: National surveys were conducted before (March 2020) and after (March 2021) the COVID-19 lockdown across England.
Methods: A telephone survey of 1676 adults (2021) and a face-to-face survey of 2202 adults (2020) across England were conducted. Key demographics were representative of the population. Weighted logistic regression with composite Wald *P*-values was used to investigate knowledge change from 2020 to 2021.
Results: Compared with 2020, significantly more respondents correctly stated that infections can spread by shaking hands (86% post vs 79% pre; $P < .001$) and that microbes are transferred through touching surfaces (90% vs 80%; $P < .001$). More knew that hand gel is effective at removing microbes if water and soap are unavailable (94% vs 92%; $P = .015$); that when you cough, you may infect other people near you in a room (90% vs 80%; $P < .001$). Knowledge that vaccination protects others from infection also increased (63% post vs 50% pre; $P < .001$). There was also significant increase in those confident in their answers.
Conclusion: Knowledge of IPC measures was higher in 2021 than before the pandemic. Future public health hygiene campaigns should capitalise on this and emphasise that continuing hygiene behaviours, and vaccination can help prevent acquisition and illnesses with other non-COVID-19 infections, thus reducing the strain on the national health service.

Introduction

In the 19th century, Semmelweis, ‘father of infection control’, noted the importance of good hygiene in the prevention of spreading infections.[1] To this day, hand washing remains one of the most effective methods for infection prevention and control (IPC)[2] and thus featured in Government guidelines to help to curb the risk of infection transmission during the COVID-19 pandemic.[2–4] The pandemic wreaked destruction worldwide, and the United Kingdom was one of the hardest hit countries, with almost 23 million cases, resulting in more than 180,000 deaths.[5] It is feared the pandemic may have had caused greater morbidity and mortality had these hygiene guidelines not been issued to the public.

Existing studies have explored public understanding of COVID-19[6] as well as behaviour change in response to the pandemic, such as social distancing and frequency of hand washing.[7,8] There is also a plethora of literature reporting handwashing techniques and adherence in a healthcare setting,[4,9,10] especially in-light of COVID-19;[11] however, it cannot be assumed that the knowledge of trained professionals is comparable to that of the general public. This article seeks to address this gap by assessing public understanding of IPC.

Public Health England regularly conducts surveys of the English population to determine health-seeking and self-care behaviours for common infections and understanding of antibiotics.[12,13] In

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2020, nine IPC questions were introduced. Given the recent COVID-19 pandemic, and the abundance of UK Government messaging and recommendations relating to IPC, including the slogan 'hands, face, space',[14] it is important to monitor changes in public understanding of IPC, so to indirectly assess the impact of public health messaging, and to ensure the public are equipped with the knowledge needed to keep themselves and others safe. To this end, the survey was repeated in 2021, with the results from early March 2020 (presented herein) serving as a prepandemic baseline from which to investigate changes in public understanding of IPC.

Methods

The market research company Ipsos MORI conducted interviews as part of routine surveys across England. The baseline survey,[13] carried out between January 24 and February 24, 2020 (before the COVID-19–related lockdown in England) was performed face-to-face in the interviewees' own home via computer-aided personal interviews. Because of national lockdown restrictions, the 2021 survey, carried out between 26 February and 2 March, could only be conducted remotely and therefore was undertaken via computer-aided telephone interviews. Partially completed interviews (i.e. if the participant terminated the interview) were excluded. Representativeness of the sample was ensured (in 2020) by two-stage random sampling,[12] where interviewers were given age, gender, household tenure, and working status quotas of respondents; and (in 2021) by random digit dialling, and publicly available targeted data (see the appendix for more details).

Questionnaire

Questions were developed in collaboration with researchers, general practitioners, non-healthcare advisors, and the Ipsos MORI's health questionnaire team. Computer-assisted interviewing ensured that the questionnaire was followed correctly for all respondents; partially completed interviews (if participants terminated the interview) were excluded. Nine IPC statements, incorporating hand and respiratory hygiene, were asked (see box 1). Participants were asked to give a single response for each statement, indicating whether they thought statements were definitely true, probably true, probably not true, definitely not true, or don't know. The use of this 5-point scale provides insight into confidence of respondents' answers and encourages participants to provide an answer, rather than responding 'don't know'. Statements were randomly ordered, the response scale was reversed for half the respondents, and interviewers were asked not to prompt.

Data analysis

To ensure the results are broadly representative of the population, Capibus uses a random iterative weighting system to correct for known selection biases, which weights survey data to the latest set of census data or mid-year estimates and national readership survey profiles for age, social grade, region and working status, within gender and additional profiles on tenure and ethnicity. Pearson's Chi-squared test, corrected for survey design,[15] was used to test for differences in proportions across levels of categorical variables and between each statement in the 2020 and 2021 surveys. Weighted logistic regression was performed on each outcome separately. Wald (composite) *P*-values were quoted, with the odds ratio (OR) and 95% confidence intervals (CIs). A series of models were fitted for each outcome and all explanatory variables. Each model consisted of an interaction between survey year (2020/2021) and explanatory variable under consideration together with their main effects, and the remaining explanatory variables as main effects only. The *P*-value was for the interaction, with 5% taken as the significance level. Stata was used for all analyses (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

Box 1
New questions asked in 2020 about infection prevention (correct answer)

Infection prevention and control statements asked of respondents. Statements were presented in a random order Possible responses: definitely true, probably true, probably false, definitely false, don't know. Next you will see a series of statements about preventing infections. For each statement, please tell me whether you think it is true or false.

Hand hygiene

1. Washing your hands with soap and water removes more microbes than just water True
2. Using hand gel can help stop the spread of infection if soap and water is not available True
3. Infections do not spread from you to others by shaking hands False
4. We do not pick up microbes on our hands from surfaces (such as tables and chairs) False

Respiratory hygiene

5. Bacteria and viruses get on your hands when you sneeze into a tissue True
6. People don't need to clean their hands after sneezing into a tissue False
7. You do not infect other people around you when you cough False
8. Microbes in sneezes can travel the length of a bus True

Vaccination

9. Vaccination of one person also protects other people from infection True

Explanatory variables

Table 1 details the explanatory variables of the multivariable analysis. Social grade of the household is determined by the occupation of the chief income earner. Social grade AB comprises high or intermediate managerial, administrative, or professional workers; C1 Supervisory, clerical and junior managerial, administrative or professional workers; C2 skilled manual workers; D semi/unskilled manual workers; E State pensioners, casual or lowest grade workers, unemployed with state benefits only. A respondent's highest level of educational attainment was classified according to general certificate of secondary education: further education (A level or equivalent) and higher education (degree or equivalents). Ethnicity was dichotomized, and the results from non-White respondents were collapsed into the category termed BAME (Black, Asian and minority ethnic) respondents, with data compared against that from White respondents. The authors would like to address that the use of the phrase BAME refers to any respondent who did not self-identify as White (which accounts for ~15% of the population in England[16]). The implications of dicotimising ethnicity are discussed in the limitations. In the larger survey, of which this forms part,[13] respondents were asked

Table 1
Respondent demographics for 2020 and 2021 on the left, with the population demographics on the right.

Demographics and Explanatory Variables from Surveys						Population in England			
		2020		2021		2020		2021	
		n	%	n	%	n	%	n	%
Gender	Male	997	49.1%	815	48.6%	22,643	49.1%	22,599	49.1%
	Female	1035	50.9%	851	50.8%	23,502	50.9%	23,438	50.9%
Age	15–24	291	14.3%	238	14.2%	6534	14.2%	6486	14.1%
	25–34	340	16.7%	276	16.5%	7659	16.6%	7519	16.3%
	35–44	310	15.3%	256	15.3%	7185	15.6%	7233	15.7%
	45–54	338	16.6%	277	16.5%	7581	16.4%	7368	16.0%
	55–64	296	14.6%	247	14.7%	6818	14.8%	6992	15.2%
	65+	458	22.5%	378	22.6%	10,368	22.5%	10,439	22.7%
Social Grade	AB	541	26.6%	437	26.1%	12,350	26.8%	12,536	27.2%
	C1	594	29.2%	411	24.5%	13,598	29.5%	15,979	34.7%
	C2	423	20.8%	352	21.0%	9421	20.4%	8819	19.2%
	DE	474	23.3%	398	23.7%	10,776	23.4%	8703	18.9%
Education	No formal qual.	215	10.6%	253	15.1%	9838	21.3%	10,956	23.8%
	GCSE	560	27.6%	370	22.1%	11,232	24.3%	12,477	27.1%
	A-Level	408	20.1%	322	19.2%	8174	17.7%	7047	15.3%
	Degree	560	27.6%	597	35.6%	16,902	36.6%	15,557	33.8%
Ethnicity	White	1727	85.0%	1445	86.2%	39,330	85.2%	39,128	85.0%
	BAME	290	14.3%	222	13.2%	6816	14.8%	6884	15.0%
	Black	55	2.7%	66	3.9%	1690	3.7%	1227	2.7%
	Asian	193	9.5%	84	5.0%	3953	8.6%	3066	6.7%
	Mixed	24	1.2%	49	2.9%	578	1.3%	1172	2.5%
	Other	18	0.9%	23	1.4%	594	1.3%	1418	3.1%
HCP	GP-Only	270	13.3%	171	10.2%				
	Pharm-Only	82	4.0%	63	3.8%				
	GP & Pharm	322	15.8%	151	9.0%				
	Neither GP nor Pharm	1683	82.8%	1460	87.1%				
Infection last 12 months	Infection	1456	71.7%	773	46.1%				
	No Infection	746	36.7%	903	53.9%				

2020 n = 2022; 2021 n = 1676

whether, in the last 12 months, they had an infection or visited a healthcare professional.

Ethics approval

The Ipsos MORI surveys and interviews were undertaken outside the national health service (NHS) setting, and NHS Research Ethics Committee review is not required for healthcare market research conducted by professional market researchers. This ethical position was confirmed by the Head of Research Governance, Research Translation & Innovation Division at Public Health England. Ipsos MORI is an independent research agency bound by the rules of the Market Research Society. The surveys are regular household 'consumer' surveys into which clients of Ipsos MORI can insert sets of questions. Consent for personal responses to be used by Ipsos-MORI clients for research purposes is indicated by verbal agreement and by the member of the household voluntarily completing the survey questionnaire/interview. There were no financial or other incentives, and participants were free to withdraw their participation during the interview. All data processing and storage comply with the General Data Protection Regulation and UK Data Protection Act 2018.

Results

Responses were obtained from 2022 in 2020 and 1676 in 2021. Table 1 provides demographic breakdown of respondents and how this compares to the general population.

Compared with 2020, more knew that *soap and water removes more microbes than just water* (97% vs 94%; $P < .001$). Twenty-four percent more knew this was definitely true than in 2020 ($P < .001$), and this did not differ according to demographic group.

In 2021, 95% of people knew that *if soap and water is not available, hand gel can stop the spread of infection;* a 3% increase from 2020 ($P = .015$). In 2020, females had a lower OR (OR = 0.53, CI 0.35–0.79; correct responses 90%) of answering correctly than males; yet, in 2021, females had a higher OR (OR = 1.29, CI 0.79–2.13; correct responses 95%) than males (OR = 1.10, CI 0.65–1.87; correct responses 94%). Thus, from 2020, females improved their knowledge to a greater extent than males ($P = .03$).

Significantly more respondents correctly answered 'false' to the statement *infections do not spread from you to others by shaking hands* in 2021 than 2020 (86% vs 80%; $P < .001$). Knowledge change for this statement differed according to social grade ($P < .001$). Those in social grades AB, C1 and C2 had similar knowledge improvement over the year; DE did not. Social grades DE had a lower odds ratio of answering correctly in both 2020 (OR = 0.60, CI 0.40–0.92; correct responses 72%) and 2021 (OR = 0.60, CI 0.40–0.93; correct responses 70%), with no change in knowledge over the year. Knowledge gain also differed according to educational attainment ($P = .01$). There were significant differences in knowledge improvements between those reporting and not reporting an infection in the previous year ($P = .03$), where the former had no knowledge change and the latter significant knowledge improvement.

Similarly, 9% more people correctly answered 'false' to the statement *we cannot pick up microbes on our hands from surfaces* in 2021 than in 2020 (90% vs 81%; $P < .001$). Knowledge change varied according to age groups ($P = .01$). Knowledge in under 25-year-olds improved the most (OR = 3.70, CI 1.41–9.01; correct responses 96%) from 2020 (correct responses 84%). Improvements generally decreased with age, such that over 65-year-olds had no significant knowledge change from 2020 (OR = 0.70, CI 0.43–1.12; correct responses 79%) in 2021 (OR = 0.88, 0.66, 1.64; correct responses 80%). Knowledge for this statement also differed according to educational attainment (*P* = .03). (Fig. 1)

In both 2020 and 2021, 9 of 10 respondents knew that *microbes get on your hands when you sneeze into a tissue* (90% 2020 vs 91% 2021, *ns*). However, in 2021, there was a significant increase in the percentage who knew this was 'definitely true' compared with 2020 (54% vs 44%; *P* < .001). There is some evidence to suggest that change in knowledge from 2020 to 2021 may have differed according to age (*P* = .06; see able 4).

In 2021, knowledge that *when a person sneezes, microbes can travel the length of the bus* decreased by 8% from 83% in 2020 to 75% in 2021 (*P* < .001).

Significantly more respondents in 2021 correctly answered 'false' to the statement *people don't need to clean their hands after sneezing into a tissue* compared with 2020 (89% vs 83%, *P* < .001). Knowledge improvements from 2020 differed according to age (*P* = .03). In 2021, the odds of answering this statement correctly more than doubled for under 25-year-olds (OR = 2.33, CI 1.01–5.26; correct responses 92%), whereas the odds remain relatively unchanged for over 65-year-olds from 2020 (OR = 0.89, CI 0.56–1.45; correct responses 81%) to 2021 (OR = 1.19, CI 0.71–1.96; correct responses 81%). Knowledge improvements differed according to social grade (*P* = .02); DE showed little change in their odds for answering the statement correctly from 2020 (OR = 0.62, CI 0.40–0.96; correct responses 78%) to 2021 (OR = 0.72, CI 0.46–2.44; correct responses 79%). Conversely, social grades AB almost doubled their odds in 2021, but the greatest increase was in social grade C1 from 2020 (OR = 0.79, CI 0.53–1.18; correct responses 87%) to 2021 (OR = 2.22, CI 1.37–3.57; correct responses 93%). Knowledge improvements also differed according to ethnicity (*P* = .02) and education (*P* = .04; see table 4 (appendix)' and 'see table 5 (appendix)).

Ten percent more respondents correctly answered 'false' to the statement *when you cough, you do not infect other people who are near you in a room* in 2021 compared with 2020 (90% vs 80%, *P* < .001). Knowledge improvements varied according to ethnicity (*P* = .008). In 2020, the OR for BAME respondents answering this question correctly was less than half of that of White respondents (OR = 0.39, CI 0.29–0.52; correct responses 65%), yet in 2021, the odds for White (OR = 2.27, CI 1.72–2.94; correct responses 90%) and BAME respondents (OR = 2.27, CI 1.19–4.35; correct responses 90%) were comparable. (Fig. 2)

Compared with 2020, significantly more people knew that *vaccination of one person also protects other people from infection* (63% vs 50%, *P* < .001). Of note, there was a 14% increase in respondents answering definitely true for this statement, which is a significant increase from 21% in 2020 (*P* < .001). Knowledge gain varied according to age (*P* = .002). Generally, knowledge improvements increased with age, such that in 2021, 55- to 64-year-olds had the largest knowledge improvement with odds answering correctly (OR = 2.16, CI 1.46–3.20; correct responses 68%) compared with 2020 (OR = 0.73, CI 0.51–1.04; correct responses 53%). There was some evidence to suggest that differences in knowledge improvements were observed according to ethnicity (*P* = .051); however, in 2021, the odds of answering correctly was comparable between White (OR = 1.89, CI 1.58–2.25; correct responses 49%) and BAME respondents (OR = 1.60, CI 1.09–2.33; correct responses 55%). (Fig. 3)

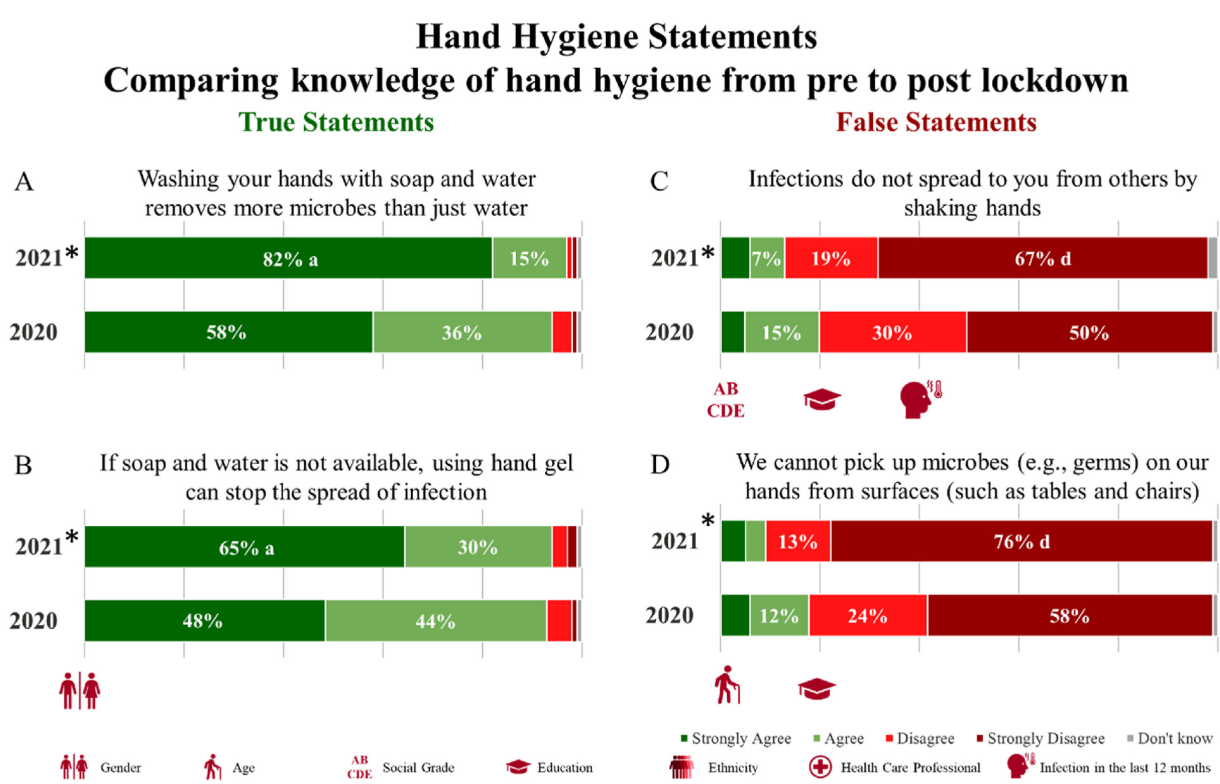

Fig. 1. Response to the four hand hygiene statements for 2020 (bottom) and 2021 (top). Asterisks denote significant differences (P < .05) in the proportion of net correct answers (definitely true/true for parts A and B; false/definitely false for parts C and D) between 2020 and 2021. Letters represent significant differences (P < .05) in the percentage of: definitely true (a), true (b), false (c), and definitely false (d) responses within each statement between 2020 and 2021. Icons represent significant changes (P < .05) in the explanatory variable on the outcome variable between 2020 and 2021.

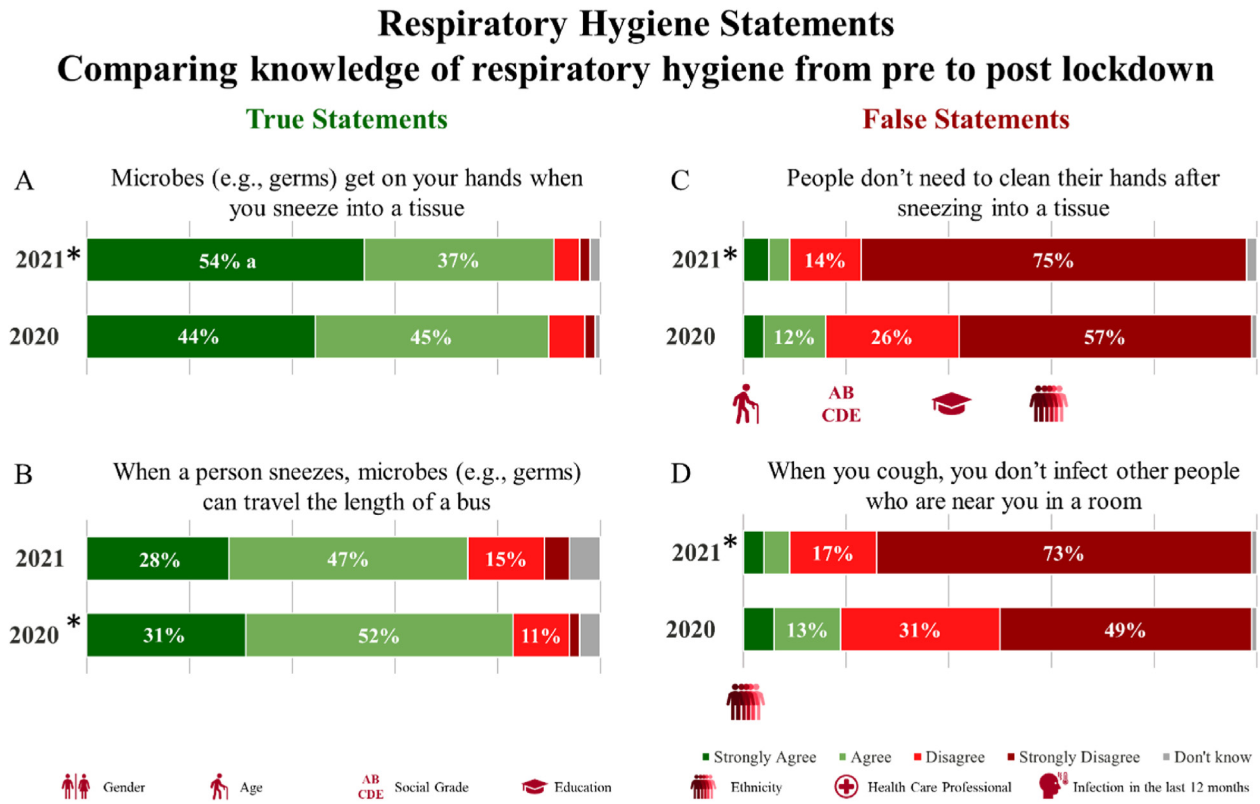

Fig. 2. Response to the four respiratory hygiene statements for 2020 (bottom) and 2021 (top). Asterisks denote significant differences ($P < .05$) in the proportion of net correct answers (definitely true/true for parts A and B; false/definitely false for parts C and D) between 2020 and 2021. Letters represent significant differences ($P < .05$) in the percentage of: definitely true (a), true (b), false (c), and definitely false (d) responses within each statement between 2020 and 2021. Icons represent significant changes ($P < .05$) in the explanatory variable on the outcome variable between 2020 and 2021.

Discussion

Despite reasonably high baseline public knowledge, compared with 2020, public knowledge in 2021 improved in eight of nine infection prevention control statements. Whilst some areas reflect only modest net improvement in correct responses, it is particularly encouraging to note that there is significant growth in those correctly responding definitely true or definitely false, as appropriate, suggesting the public are more confident in their knowledge of IPC compared with before the pandemic.

Hand hygiene played a pivotal role in COVID-19 preventative strategies; on 4 March 2020, the UK government initiated a handwashing campaign to emphasise the necessity of hand washing with soap and water or hand sanitiser for at least 20 s.[3] Alcohol hand gels/sanitisers were provided in public places to encourage said behaviour. This messaging was reinforced on 9 September 2020 with the new government strapline 'hands, face, space'. Other preventative strategies included enforced social distancing and replacing the handshake, fundamental to social interactions,[17] with elbow-bumps or foot taps, where the risk of spreading infection is substantially lower.

Atchinson et al.[18] revealed that during the week before lockdown restrictions in England (23 March 2020), 86% of the English population reported washing their hands with soap more frequently. This coincides with a large UK study of over 28,000 participants, which found that handwashing was the most frequently reported IPC behaviour during May 2020.[8] Such behaviour change was also observed during the 2009 Swine Flu pandemic.[19] There are several studies suggesting greater hand hygiene knowledge and behaviours in females.[20,21] Our results revealed that some hand hygiene knowledge improvements varied according to gender with some evidence that males improved their knowledge to a greater extent with regard to microbe transmission through touch and females improving their knowledge of hand gel/sanitisers to a greater extent than males. However, from our results, it remains unknown whether improved hand hygiene behaviours transpired from associated knowledge improvements.

As a continuous cough was one of the main symptoms of COVID-19, heightened knowledge around cough etiquette was expected. There was a 10% improvement in knowledge that when you cough, you may infect others nearby, coinciding with UK Government recommendations to encourage socialising outside and to ensure good ventilation indoors.[22] However, there was a decrease in knowledge regarding how far microbes can travel compared with prepandemic. This may be due to the heightened focus on SARS-CoV-2 and evidence available at the time of this survey suggesting that the virus spreads mainly between people in close proximity.[23] The UK Government also issued varying advice on face coverings, and social distancing – changing recommendations from 2 m to 1 m + safe distance[24] contributing to public confusion in the latter part of 2021 whereby more than half of the public were unclear on government rules people should follow around COVID.[25] Furthermore, the public were recommended to avoid public transport,[26] which may have added confusion to the 'length of a bus', which was used as a frame of reference for the distance a microbe can travel. That said, others report the UK public considered 'covering sneezes' as a highly effective strategy to prevent the spread of COVID-19, more so than social distancing measures.[18] This could be attributed, in part, to the success of the 2013 'Catch it. Bin it. Kill it.' Campaign, which conveyed the importance of covering sneezes, binning tissues, and washing hands after using a tissue.[27] Overall, BAME respondents observed substantial improvements in

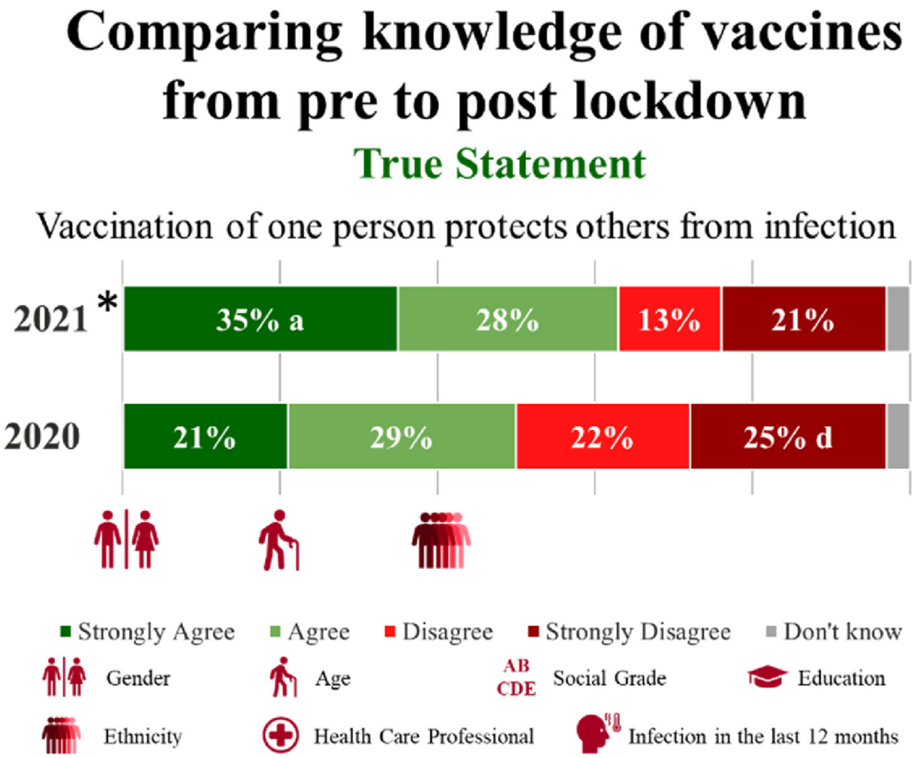

Fig. 3. Response to the vaccination statement for 2020 (bottom) and 2021 (top). Asterisks denote significant differences (P < .05) in the proportion of net correct answers (definitely true/true for parts A and B; false/definitely false for parts C and D) between 2020 and 2021. Letters represent significant differences (P < .05) in the percentage of: definitely true (a), true (b), false (c), and definitely false (d) responses within each statement between 2020 and 2021. Icons represent significant changes (P < .05) in the explanatory variable on the outcome variable between 2020 and 2021.

respiratory hygiene knowledge compared with prepandemic. This is encouraging, especially considering the greater acquisition and morbidity for some BAME groups from COVID-19[28–30] and non-COVID-19 respiratory infections.[31,32]

Knowledge improvements was greatest for the statement vaccination of one person protects others from infection. Although asked of vaccines in general, at the time of the 2021 survey, there was much discussion of a COVID-19 vaccine, with several COVID-19 vaccines in the process of development.[33] There were many media reports of the positive lifeline that a COVID-19 could serve,[34,35] which may have contributed to improved knowledge of vaccine protection. However, despite the reduction in hospitalisation rates of those who have received maximum doses of a COVID-19 vaccination,[36] there remained some opposition to the COVID-19 vaccination roll-out across the United Kingdom, as well as vaccine hesitancy.[37] There was particular concern around lower vaccine uptake among BAME groups;[38] however, our results revealed that knowledge of vaccine protection was lower in BAME than White participants in 2020, but comparable in 2021. Older adults, who were also identified as vulnerable from COVID-19,[39] saw greater improvements in their knowledge about vaccine protection than their younger counterparts. More recently, campaigns have successfully targeted demographics with low vaccine uptake,[40] such as south Asian and young adults by improving trust, reducing misinformation and increasing knowledge.

Strengths and limitations

Through weighting the data, these results are broadly representative of the English population and provide insights into understanding of IPC measures of the general public and how these have been altered by the pandemic. The 2021 telephone interview data have been compared with the data collected in March 2020 through face-to-face household interviews and due to different sampling techniques are not directly comparable. However, both data collection methods are interviewer assisted, with data recorded on a computer during the interview: telephone interviews were deemed more comparable with face-to-face sampling than online surveys whilst considering Government restrictions. Whilst there is some evidence that respondents may give more socially desirable responses via telephone, this is not thought to apply to knowledge-based questions.[41] These IPC statements were introduced in 2020, before the first COVID-19 outbreak, and as such, are not specific to other IPC measures such as social distancing or mask wearing that were pertinent during the COVID-19 pandemic; furthermore, it did not explore opportunity or motivations for behaviourally implementing IPC measures. Finally, grouping ethnicity into only two variables is crude and assumes heterogeneity amongst all non-White groups. Future surveys must oversample across all BAME groups to allow adequate power to more appropriately analyse ethnicity to reflect the diversity of the United Kingdom.

Implications and actions

Public campaigns such as ‘Catch it. Bin it. Kill it.[27] and ‘Keep Antibiotics Working’[42] have previously been used to improve knowledge and behaviours of the public,[43] and thus, public health bodies may wish to capitalise on increased knowledge reported herein to iterate the importance of IPC measures (i.e. handwashing, social distancing, mask wearing and vaccinations) among adults to prevent the spread of infections, especially in the lead up to the winter flu season. The e-Bug programme[44] provides free educational resources for children aged 3–16 years covering a range of topics including hand and respiratory hygiene, vaccinations, antibiotic use and antimicrobial resistance, all of which are pertinent to IPC. These resources were posted to all maintained schools and academies across England in January 2022 to support efforts to reinforce these messages among children, families and communities.

Conclusion

Knowledge of IPC has significantly improved following the pandemic, particularly regarding vaccinations, where base knowledge was lower, but has also improved for hand and respiratory hygiene where base knowledge was much higher.

During the COVID-19 pandemic across England, many national and regional restrictions were enforced, alongside frequently updated government advice and guidelines disseminated through daily COVID-19 briefings, online news, social media and billboards.[45] These results capture changes in knowledge of IPC immediately before (March 2020) and 12 months after national lockdown restrictions were first imposed in England, providing insight into the effectiveness of said communications and the receptiveness of the public to IPC information. Knowledge alone does not drive behaviour change; however, the empowering, preventative messaging linked to the public's own goals and interests is likely to have played a part in improving public knowledge around IPC and vaccinations. The challenges moving forward will be maintaining these positive behaviour changes when the perceived threat of COVID-19 reduces. Future work should seek to understand this relationship and the role of messaging on sustained behaviours to enable continued encouragement of hand washing as one of the single most effective forms of IPC,[2] which will serve to alleviate strain on the NHS,[22] especially as the United Kingdom moves towards the next stage of living with COVID-19, and non-COVID-19 community infections rise.[46]

Author statements

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Ethical approval

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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.2022.08.015.

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Short Communication

Costs of healthy living for older adults: the need for dynamic measures of health-related poverty to support evidence-informed policy-making and real-time decision-making

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A B S T R A C T

Objectives: This study aimed to examine the dynamic properties of the costs of healthy living for older adults and to compare these costs to the timing and levels of Pension Credit for older adults on low incomes.
Study design: This was a longitudinal descriptive study.
Methods: We used monthly inflation data and the concept of a '*Minimum Income for Healthy Living*' (MIHL) to estimate the dynamic changes in *MIHL* from 2003 to 2022 and compared these costs with Pension Credit levels for older adults on low incomes.
Results: Progress in closing the gap between the *MIHL* and Pension Credit has been reversed by recent sharp increases in costs. From April 2021 to April 2022, the *MIHL* for single older adults rose from £5.57 per week below to £8.29 per week above Pension Credit levels.
Conclusions: There is a need for dynamic measures of health-related poverty to support evidence-informed policy-making and real-time decision-making to mitigate the health impacts on older adults.

Introduction

The concept of a '*Minimum Income for Healthy Living*' (MIHL) is well established based on the work of pioneering epidemiologist Jerry Morris, who applied the concept to older adults.[1] The basic principle of this concept is that there is little point in lecturing people about healthy living if they do not have the financial means of achieving it. Recent analyses by Age UK show that two million UK households in which an older adult lives will not be able to cover essential spending needs in 2022–2023.[2] In these households, older adults will be forced to make spending choices that may impact their health. Indeed, older adults whose income falls below the *MIHL* are at a greater risk of poorer health outcomes, including frailty.[3]

The current cost of living crisis is driven largely by sharp increases in the costs of food, fuel and energy bills in the United Kingdom and many other countries.[4] Older adults are disproportionately impacted due to the steepest increases affecting food and energy prices, which constitute a large proportion of the income older adults require for healthy living.[1] The idea that poverty can be transient and influenced by external shocks such as a war, pandemic, or global financial crisis is also well known.[5] However, policies seldom account for these dynamic characteristics of poverty, which is too often treated as a static condition experienced by 'the poor'. The cost of living crisis is likely to push many older adults into health-related poverty, and for some, this will be for the first time in their lives.

The current crisis highlights that dynamic costs of healthy living do not fit conveniently within the timing of government budget cycles or long-term strategies to reduce health inequalities. In the United Kingdom, increases in the State Pension and Pension Credit for older adults on low incomes are typically calculated annually, many months in advance. For example, the April 2022 increases in Pension Credit were announced in November 2021 before the consequences of sharp increases in costs were experienced by many older adults. Indeed, Office for National Statistics data show that the proportion of adults aged ≥70 years who report increased monthly costs has risen from 71% in November 2021 to 89% in April 2022.[6]

In this article, we use the concept of a 'MIHL' to demonstrate how dynamic changes in the cost of healthy living for older adults

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compared with longer term increases in Pension Credit for older adults on low incomes.

Methods

We used a longitudinal descriptive study design to examine the dynamic changes in the *MIHL* for older adults compared with periodic increases in Pension Credit. The original estimates for the weekly *MIHL* for older adults were calculated by Morris et al. for 2005 using information on prices from low-cost retailers and suppliers, national data on the expenditure of low-income older people, published research and expert reviews.[1] We have disaggregated the estimates for singles and couples into their component parts and, using the corresponding item from the Consumer Price Index 'basket of goods and services', have updated the costs of constituent items for each month to reflect current and historic prices. The component parts of the *MIHL* and corresponding Consumer Price Index item codes are as follows: (1) Diet/Nutrition (D7BU); (2) Physical Activity: anti-ageing, autonomy (D7FH); (3) Housing, a home (D7BX); (4) Healthcare (D7BZ); (5) Psychosocial relations/social inclusion (D7C4); (6) Hygiene (D7CY); (7) Getting about (D7C2); (8) Other costs of social living (e.g. clothing) (D7BW); and (9) Contingencies, inefficiencies (D7BT). We have compared these inflation-adjusted levels of the *MIHL* with changes in the level of Pension Credit since it was introduced in October 2003 until the most recent increase in April 2022.

Results

Fig. 1 shows the dynamic monthly trends in the *MIHL* for single and coupled older adults alongside increases in Pension Credit from October 2003 to April 2022. In the last year, from April 2021 to April 2022, the *MIHL* for single older adults has risen from £5.57 per week below Pension Credit levels to £8.29 per week above, despite the latest increase in Pension Credit in April 2022. The corresponding figures for an older couple are £7.53 below in April 2021 and £10.33 above in April 2022. This means that an older adult claiming Pension Credit would receive approximately £36 per month below the *MIHL* each month. An older couple would receive approximately £45 below *MIHL* each month.

When Pension Credit was first introduced in October 2003, it was well below the *MIHL* at that time (£18.22 below for singles and £34.22 below for couples). Between 2003 and 2012, the total *MIHL* and Pension Credit levels increased at approximately the same rate, meaning that the gap between the two measures was maintained. From 2013 to 2016, the average increases in levels of Pension Credit were greater than the changes in the *MIHL* threshold, meaning that the gap between the two measures closed and remained close together until the recent increases in the cost of living crisis began to take effect in early 2022.

Discussion

With current Pension Credit levels fixed until April 2023, and prices of essential items rising, many older adults will not be able to cover essential health-related costs. This is compounded by Government figures showing that Pension Credit is not claimed by 850,000 families who are entitled to an average of £1900 per year.[7] Some older adults are entitled to other benefits such as support with housing costs,[8] but there are concerns that these benefits are not taken up by a large number of older adults.[9] It is also important to note that Morris' original estimate of the MIHL was conservative because it underestimates the costs of heating and excludes the costs of having a chronic illness, which would impact approximately 40% of those aged >65 years.[1]

We need dynamic approaches to understanding and mitigating the health impacts of changes in the cost of healthy living on older adults. Calls to action such as an 'emergency budget' may provide a short-term solution but do not prepare governments for future dynamic changes in costs. Indeed, while the latest UK Government announcements about additional help with the cost of living will be welcome to many, these announcements are reactive rather than proactive and are described by the Government as a 'one-off'.[10]

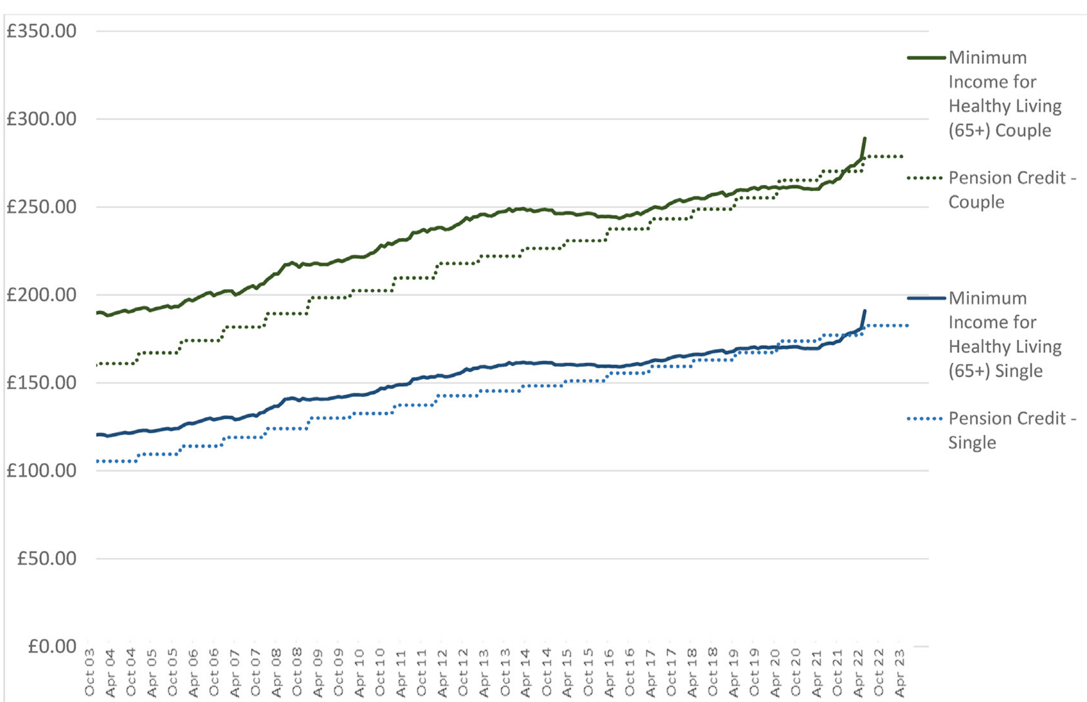

Fig. 1. Trends in the minimum income for healthy living for couples and singles aged ≥65 years (2003–2022) and Pension Credit levels (2003–2023).

Dynamic measures of health-related poverty for older adults can make the best use of social, economic and epidemiological data sets to estimate the close to real-time changes in the cost of living experienced by older adults. Such measures can underpin evidence-informed policy-making and real-time decision-making on the levels of support older adults need through instability in the costs of healthy living, recognising that at other times, these costs may go down as well as up. By being responsive to the dynamic changes in the costs of healthy living for older adults, there is potential to provide interventions that more effectively mitigate the impacts of these changes on the health of older adults and increased strain on health and social care services.

Author statements

Ethical approval

This research uses publicly available secondary data; therefore, ethical approval was not required.

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Competing interests

None.

Data statement

Data are available from the authors on request.

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Review Paper

COVID-19 vaccine acceptance and hesitancy among patients with cancer: a systematic review and meta-analysis

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ABSTRACT

Objectives: Patients with cancer are more vulnerable to COVID-19 morbidity and morbidity than the general population and have been prioritised in COVID-19 vaccination programmes. This study aims to investigate COVID-19 vaccine acceptance and hesitancy among patients with cancer.
Study design: This was a systematic review and meta-analysis.
Methods: PubMed, ScienceDirect and the Cochrane COVID-19 study registry were searched in addition to secondary literature using a predefined search method. Two authors independently performed the study identification, screening and eligibility assessment. This study followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses 2020 guidelines and Joanna Brides' Institute quality appraisal tools.
Results: A total of 29 studies and reports were selected for the final review. The pooled prevalence of vaccine acceptance was 59% (95% confidence interval 52–67%, I^2: 99%). Concerns about vaccine-related side-effects, uncertainty about vaccine efficacy and safety, ongoing active anticancer therapies and scepticism about rapid vaccine development were the leading causes for vaccine hesitancy. Female gender and undergoing active anticancer treatments were significant factors associated with COVID-19 vaccine hesitancy. Early cancer stages (stages I and II) and good compliance with prior influenza vaccinations were significant factors associated with the acceptance of the COVID-19 vaccine.
Conclusions: Many patients with cancer are hesitant about COVID-19 vaccination. Well-designed problem-based educational interventions will increase compliance with COVID-19 vaccination.

Introduction

The National Comprehensive Cancer Network has released COVID-19 vaccination guidelines and recommendations for patients with cancer.[1] Full COVID-19 vaccination is recommended for patients with cancer, their family members, caregivers and close contacts.[2] Patients with cancer are at an increased risk of COVID-19 due to anticancer treatments and compromised immune systems.[3] These individuals are prioritised in COVID-19 vaccination programmes because of their high risk of mortality after COVID-19 infection.[4]

Patients with cancer are recommended COVID-19 vaccination,[5–7] despite the lack of evidence on immunomodulation and safety and adverse events of the COVID-19 vaccines. A study by Monin et al. showed a significant increase in immunogenicity after the booster dose.[8] There are more reported benefits than adverse events for vaccinated patients with cancer.[9,10]

Evidence on attitudes, perceptions, acceptance and hesitancy of COVID-19 vaccines among patients with cancer is limited. It is crucial to assess the perspectives of patients with cancer on COVID-19 vaccination, with the ultimate goal of implementing necessary actions to overcome vaccine hesitancy. This systematic review with meta-analysis aims to provide a comprehensive understanding of the factors associated with COVID-19 vaccine acceptance and hesitancy among patients with cancer.

Methods

The protocol for this study was registered in the International prospective register of systematic reviews (PROSPERO) on 6 September 2021 (CRD42021276950).

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Data sources, study selection and search strategy

The primary search was performed in PubMed, Science Direct and the Cochrane COVID-19 study register according to a predetermined search method. The authors selected the keywords, databases and the exact search string during the pilot study. The electronic databases were searched from 25th April 2021 to 21st May 2022. Keywords were truncated and combined via Boolean operators to make the exact search string. In the secondary search, keywords were used in combination and alone in Google, Google Scholar and ResearchGate.[11] Used keywords were 'willingness', 'intention', 'hesitancy', 'acceptance', 'perception', 'attitudes', 'cancer', 'malignancy', 'neoplasm', 'tumour', 'COVID 19', 'coronavirus', 'SARS CoV 2', 'nCoV', 'vaccine', 'vaccination', 'immunisation' and 'injection'. The search strategy is shown in Appendix 1 in the supplementary material. Only articles published in the English language were selected. When a potential study was identified, the full text was downloaded (note: when the free full text was unavailable online, an original paper or report was requested from the corresponding author or associated affiliations). The reference lists of selected studies were assessed to identify any additional relevant articles. This study followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses 2020 (PRISMA 2020) guidelines (see Appendix 2 in the supplementary material).[12]

Inclusion and exclusion criteria

Original studies published in the English language assessing attitudes, perceptions, willingness or hesitancy to COVID-19 vaccination in adult (aged ≥18 years) patients with cancer or cancer survivors who were being treated or followed up for cancers were included. Patients with recent cancer diagnoses who were waiting for treatment were also included.

'Vaccine acceptance' was defined as those patients who had been vaccinated, who were willing to get the vaccine or who were waiting to get the COVID-19 vaccine. 'Vaccine hesitancy' was defined as those patients who were reluctant to get the vaccine or refused to get vaccinated. Cross-sectional studies meeting the eligibility criteria were included; randomised controlled trials and case–control studies were excluded. Reports providing evidence relevant to the study objectives were included in the final review (latest PRISMA 2020 updates: 'report' could be a journal article, preprint, conference abstract, study register entry, clinical study report, dissertation, unpublished article, government report or any other document providing relevant information).[12]

Evaluation process

After the removal of duplicate articles, two authors (K.I.P.P. and H.D.W.T.D.) independently screened the titles and abstracts of selected studies for their eligibility to be included in full text screening. The full tests of potential articles were retrieved, and an in-depth evaluation was undertaken (by K.I.P.P. and H.D.W.T.D.) to assess the eligibility to be included in the final analysis. Included studies were assessed for quality according to the Joanna Brides' Institute quality appraisal tool[13] by the principal author (K.I.P.P.) and cross-checked by a co-author (H.D.W.T.D.). Any discrepancies in the screening process and risk of bias assessment were resolved by consensus. Article quality was considered to be 'fair' if the answer was 'no' or 'unclear' to two to three of eight questions in the Joanna Brides' Institute quality appraisal tool and 'high' if the answer was 'no' to only 1 or 'yes' for all questions.[14]

Data extraction, analysis and data synthesis

Data extraction was conducted according to a predefined data extraction table. Extracted data were cross-checked, and discrepancies were discussed. Authors, study year, study design and methodology, study location, sample collection dates, sample characteristics, study objectives, main findings (percentages, statistically significant and non-significant findings) and study limitations were extracted. Similarities and differences if the findings, sample-specific characteristics, trends and limitations were identified. The corresponding author was contacted in cases of any identified discrepancy.

Qualitative synthesis was carried out as a narrative summary, and meta-analyses were undertaken in Review manager 5.4.1 when the data were available to pool. People aged >65 years were considered as 'elderly', and people aged between 50 and 65 years were considered as 'advanced middle-aged adults' for the current systematic review.[15,16] The heterogeneity among pooled studies was described as per the I^2 statistics.[17,18] Heterogeneity among studies was not considered for the prevalence data during the meta-analysis. Study heterogeneity was categorised as low (0–40%), moderate (41–60%), substantial (61–80%) and considerable (81–100%).[18] Heterogeneity was addressed; moderate heterogeneity was fixed with a random effects model to incorporate sample variation among pooled studies,[19] and studies with low heterogeneity were analysed with a fixed effects model.[19] Meta-analysis was not performed for the studies with significant heterogeneity.[19] Pooled prevalence of patients with cancer were calculated for vaccine acceptance, vaccine hesitancy due to the fear of side-effects and uncertainty of effectiveness of the COVID-19 vaccines. The generic inverse variance method was used in pooled prevalence data analysis (95% confidence interval [CI], random effects model).[17] Factors associated with vaccine acceptance and hesitancy were identified during the meta-analysis and described using odds ratios (ORs). Significant factors were identified and interpreted with the overall effect size (Z) and *P*-values. Studies that were not included in the pooled meta-analysis were narratively summarised.

Results

In total, 167 articles were identified during the initial search, and 101 in the secondary search. The study selection process is shown in Fig. 1. Finally, 29 studies were selected for the review.[20–48] The current systematic review reports studies from the following different geographical areas: Australia,[42] Serbia,[47] Germany,[25,26] Portugal,[28] Bosnia and Herzegovina,[45,48] Italy,[37] France,[27,35] Poland,[31,40] Korea,[39] the US,[23,38,41] Cyprus,[24] Mexico,[36] Tunisia,[33,43] China,[20,22,30,34,46] Turkey,[29] Ethiopia,[44] India[33] and Lebanon.[21] Study characteristics are presented in Table 1.

The pooled prevalence of COVID-19 vaccine acceptance was 59% (95% CI 52–67%), I^2: 99% (see Fig. 2(a)).[20–48] The pooled prevalence of vaccine hesitancy due to fear of vaccine-related side-effects was 53% (95% CI 40–67%), I^2: 99% (see Fig. 2b)[21,34,35,37,38,40,42] and due to uncertainty about the vaccine effectiveness was 36% (95% CI 17–55%), I^2: 99% (see Fig. 2c).[21,34,37,40,49]

Study participants were sceptical about the rapid development of COVID-19 vaccines[31] and reported low confidence in scientific results and the healthcare system.[35,36] Frequently reported misconceptions included the potential of vaccines to cause infections (because they contain viruses), COVID-19 vaccines being contraindicated for patients with breast cancer, potential infertility and concern about a concealed chip within the vaccine to collect personal data.[36] Patients who were doubtful about COVID-19 vaccination perceived that there was insufficient knowledge of the side-effects and medical indications of the vaccines for patients with

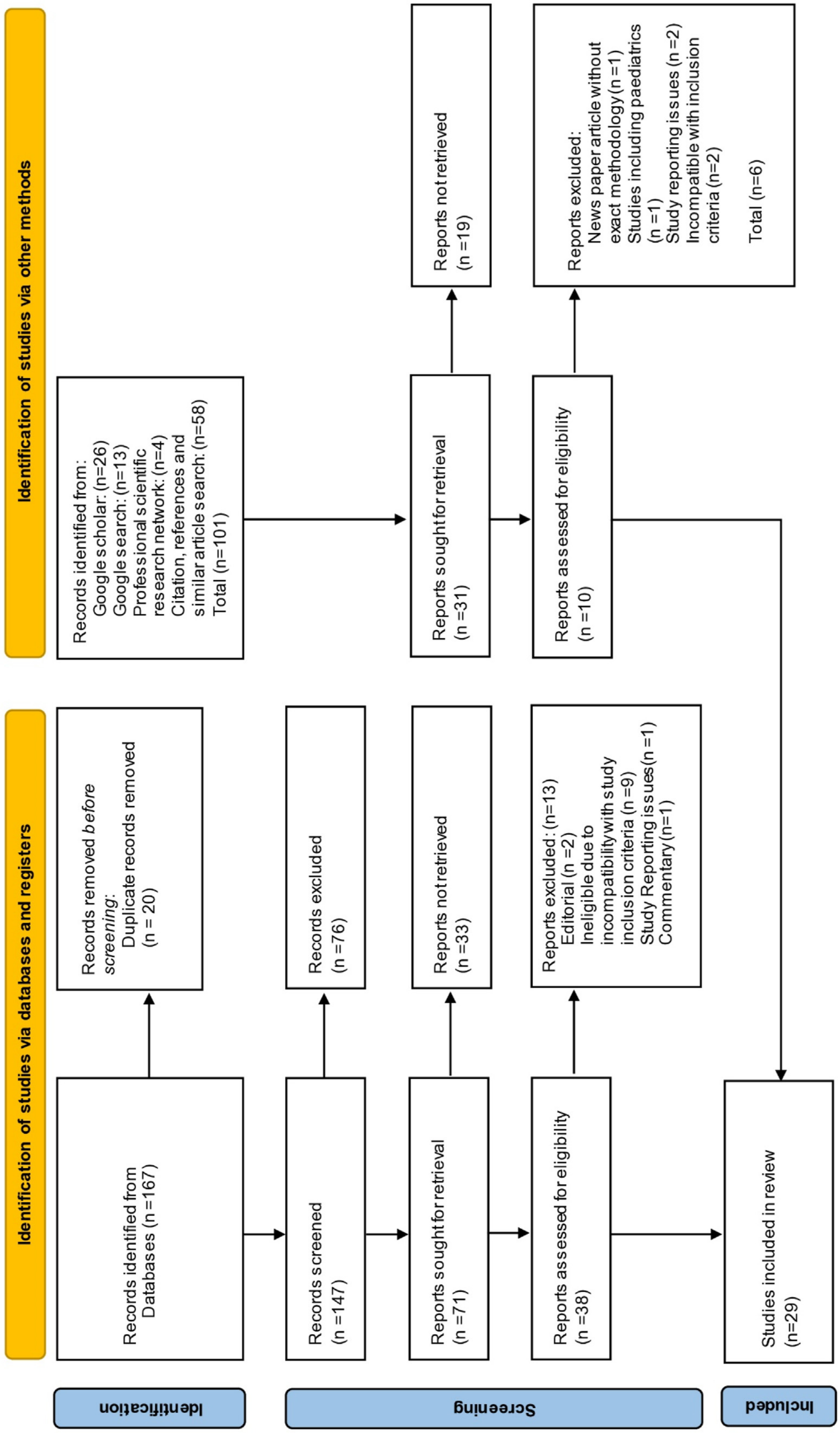

Fig. 1. Study selection process.

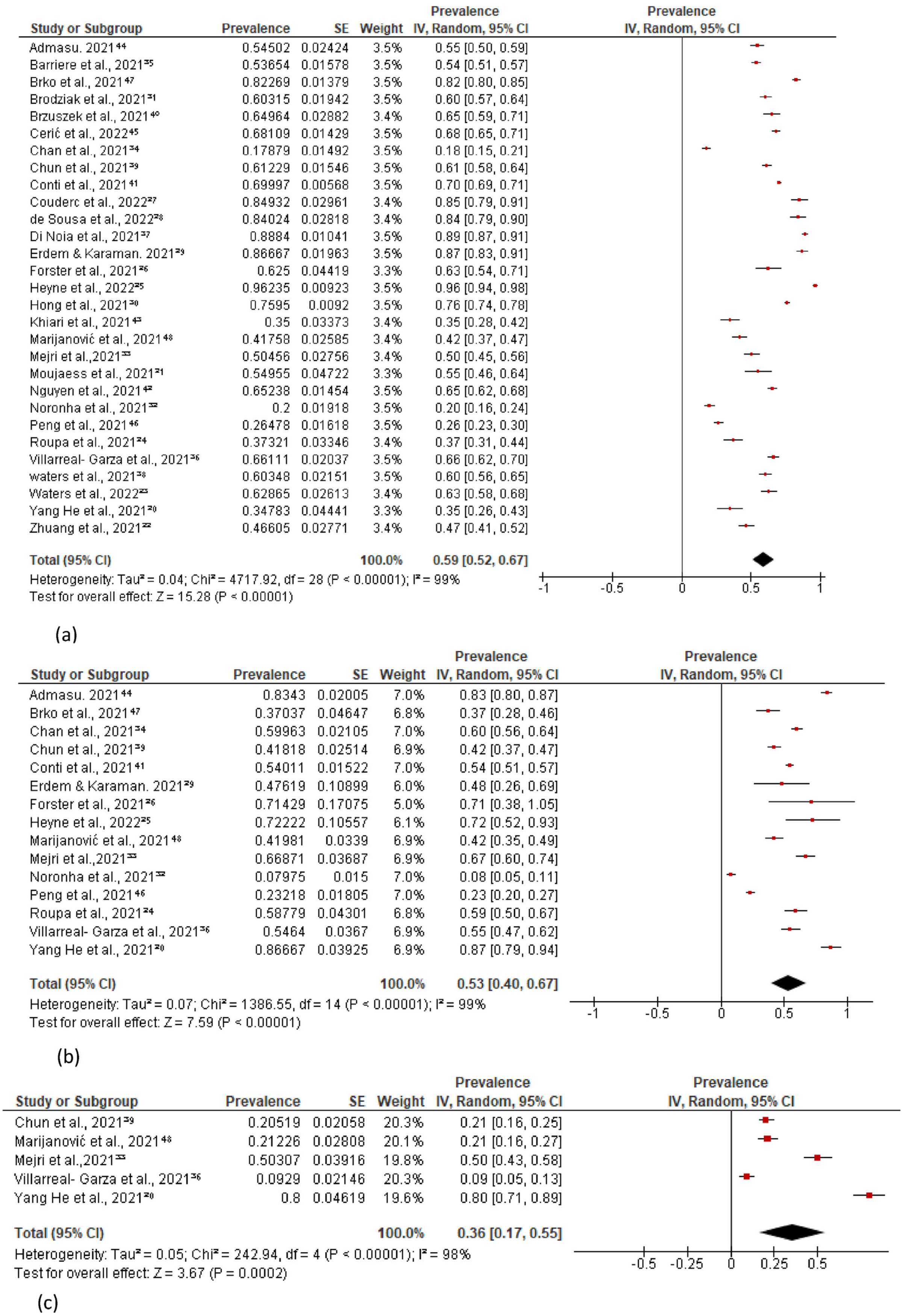

Fig. 2. Pooled prevalence of (a) vaccine acceptance, (b) vaccine hesitancy due to fear of side-effects and (c) vaccine hesitancy due to uncertainty of vaccine effectiveness. CI, confidence interval; SE, standard error.

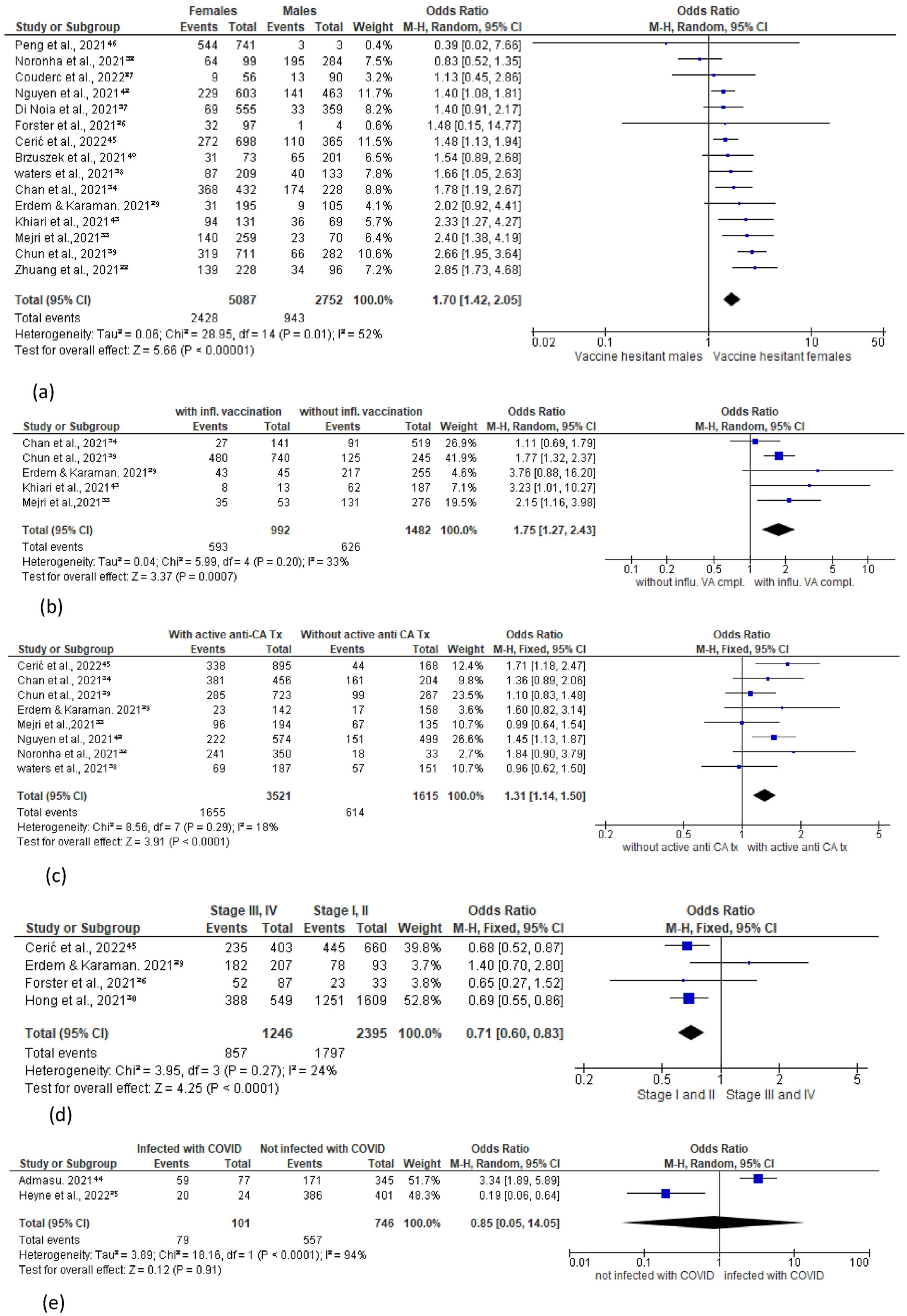

Fig. 3. Meta-analysis findings of factors associated with COVID-19 vaccine acceptance or hesitancy; (a) Gender, (b) compliance with previous influenza vaccination, (c) being with active anticancer treatments (d) advance stage of the cancer, and (e) history of COVID-19 infection.

Table 1
Key characteristics of included studies.

Study no.	Author, year and country	Study period	Sample characteristics				Quality appraisal
			Sample size	Median/mean age in years	Gender		
					Male	Female	
1.	Di Noia et al., 2021,[37] Italy	1/03/2021 to 20/03/2021	914	62 (21–97)	39%	61%	Fair
2.	Barrière et al., 2021,[35] France	1/11/2020 to 12/12/2020	999	67 (18–97)	43.9%	56.1%	Fair
3.	Brodziak A et al., 2021,[31] Poland	26/01/2021 to 18/02/2021	635	53 (18–89)	19.8%	80.2%	Good
4.	Conti et al., 2021[41]	1/12/2020 to 21/12/2020	6516	63.93 ± 12.28	40.2%	59.8%	Fair
5.	Villarreal-Garza et al., 2021,[36] Mexico	12/03/2021 to 26/03/2021	540	49 (23–85)	–	100%	Fair
6.	Waters et al., 2021,[38] USA	10/2020– to 01/2021	342	29.5 ± 6.5	38.9%	61.1%	Fair
7.	Mejri et al., 2021,[33] Tunisia	02/2021 to 05/2021	329	54 ± 13.4	21.3%	78.7%	Good
8.	Yang He et al., 2021,[20] China - Hubei	Not indicated	115	–	–	–	Fair
9.	Moujaess et al., 2021,[21] Lebanon	25/01/2021– to 12/02/2021	111	61 (23–85)	33.3%	66.7%	Fair
10.	Brzuszek et al., 2021,[40] Poland	Not indicated	280	–	73%	27%	Fair
11.	Chun et al., 2021,[31] Korea	02/2021– to 04/2021	993	57.4 ± 12.0	28.3%	71.7%	Fair
12.	Chan et al., 2021,[34] China–Hong Kong	31/01/2021– to 15/02/2021	660	–	34.5%	65.5%	Good
13.	Brko et al., 2021,[47] Serbia	1/07/2021– to 15/08/2021	767	–	–	–	Fair
14.	Heyne et al., 2022,[25] Germany	09/2021– to 11/2021	438	61.4 ± 12.3	39.5%	60.5%	Fair
15.	De Sousa et al., 2022,[28] Portugal	08/03/2021– to 02/04/2021	169	61 (29–82)	35.5%	64.5%	Good
16.	Cerić et al., 2022,[45] Bosnia and Herzegovina	22/10/2021– to 30/11/2021	1063	61.9 ± 11.5	34.3%	65.7%	Fair
17.	Waters et al., 2022,[23] USA	10/2020– to 01/2021	341	–	39.3%	60.7%	Fair
18.	Roupa et al., 2021,[24] Cyprus	22/01/2021– to 12/02/2021	211	52.6 ± 12.4	34.6%	64.9%	Fair
19.	Khiari et al., 2021,[43] Tunisia	02/2021	200	54.4 ± 12.7	34.5%	65.5%	Good
20.	Nguyen et al., 2021,[42] Australia	30/07/2021– to 07/08/2021	1073	62 ± 11.97	43.2%	56.2%	Good
21.	Peng et al., 2021,[46] China	05/06/2021– to 12/06/2021	744	48 (40–54)	0.4%	99.6%	Good
22.	Erdem and Karaman, 2021,[29] Turkey	05/2021– to 06/2021	300	55.16 ± 12.91	35%	65%	Fair
23.	Admasu, 2021,[44] Ethiopia	05/2021– to 08/2021	422	35.7 ± 6.86	42.8%	57.2%	Good
24.	Zhuang et al., 2021,[22] China	03/2021– to 05/2021	324	–	–	–	Good
25.	Foster et al., 2021, Germany	15/03/2021– to 28/07/2021	120	Breast cancer: 57 (23–85) Gynaecological cancer: 56 (34–78)	3.33%	96.67%	Fair
26.	Hong et al., 2021,[30] China	17/06/2021– to 03/09/2021	2158	–	48.89%	51.11%	Good
27.	Marijanović et al., 2021,[48] Bosnia and Herzegovina	02/2021	364	61.6 ± 11.2	38.5%	61.5%	Good
28.	Couderc et al., 2021,[27] France	18/01/2021– to 07/05/2021	150	81 ± 0.5	61.3%	38.7%	Fair
29.	Noronha et al., 2021,32 India	07/05/2021– to 10/06/2021	435	58 (52–65)	73.8%	26.2%	Fair

cancer.[31] Patients who had a neutral view on COVID-19 vaccination were more likely to get vaccinated after receiving sufficient information on vaccine efficacy and safety.[35,36] A meta-analysis for age-wise comparison was not performed due to inconsistency within the data.[31,33,35,39–41] However, several studies reported that elderly individuals were more likely to get vaccinated and less likely to refuse the vaccine.[31,33,35] Patients aged <50 years were more likely to be hesitant about receiving the COVID-19 vaccine.[33,40] According to the eight included studies, education level was not significantly associated with vaccination status.[22,29,30,33,34,39,42,46] According to Barrière et al., the vaccine-hesitant population relied on their own opinions on COVID-19 vaccination, whereas those who accepted the COVID-19 vaccine followed their oncologist's opinion.[35] Brodziak et al. showed that most people depend on their healthcare professionals' opinions (i.e. oncologist or general practitioner) on COVID-19 vaccination.[22,24,29,31,36,46]

Factors associated with vaccine acceptance and hesitancy

A meta-analysis was undertaken for the following variables: gender, compliance with previous influenza vaccination, active anticancer treatments, stage of cancer, and history of COVID-19 infection. Fig. 3 presented the analysis results and Fig. 4 shows publication bias in the pooled studies in each analysis.

Gender

Seventeen studies were initially pooled for the gender meta-analysis and revealed to have a substantial statistical heterogeneity (I^2: 87%). Two sources of statistical heterogeneity were identified[30,44] due to extreme narrow values for the CIs with considerable weight on both studies (Admasu: weight: 6.8%, n = 422, OR: 0.24 [95% CI 0.16–0.36];[44] and Hong et al.: weight: 7.6%, n = 2158, OR: 0.94 [95% CI 0.77–1.14]).[30] Fifteen studies were finally pooled for the gender variable (see Fig. 3a). Because of the moderate statistical heterogeneity among the 15 pooled studies, the random effects model was used to analyse the data.[24,38,40,41,43,27,30–32,35–37] Meta-analysis of the pooled studies indicated that female gender is significantly associated with vaccine hesitancy (pooled OR: 1.70 [95% CI 1.42–2.05] I^2: 52%, overall effect: Z = 5.67, $P < 0.00001$).

Prior compliance with previous influenza vaccination

Five studies were grouped to assess the effect of influenza vaccination and COVID-19 vaccine hesitancy (see Fig. 3b).[29,33,34,39,43] Patients with prior influenza vaccination were more likely to accept COVID-19 vaccination (pooled OR: 1.75 [95% CI 1.27–2.43], I^2: 33%, overall effect: Z = 3.37, $P = 0.0007$).

Undergoing active anticancer treatments

Nine studies were pooled to investigate the association between undergoing active anticancer treatments and vaccine hesitancy (Fig.: 3c).[29,30,32,33,38,39,42,45,47] Brko et al. and Hong et al. showed significantly high heterogeneity (I^2: 79%), which can be explained by inappropriate data reporting.[30,47] A total of seven studies were pooled for the final analysis. Meta-analysis of the pooled studies indicated that patients undergoing active anticancer treatments were more likely to be hesitant about COVID-19 vaccination (pooled OR: 1.31 [95% CI 1.14–1.50], I^2: 18%, overall effect: Z = 3.91, $P < 0.0001$).

Cancer stage

Four studies were pooled to identify the effect of cancer stage on COVID-19 vaccine acceptance (see Fig. 3d).[26,29,30,45] Patients with advanced stages of cancer (stages III and IV) showed low

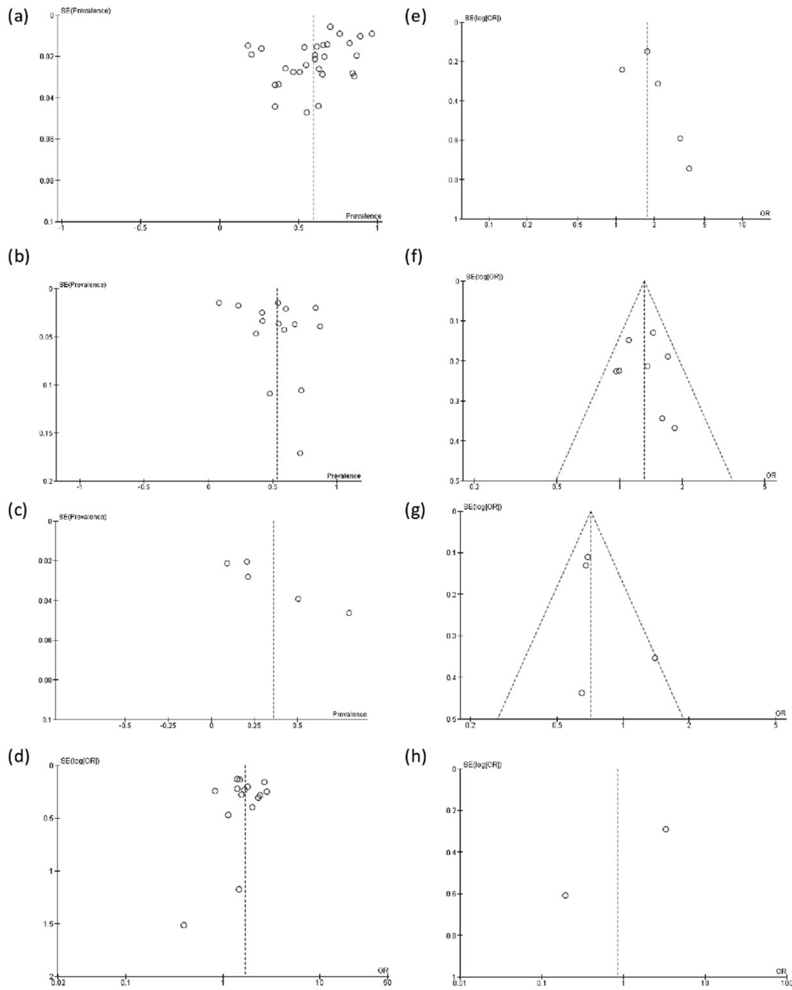

Fig. 4. Funnel plots of the analysis. (a) Pooled prevalence of vaccine acceptance; (b) pooled prevalence of vaccine hesitancy due to fear of side-effects; (c) pooled prevalence of vaccine hesitancy due to the uncertainty of vaccine efficacy; (d) effect of gender on COVID-19 vaccine hesitancy; (e) effect of previous influenza vaccination on vaccine acceptance; (f) effect of active anticancer treatments on vaccine hesitancy; (g) effect of cancer stage on vaccine hesitancy; and (h) effect of history of COVID-19 infection on vaccine acceptance. CI, confidence interval.

acceptance of the COVID-19 vaccination (pooled OR: 0.71 [95% CI 0.60–0.83], I^2: 24%, overall effect: Z = 4.25, $P < 0.0001$).

Previous COVID-19 infection

Two studies were pooled to assess the effect of previous COVID-19 infection and vaccine acceptance (see Fig. 3e).[25,44] The results showed no statistically significant association between prior COVID-19 infection and COVID-19 vaccine acceptance (pooled OR: 0.85 [95% CI 0.05–14.05], I_2 =94% overall effect: Z = 3.19, $P = 0.91$).

Discussion

The current systematic review and meta-analysis investigated whether gender, compliance with previous influenza vaccination, active anticancer treatments, stage of the cancer and history of COVID-19 infection were related to COVID-19 vaccine acceptance.

Pooled prevalence statistics found that approximately half of the patients with cancer accepted COVID-19 vaccines.[20–48] In total, 58% of the pooled population were willing to be vaccinated against COVID-19. Patients with cancer who received the COVID-19 vaccination reported mild reactions, such as a sore arm, fatigue and headache; however, concerns about vaccine safety may cause considerable COVID-19 vaccination hesitancy.[7] Studies recommend all doses of COVID-19 vaccines for patients with cancer, as this significantly reduces COVID-19–related morbidity and mortality.[49] National Comprehensive Cancer Network guidelines recommend COVID-19 vaccination for all patients with cancer unless there is a clinical contraindication.[1]

A meta-analysis of this systematic review found that the female gender and undergoing active anticancer treatments are associated with vaccine hesitancy. Good compliance with previous influenza vaccination and being in the early stages of cancer (stages I and II) are associated with COVID-19 vaccine acceptance. According to the results of the narrative synthesis, elderly individuals (aged >65 years) are more likely to accept the vaccine (note: a meta-analysis on the age variable could not be performed because of significant heterogeneity among studies). This result is supported by previous literature showing that older and middle-aged adults are more likely to accept the COVID-19 vaccine than the younger population.[50,51] Females in the general population have been shown to be more hesitant about COVID-19 vaccines[52,53] and are significantly concerned about the side-effects of COVID-19 vaccination.[33,54]

Concerns about COVID-19 vaccine–related side-effects and effectiveness were highly prevalent among patients with cancer. Fear of unknown future COVID-19 vaccine–related side-effects and doubt about vaccine benefits were common factors associated with vaccine hesitancy in the community.[55] Specific educational programmes on COVID-19 vaccine safety and efficacy for patients with cancer are essential for increasing vaccine acceptance and reducing mortality associated with COVID-19.[56] These findings are important when implementing educational interventions, which need to be tailored according to sociodemographic characteristics.[57] Personal mobile communications, such as text messages emphasising the basic information on COVID-19 vaccines, social benefits and their contribution to herd immunity, have been shown to enhance vaccine acceptance.[58–60] In addition, personal reminders of COVID-19 vaccine doses increases vaccine acceptance.[59,60]

According to the narrative synthesis, education level is not likely to impact vaccine acceptance or hesitancy. However, previous studies suggest that people with a higher education level are more likely to accept the vaccine than those with a low education level in the general population.[52,61] This is supported by the study of Matsuyama et al. that showed educational attainment is significantly associated with health information needs.[62] Patients with cancer with poor health literacy levels poorly adhere to their treatments, have ineffective communication and have high anxiety levels.[63] Therefore, patients with cancer may require more information regarding COVID-19 vaccines from a trusted source.

A history of receiving the influenza vaccination was compatible with the willingness to be vaccinated against COVID-19 in general and cancer populations.[52,61] Some believe that influenza vaccines prevent the spread of COVID-19.[64] Trust in health interventions and scientific findings may enhance vaccine compliance in the community.[65]

Strengths and limitations

This systematic review is the first attempt to collate evidence on COVID-19 vaccine acceptance or hesitancy in patients with cancer. An extensive literature search, independent screening and adherence to the PRISMA guidelines strengthened the methodological quality of this study. The small number of databases searched was a limitation of this study; however, this could not be avoided due to the lack of free databases available in the country of the present publication. This study presents information from 18 countries, and therefore, results can be generalised globally; however, it should be noted that this review included online surveys and single-centre studies, which is a limitation to the results.

Conclusions

The findings from the present study highlight the requirement of problem-based educational interventions to address vaccine hesitancy of patients with cancer and their caregivers. Knowledge on vaccine efficiency, side-effects and oncological indications for vaccinating against COVID-19 should be disseminated effectively. According to the current study, oncologists were the most favourable means of delivering information about COVID-19 vaccines for patients with cancer. Motivational interviewing is important to enhance vaccine compliance[66] and responding to individual concerns about specific reasons for their vaccine hesitancy is essential.[66] Moreover, trust in healthcare providers significantly improves vaccine acceptance.[67] Kelkar et al. stated that patient education programmes delivered by oncologists enhance COVID-19 vaccine enthusiasm.[68] When restrictions are in place and face-to-face meeting are prohibited, online education interventions can be used. Kelkar et al. reported the effectiveness of webinars in reducing COVID-19 vaccine hesitancy of patients with cancer, caregivers, and other people who engage with patients with cancer and cancer care.[69] Provision of information via positive framing enhances vaccine acceptance.[68] Moreover, the current review highlights the need for well-designed qualitative studies to provide in-depth analyses of cancer patients' attitudes, perceptions, willingness or hesitancy towards COVID-19 vaccines.

Author statements

Ethical approval

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Competing interests

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.09.001.

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Short Communication

Evidence for changes in population-level subjective well-being during the COVID-19 pandemic from 30 waves of representative panel data collected in Austria between March 2020 and March 2022

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A B S T R A C T

Objectives: This study was conducted to describe how population-level subjective well-being (SWB) evolved throughout the pandemic.
Study design: Thirty waves of panel data representative of the Austrian population aged ≥14 years were collected between March 2020 and March 2022. Participants were quota sampled from a pre-existing online panel based on key demographics closely mirroring the Austrian resident population.
Methods: We present wave-specific means of SWB throughout 2 years of the COVID-19 pandemic next to the evolution of the pandemic (cases and deaths) and stringency of lockdown measures in Austria as well as estimate their bivariate correlations.
Results: The analysed sample consisted of 3,293 participants contributing to a total of 46,168 observations. All components of SWB – negative affect, positive affect and life satisfaction – showed population-level fluctuation between March 2020 and March 2022. The magnitude of these changes was small. Population-level SWB correlated with the incidence rate of COVID-19 deaths (negative affect: $r = 0.69$, positive affect: $r = -0.70$, life satisfaction: $r = -0.47$), the Stringency Index (negative affect = 0.50, positive affect = –0.47, life satisfaction = –0.47) and less so with the incidence of COVID-19 cases (negative affect = 0.43, positive affect = –0.31, life satisfaction = –0.38).
Conclusions: Population-level SWB fluctuated in accordance with rises and falls in COVID-19 cases and deaths as well as with the stringency of lockdown measures. This connection suggests that incidence of COVID-19 cases and deaths, as well as public health measures to contain the pandemic affect population-level SWB and could thereby impact population health and productivity.

Introduction

As the COVID-19 pandemic continues, early and sustained efforts to collect longitudinal data offer opportunities for a better understanding of how the pandemic affects mental health and subjective well-being (SWB). So far, studies have shown that population mental health and SWB deteriorated after the pandemic hit in early 2020 compared with prepandemic levels.[1–6] To 'break' waves of COVID-19 infections during the pandemic, governments responded with policies aiming to restrict social contacts and thereby contain the spread of COVID-19. Evidence on whether population mental health and SWB changed in accordance with pandemic waves and respective government responses – deteriorating when restrictions got more stringent and improving when restrictions were eased – is still conflicting. SWB is not only a desirable outcome in itself [7] but has also been associated with better illness prognosis[8] and lower all-cause and cause-specific mortality.[9] Answering whether and how the COVID-19 pandemic is affecting population-level SWB requires frequent monitoring of representative samples of the target population under different levels of exposure to the pandemic threat (new COVID-19 cases and deaths) and pandemic-related mitigation measures.

Exploiting differences in stringency of containment policies between England and Scotland against similar pandemic

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trajectories in May 2020, easing lockdown measures was associated with improvements in population mental health.[2] Using monthly panel data from December 2018 to December 2020, another study[5] found that mental health and SWB among German workers were reduced during the first and second wave of the COVID-19 pandemic, but recovered between waves. Latent class analyses of mental health trajectories during the pandemic support these observations: Although most included study participants were able to maintain very good or good mental health throughout the respective observational period, the mental health of a fair share of respondents was either recovering after an initial shock or fluctuating seemingly in accord with pandemic waves.[3,4] In contrast, a comprehensive study in the United Kingdom,[1] which combined data from 11 longitudinal studies, has not found consistent time-varying effects of the COVID-19 pandemic on mental health.

In this short report, we leverage 30 waves of population-representative panel data collected between March 2020 and March 2022 in Austria to assess population-level changes in SWB throughout 2 years of the COVID-19 pandemic using.

Methods

Data

We used data from the Austrian Corona Panel Project,[10] a high-frequency online panel survey conducted by the University of Vienna (https://viecer.univie.ac.at/en/projects-and-cooperations/austrian-corona-panel-project/). Between 27 March 2020 and 25 March 2022, 30 waves of initially weekly and later monthly interviews were conducted, each with >1,500 participants. Inclusion criteria were Austrian residency and age ≥14 years. Participants were quota sampled from a pre-existing online panel based on key demographics (age, gender, region, municipality size, educational level) closely mirroring the Austrian resident population. The initial participation rate was 35%, and the retention rates for panellists ranged from 86% in wave 2 to 48% in wave 30. In total, 3,293 participants provided 46,168 repeated observations (14 interviews per person on average).

The Austrian Corona Panel Project is a social science survey study for which an ethical statement was deemed not necessary as no patients were examined, no invasive methods were used, and there were no risks for survey participants. The data used for this study are openly available (https://viecer.univie.ac.at/coronapanel/austrian-corona-panel-data/access-request/).

Variables

Individual-level measures of SWB[7] included negative affect, positive affect and life satisfaction. For negative affect, participants were asked how often during the week before questioning (1 = 'never', 2 = 'on some days', 3 = 'multiple times a week', 4 = 'almost every day' and 5 = 'every day') they felt lonely, angry, depressed, nervous, anxious, or sad. Confirmatory factor analysis with R-package *lavaan* indicated this to be a valid (χ^2 (df) = 1670 (415), *P*-value <0.001, Comparative Fit Index (CFI) = 0.980, Tucker-Lewis Index (TLI) = 0.978, Root Mean Square Error of Approximation (RMSEA) = 0.068, Standardized Root Mean Square Residual (SRMR) = 0.031) and reliable (ω = 0.89) indicator. Positive affect was based on how often participants felt happy, relaxed and full of energy, also with good measurement properties (χ^2 (df) = 80 (58), *P*-value = 0.023, CFI = 1.000, TLI = 0.999, RMSEA = 0.016 and SMR = 0.013, ω = 0.85). For both multi-item indicators, we extracted the factor scores with the original scaling. Life satisfaction was measured with a single item ("In summary, how satisfied are you currently with your life?") with possible answers ranging from 0 = 'highly unsatisfied' to 10 = 'highly satisfied.'

Country-level measures of the pandemic threat level included the daily incidence of COVID-19 cases and deaths (source: OurWorldInData) and the COVID-19 Government Response Stringency Index,[11] a sum index based on nine measures (school closing, workplace closing, cancelling of public events, restriction on gathering size, public transport closing, stay at home requirements, restrictions on internal movement, international travel control and public information campaigns) that quantifies pandemic-related containment and closure policies (range = 0–100). As the affect items refer to the last week before each interview, we calculated lagged 7-day smoothed values for all three time-varying country-level measures for the correlation analysis.

Statistical analysis

We plotted changes in country-level pandemic parameters and wave-specific mean values of SWB during the 2-year period and calculated Pearson correlation coefficients. For SWB, we applied demographic weights to obtain population-level representative values. All analyses were conducted in R (v4.1.2).

Results

The mean age of the sample in March 2020 was 40.0 (standard deviation [SD] = 17.5, range = 14–85) years, 51.2% were women, and 32.1% had completed high school education. The mean values of SWB in the pooled sample were 1.7 (SD = 0.6) for negative affect, 3.1 (SD = 0.9) for positive affect, and 6.6 (SD = 2.4) for life satisfaction.

Fig. 1 shows that the number of new COVID-19 infections remained low initially, increased in November 2020 (<8000 cases) and peaked toward the end of the observation period (>45,000 cases in March 2022). COVID-19 deaths were highest in November and December 2021. Stringency of Austrian mitigation measures also varied across the pandemic: they peaked with the first three lockdown periods (March to April 2020, November to December 2020 and January to February 2021) and were lowest during the summer 2020. As indicated by Fig. 1, the wave-specific mean values of SWB (n = 30) correlated with the incidence rate of COVID-19 deaths (negative affect = 0.69, positive affect = −0.70, life satisfaction = −0.47) and the Stringency Index (negative affect = 0.50, positive affect = −0.47, life satisfaction = −0.45). The incidence of COVID-19 cases correlated with wave-specific mean SWB to a lesser extent (negative affect = 0.43, positive affect = −0.31, life satisfaction = −0.38). The difference between the minimum and maximum wave-specific mean values amounted to 0.30 SD for negative affect, 0.26 SD for positive affect and 0.17 SD for life satisfaction. The mean negative affect, for example, fluctuated between 1.6 and 1.8, that is, it shifted in accordance with pandemic parameters somewhat away from reporting to 'never' (=1) have negative emotions towards having negative feelings 'on some days' (=2).

Discussion

More than 2 years after the World Health Organisation declared COVID-19 a pandemic, it is still not clear how population-level SWB responds to recurring pandemic waves. Analysing 30 waves of representative Austrian panel data collected between March 2020 and March 2022, we observed population-level changes in average SWB in accordance with rises and falls in new COVID-19 cases and deaths as well as with the stringency of lockdown measures. Our findings corroborate previous longitudinal studies documenting

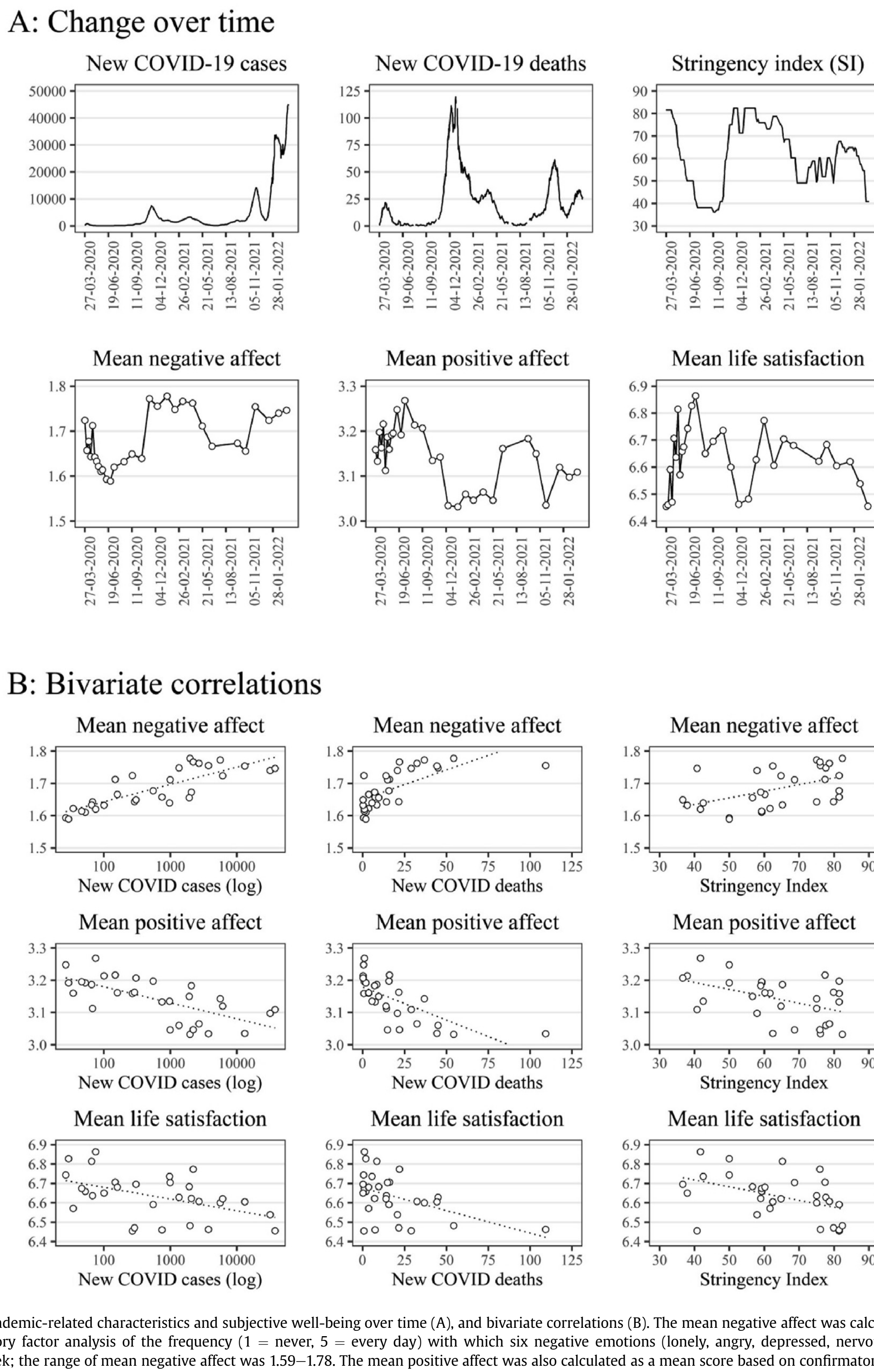

Fig. 1. Change in pandemic-related characteristics and subjective well-being over time (A), and bivariate correlations (B). The mean negative affect was calculated as a mean score based on confirmatory factor analysis of the frequency (1 = never, 5 = every day) with which six negative emotions (lonely, angry, depressed, nervous, anxious, sad) were experienced last week; the range of mean negative affect was 1.59–1.78. The mean positive affect was also calculated as a mean score based on confirmatory factor analysis of the frequency (1 = never, 5 = every day) with which three positive emotions (happy, relaxed and full of energy) were experienced last week; the range of mean positive affect was 3.03–3.27. The mean life satisfaction refers to the average reported life satisfaction (answers categories ranged from 0 = 'highly unsatisfied' to 10 = 'highly satisfied'); the range of mean life satisfaction was 6.45–6.86. New COVID cases refers to the smoothed number of new COVID-19 cases during the last 7 days; range = 26.9–37,628. New COVID deaths refers to the smoothed number of new COVID-19 deaths during the last 7 days; range = 0.29–109. Stringency index measures pandemic-related containment and closure policies; range = 36.6–82.4.

similar time-varying patterns in population mental health and SWB during the pandemic and contradict those showing mostly unchanged trajectories. Patel et al.[1] found that the prevalence of high psychological distress remained relatively stable between March and December 2020 for nine longitudinal studies in the United Kingdom, whereas they observed significant increases and decreases within only two studies. Applying latent class mixture modelling to one of those data sources – the Understanding Society Study – Ellwardt and Präg[4] reported that 24% of their sample had shown repeated elevation in psychological distress. Fancourt et al.,[12] estimating mean trajectories for a convenience sample drawn from the UK population, found declining depression and anxiety scores throughout 20 weeks after the first lockdown. Finally, analysing high-frequency longitudinal data from the YouGov survey (UK) and Google Trends, Foa et al. reach a conclusion similar to our findings. Although their measurements of negative affect are different from ours, the authors observed that changes therein mirror those in daily COVID-19 case fatalities between January 2020 and July 2021.[6]

SWB, especially when operationalised as life satisfaction, is associated with objective health status.[13] In addition, SWB is linked to objective and subjective socio-economic status.[14] Thus, SWB is considered to be key for a healthy and productive society.[15] Against the backdrop of the SWB literature, it can be argued that the COVID-19 pandemic has not only directly harmed population health via COVID-19–related illness and death but also indirectly impacted population health and productivity by affecting population-level SWB.

The strengths of our short report stem from the quality of the data source and the valid and reliable measurement of SWB. As a limitation, we are lacking prepandemic observations and thus cannot describe initial or sustained effects of the COVID-19 pandemic on SWB. Also, given that all interviews were conducted online, it is likely that the data are not representative for the older population despite the use of demographic weights.

In this short report, we focussed on describing population-level changes in the three components of SWB (negative and positive affect, life satisfaction) and their relation to the country-level number of new COVID-19 cases and deaths as well as stringency of government responses to the pandemic. We found that all three measures of SWB correlated over time with the pandemic threat level and mitigation measures. The unique data source used in the current study, although limited to the Austrian context, offers ample opportunities for future public health research to test hypotheses about causal pathways involved in the effects of the COVID-19 pandemic on SWB.

Author statements

Ethical approval

None required.

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Competing interests

None declared.

Data and code availability

Data from the Austrian Corona Panel Project are freely available for scientific research via the University of Vienna (pre-releases: https://viecer.univie.ac.at/coronapanel/austrian-corona-panel-data/access-request/) as well as via the Austrian Social Science Data Archive: https://doi.org/10.11587/28KQNS. Data on the Stringency Index are available from the University of Oxford, and data on daily COVID-19 case numbers are available from OurWorldInData. The R code and Stata code are available via OSF (https://osf.io/pfmv3/).

Author contributions

M.O. and E.W. conceived the study. E.W. prepared and analysed the data using R. M.O. reviewed the R code. M.O. and E.W. wrote the article. M.O., E.W. and T.E.D. provided critical feedback on the article drafts and approved the final version of the article.

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Review Paper

Factors influencing international collaboration on the prevention of COVID-19

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Global
International

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Objectives: COVID-19 has spread rapidly throughout the world, which has highlighted the importance of collaboration between countries to prevent further transmission of the virus. This review aims to identify the factors that influence international collaboration between policymakers for COVID-19 prevention and consider strategies to manage pandemics in the future.
Study design: A scoping review was conducted using the Arksey and O'Malley framework for scoping reviews.
Methods: A literature search was performed across PubMed, Google Scholar, Scopus and Embase databases using relevant keywords. The initial search identified 1010 articles; after selection criteria were applied, 28 studies were included in the review.
Results: Most of the selected articles were literature reviews, and China had the greatest contribution of articles to this study. The following seven key categories influencing international collaboration were identified: political, structure, infrastructure, leadership and governance, knowledge and information sharing, community engagement, and process/action.
Conclusion: Leadership and governance was the most important factor identified in international collaboration between countries. In addition, knowledge and information sharing were seen to help avoid repetition of negative situations experienced in other countries. Moreover, controlling COVID-19 on a global scale is more likely to be achieved when there are sufficient structures and resources and when appropriate communication between countries, health systems and communities is used. This collaboration can also greatly benefit low- and middle-income countries where resources and expertise are often limited.

Introduction

The COVID-19 pandemic has spread rapidly throughout the world over the last 2 years. According to the World Health Organisation (WHO), as of February 2022, there have been more than 396 million confirmed COVID-19 cases worldwide and more than 5 million deaths.[1] In addition to COVID-19 spreading rapidly, 12 new variants of the disease have been identified by the WHO and the Centers for Disease Control and Prevention, necessitating a global prevention strategy.[2]

Current global policies seek to reduce the spread, morbidity and mortality, as well as prevent the harmful side-effects of COVID-19 through various means, including prompt testing and treatment of patients, travel restrictions, contact tracing, quarantine measures and cancellation of events involving large gatherings.[3]

Global health can be thought of as a notion (the current state of global health), an objective (a world of healthy people, a condition of global health) or a mix of scholarship, research and practice (with many questions, issues, skills and competencies).[4] There are six

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types of cross-border flows that both threaten and provide opportunities for improved health globalisation: environmental elements, people, goods and services consumption, information, knowledge and culture, and transnational rules.[5]

In addition, there are five metaphors that can be applied to global health. The first metaphor is global health as foreign policy. The second metaphor, global health as security, is where health policy seeks to protect one's own population. Third, global health as charity involves the promotion of health as a key element in the fight against poverty. In the fourth metaphor, global health is seen as an investment and involves the use of health as a means of maximising economic development. The final metaphor, global health as public health, seeks to decrease the worldwide burden of disease, with priority given to those risk factors and diseases that make the greatest contribution to this burden.[6] The fight against COVID-19 requires this final approach.

The transcontinental spread of COVID-19 has shown the interconnectedness of the world and hence the importance of collaborations between countries internationally. There are many reasons for cooperation, three of which include (1) greater relations between countries and increasing collective health risks, (2) the rapid spread of diseases justifying the need for global communication, and (3) accelerating global learning and progress by sharing knowledge and experience.[7]

Collaboration is contributed to by multiple founders at several levels, beginning with the participation of diverse countries in multilateral organisations, such as the WHO, where the World Health assembly provides a platform for sharing the best practices, debating healthcare reforms and pledging support for collective resources. The launch of the WHO COVID-19 Solidarity Response Fund, the External WHO Foundation and the Accelerator to COVID-19 Tools (ACT) has helped the entire world with the technology, accessibility and availability of diagnostic tests, medications and vaccination against COVID-19.[8]

Achieving success in tackling the COVID-19 pandemic requires strong leadership and health advocates to forge both intercontinental and transcontinental alliances. This can be made possible by linking the COVID-19 pandemic response strategies to existing structures for better healthcare delivery. Increased investments to research would enable the study of the disease in more detail and develop scientific collaboration through the involvement of international networks.[9,10] Thus, this review aims to identify the factors that influence international collaboration between policymakers to prevent the spread of COVID-19 and consider strategies to manage pandemics in the future.

Methods

This scoping review was conducted to explore the factors influencing international collaboration in COVID-19 prevention. This review aims to identify current progress, existing evidence and key concepts and identify gaps in the literature.[11,12]

Research design

The Arksey and O'Malley methodological framework for scoping reviews[12] was used to derive the research design. This framework consists of six key components: identification of research questions; identification of related studies; study selection; charting the data; collection, summarising and reporting the results; and optional expert consultation (not conducted in our study).[13]

Research questions

The following research questions were chosen on agreement with all the contributing authors:

1. What are the factors that influence the international collaboration to prevent COVID-19?
2. What has been done so far regarding COVID-19 prevention?
3. What can be done?

Identification of related studies

The initial keywords were chosen based on a search in PubMed and Google scholar databases. The final combination of terms included communication, collaboration, cooperation, coordination, prevention of COVID-19, SARS-CoV-2, coronavirus, outbreak, international, global, WHO, governance and one health approach. Four databases were searched (PubMed, Google Scholar, Scopus and Embase) with no restriction on starting date. The Scopus search strategy is provided in Table 1.

Study selection

Relevant studies were screened by two reviewers (M.N. and S.D.) according to the following inclusion criteria: studies published in English, studies mentioning data pertinent to research questions, and full-text availability. Discrepancies were resolved on agreement of both reviewers. Full articles that did not fulfil all the inclusion criteria were excluded.

In total, 1010 articles were identified using the keywords; initial screening resulted in the exclusion of 545 studies. In the title and abstract screening stage, a further 349 articles were excluded due to irrelevance to the topic, and 88 articles were excluded as they did not answer the research questions. After full-text screening, 28 articles were selected for the current review (Fig. 1).

Collection, summarisation and reporting of results

In a scoping review, an overview of the existing studies is provided irrespective of the quality of the studies included.[14] The present study reports the available information on the factors influencing international collaboration in the prevention of COVID-19.

The data were analysed using the Braun and Clarke's six-step thematic analysis method. This includes familiarity with the data, identifying the source code, searching for themes, reviewing themes, defining themes and reporting.[15]

Results

This review included 28 articles; the majority being review articles (Fig. 2). In terms of country of origin of the included studies, most were published in China (six papers), Canada (five papers), and the United States (three papers; Fig. 3).

Seven categories influencing international collaboration in COVID-19 prevention were identified, as follows: (1) political, (2) structure, (3) infrastructure, (4) leadership and governance, (5) knowledge and information sharing, (6) community engagement, and (7) process/action.

Political

Political commitment[16,17] and regulations[18–20] are necessary to address pandemic needs in the long term. Enforced rules improve accountability through inclusive participation.[21] In addition, a pandemic response built on global diplomacy, including strategic global health, vaccine and science policies, which can lead to both political and economic benefits, advancing development, health security and justice, has been identified.[22]

Table 1
Scopus search strategy.

Query
TITLE-ABS-KEY ((communication OR collaboration OR cooperation OR coordination) AND (prevention of COVID-19 OR SARS COV 2 OR coronavirus OR outbreak) AND (international OR global OR who OR governance OR one health approach))

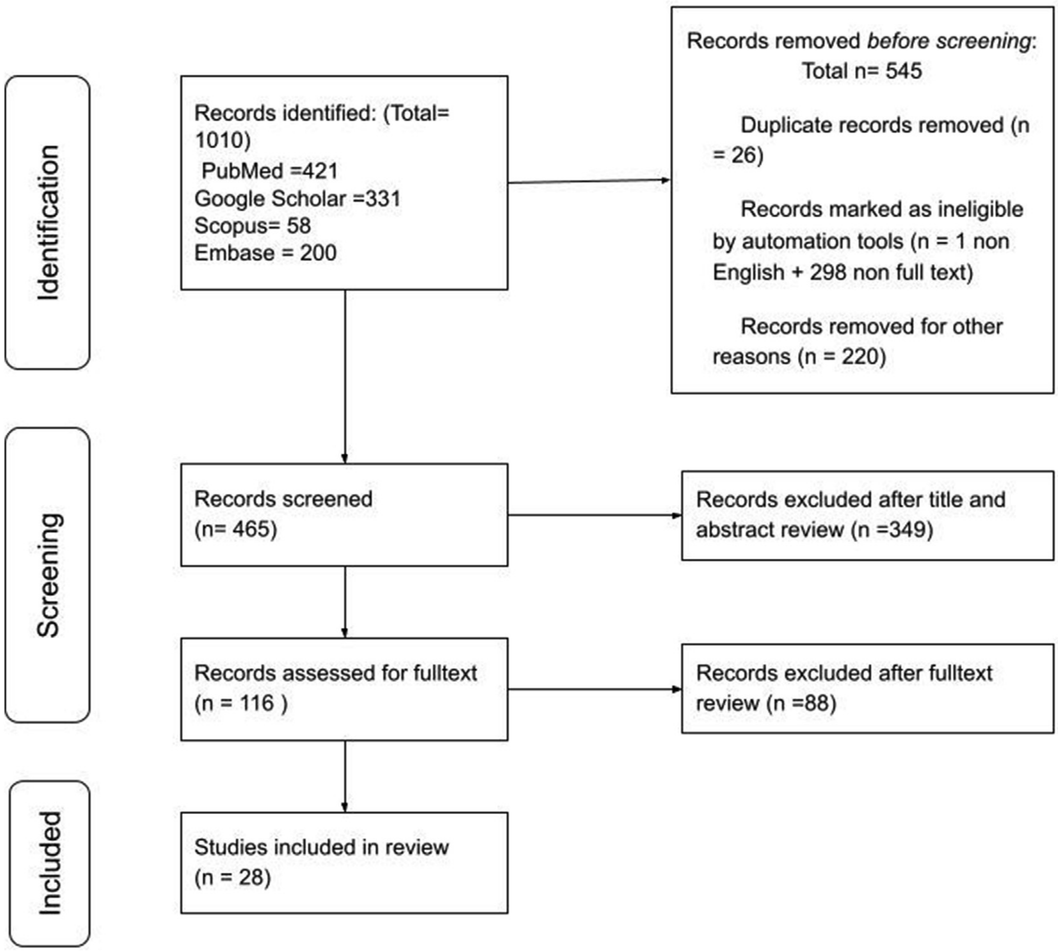

Fig. 1. PRISMA flow diagram.

Structure

A strong government structure,[17] a long-term mechanism for cooperation[18] and global or regional alliances[23] can all help to maximise the impact on sustainable development and support immunisation agendas and activities.

Infrastructure

The major personal protective equipment (PPE) shortage in healthcare facilities, particularly the lack of resources in low-income settings,[24] should be addressed by strengthening coordinated international efforts. Building human and physical capacity, strengthening regional manufacturing,[19] price adjustment, shipment, resource supplement, personal training[25] and pharmaceutical availability[26] are all long-term issues that must be addressed systematically. Partnerships can also help in the global supply and transition of affordable vaccines through different supporting programmes (e.g. Gavi/polio[23]). Long-term and sufficient financing[17,27] and the sustainability of an early warning system are also required.[28] Health systems must start "shifting their focus from reactive sick care to the proactive management of health".[29]

Leadership and governance

Planning and guidelines[29–33] are needed for good leadership and governance. Enforced rules and improved accountability are principles of good governance.[21] Also, by building capacity and establishing collaborative platforms, improvements and facilitated international coordination can be achieved.[24,27,34,35] Developing support among international organisations requires managers, coordinators and decision-makers from different international organisations to cope with international issues using well-developed technical advantages.[36] Additional examples include human solidarity[37] through electronic patient monitoring and telemedicine programmes to support colleagues around the world and provide the necessary expertise and continuing mobilisation[38] of vaccines to low- and middle-income countries (LMICs).

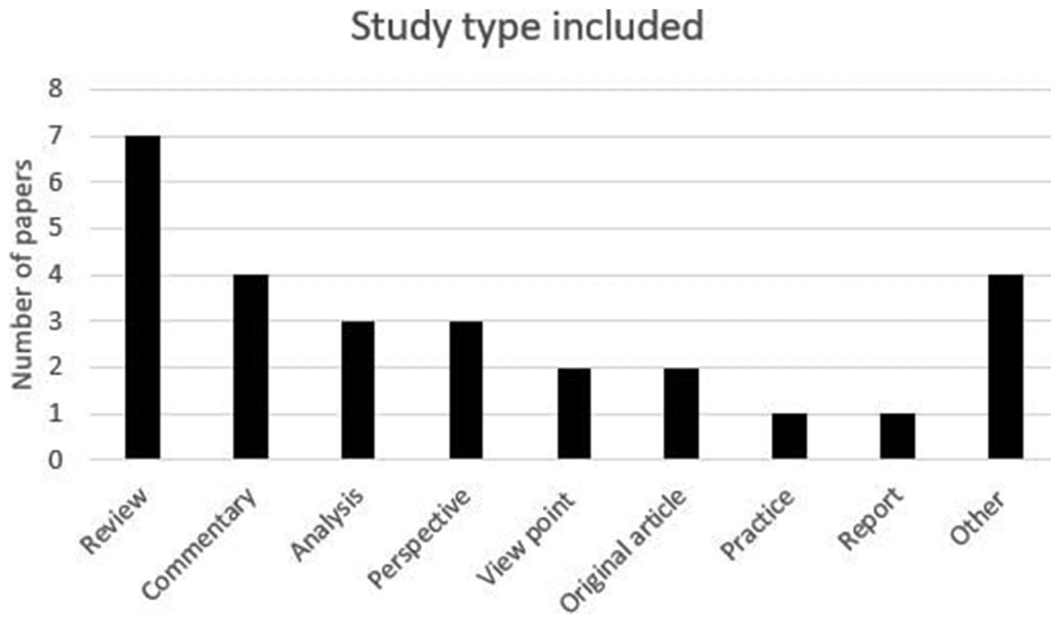

Fig. 2. Study type included in the review.

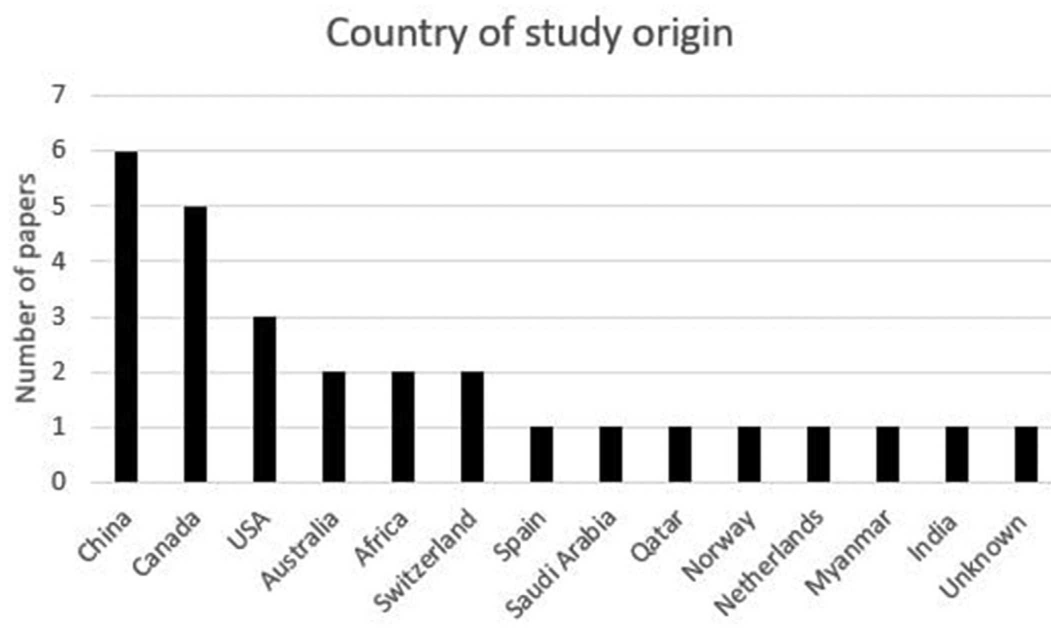

Fig. 3. Country of origin of the included studies.

However, rather than expressing a shared vision for a common future,[16] some countries are now undermining global cooperation through rising nationalism, open hostility toward multilateral institutions and a growing tendency to look after their own interests (e.g. rushing to secure supplies of potential COVID-19 vaccines), which is why global leadership and governance is required.

Knowledge and information sharing

This review underlines the vital role of the international research community, from the implementation of diagnostics and contact tracing procedures to the collective search for prevention measures.[28,39] This is achievable through worldwide collaboration and rapid dissemination of trustworthy information that is critical to mitigating harm to population health[37,40,41] and by reliable communication through the media.[24] It is also essential to facilitate international cooperation in LMICs to efficiently answer priority clinical research questions[35] and help complete trials[42] quickly to provide results that will save lives and can change the trajectory of a pandemic.

Community engagement

This study emphasises the importance of community engagement in joint prevention and control, confronting uncertainty, countering rumours effectively[34] and enhancing health literacy.

Sophisticated and sustained communication campaigns[18] and addressing populist concerns by helping states address public health threats that emerge within their borders are essential.[43]

Process/action

Multisectoral action,[18] as well as rapid development and equal distribution[16,25,27] of the vaccine supply, should be a priority. In addition, four articles emphasise the need for international collaboration to support LMICs. In these countries, building capacity[35] and continued mobilisation by the WHO and other key stakeholders in providing and distributing vaccines,[38] taking into account the shortage in healthcare facilities, and lack of financial and human resources,[24,26] is essential in the COVID-19 pandemic response.

Discussion

Most articles included in the present study were literature reviews, indicative of the holistic approach taken internationally by the 14 countries of study origin. The current review identified seven categories that influenced international collaboration in COVID-19 prevention and were included in the majority of articles. The distribution of countries covered by the selected studies was also considered. China had the greatest contribution of studies in this review, and the category that all countries reported in the most context was 'Leadership and governance'.

China published the most reviews on international collaboration in the prevention of COVID-19, primarily focussing on infrastructure and the knowledge and sharing categories. Infrastructure has been discussed in terms of shipments, resource supplements and personal training,[25] as well as in the context of the need for infrastructure for the global exchange of data.[28] Infrastructure has also been referred to in other articles in terms of the high-tech tracking systems involving smartphone applications and street camera systems.[43]

The category of knowledge and sharing in the context of China has been through the collective search for vaccines and antiviral therapies sustained by unique information sharing efforts.[28] In addition, collaborative projects between China, the WHO and other countries, including two volunteer expert teams from the Red Cross Society of China to Iran and Iraq,[41] have contributed to this knowledge sharing. Such rapid response measures undertaken by China to not only develop relevant infrastructure for the benefit of its population but also other countries through information sharing are indicative of China's stricter public health measures compared with other countries.

Canada also provided a large number of articles in this review. Similar to China, Canada's focus was mainly on the knowledge and information sharing category, with global collaboration to complete trials faster,[42] as well as data dissemination, crowdsourcing and artificial intelligence.[40] However, infrastructure was not mentioned at all in the prevention of COVID-19, indicating the focus in Canada was greater on knowledge sharing rather than the implementation of facilities and systems.

The United States was the third-largest contributor to this review, reporting primarily within the infrastructure category. The United States has also helped LMICs from a financial standpoint, supporting the COVAX programme,[33] as well as supporting Europe and other countries globally with ventilator distribution.

Leadership and governance

Leadership and governance was the most reported category influencing international collaboration by all countries, indicating the need for policies, rules and regulations in the global drive to prevent the spread of COVID-19. It is only with the help of governments that resources to fund vaccine research, either directly or by commitments developed with private funding, can we truly establish the effectiveness of COVID-19 vaccines.[33]

One article outlined key factors regarding the state of Georgia's (in the United States) governmental role that contributed to the relatively low number of COVID-19 cases and subsequent mortality rates, which included (1) an early governmental response that was also multisectoral; (2) strict adherence to International Health Regulations guidelines from the emergence of the initial epidemic; (3) monitoring, early laboratory detection and diagnosis; (4) contact tracing and forecasting; and (5) daily reports to the government and (6) raising awareness through the use of media coverage.[18] Myanmar has also been noted to have had strong political leadership to strengthen its International Health Regulations compliance.[21]

Governments need to develop risk-reduction strategies that can also be supported by educational institutions for data access and information sharing to be applied effectively.[30,35] In addition, government agencies should ensure communication with the public of relevant information on risk assessment and measures being taken to combat COVID-19.[34] A number of recommendations have been made to policymakers and world leaders, including the need to implement a system inclusive of high-quality standardised data and advanced artificial intelligence–powered processing; adopting global data standards and terminologies for all data inputs into the system; a multistakeholder and multidisciplinary system approach; and efforts to build a multinational collaboration for shared learning experiences.[29] In contrast, one cross-sectional study showed that political and economic influences were constantly perceived as inhibitors in controlling the spread of COVID-19.[44]

Building capacity

One study reviewed the importance of building capacity and international research collaboration in light of the rapid worldwide spread of COVID-19.[35] The international collaborative platforms must be further strengthened in LMICs to enable a positive change in the trajectory of the pandemic.

There have been achievements and failures of the international research collaboration in the COVID-19 response, but the main failure is that the high-income countries are not maintaining their commitment to equity. However, a positive step comes from the 20 projects funded by the Global Effort on COVID-19 Health Research by the UK National Institute of Health Research in May 2020 for LMICs. Such initiatives that aim to balance access to research funds between high- and low-income countries are required. Funding is an important issue in LMICs, the solution to which could be the creation of multilateral funding organisations, such as the Global Research Collaboration for Infectious Disease Preparedness (GLoPID-R) that funds research on new or re-emerging infectious diseases globally.

Shortage in healthcare facilities – financial and human resources

The impact of the lack of basic resources has been discussed,[26] and weak health systems with poor communication channels have been shown to have reduced chances of successfully combating COVID-19. Even developed countries with strong and well-established healthcare systems have experienced problems in treating and diagnosing COVID-19; this situation becomes worse in counties with weak healthcare systems.

Epidemics and pandemics with highly infectious viruses undermine a health system's ability to provide adequate health care when it is needed the most. A recently conducted multinational survey involving 63 countries showed that low-income countries reported a higher shortage of PPE kits than high-income countries. There was also a lack of guidelines and concerns over insufficient PPE supplies in both high- and low-income countries. The findings of this study alerted national health authorities to increase the implementation of infection prevention and control measures and focus on long-term preparedness.[24]

Knowledge and information sharing

Knowledge and information sharing are vital for the international research community working on the various aspects of COVID-19, such as the implementation of diagnostics, contact tracing procedures, vaccines and antiviral therapies. To promote international data sharing, many journals and publishers have made all relevant peer-reviewed research open access, allowing quicker access to relevant information.[28]

Connectivity and knowledge sharing are key components of research preparedness for pandemics. The WHO is responsible for coordinating global research efforts during the current COVID-19 pandemic. Other pre-existing consortia of trusted partners can immediately coordinate the formation of focus groups and the sharing resources. Some of these, such as the Platform for European Preparedness Against Re-emerging Epidemics, specifically train research preparedness concepts to the next generation of scientists. This novel virus has revealed our strengths and weaknesses, which we need to address to prepare for future responses.[39]

By mid-February 2020, the WHO had recognised that the COVID-19 outbreak was accompanied by an info-demic, of which only some parts were accurate. The WHO created a framework to manage this info-demic and, based on online crowdsourced technical consultations, also helped collect and analyse data, manage contact tracing and produce PPE by sharing open designs for 3D printing. A ventilator was also designed based on an open source design.[40] To overpower COVID-19, action must be taken as a global community with no borders.[37,41]

Limitations

Although multiple structured searches were conducted to include the most relevant and recent literature, as the studies included were hand searched, human error is possible. In addition, because of the length of time taken to complete the review, new studies may have been published on the topic that have not been included in this scoping review. More comprehensive reviews in the future, inclusive of systematic reviews or meta-analyses, are therefore warranted.

Conclusion

International efforts against COVID-19 and, thereby, future pandemic prevention, are dependent on various dimensions. In this review, political, structure, infrastructure, leadership and governance, knowledge and information sharing, community engagement and process/action were identified as the main factors essential to building this international collaboration. Leadership and governance was identified as the most prominently reported factor, with knowledge and information sharing seen as equally important in assisting countries in avoiding repeated mistakes and in learning from each other's success. Moreover, controlling COVID-19 on a global scale is more likely to be achieved by countries with sufficient structural resources, as well as appropriate communication between countries, health systems and communities. International collaboration can also greatly benefit LMIC countries, where the necessary resources and expertise are often limited. Thus, only with awareness and knowledge of these factors can pandemics be managed and equity around the world be achievable.

Author statements

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Author contributions

M.N. conceptualised this scoping review. M.N. and S.D. searched across databases and selected relevant documents for this scoping review. M.N. and S.C. analysed and summarised selected documents. All authors were involved in the writing and final review of the manuscript.

Data availability

The authors declare that data supporting the findings of this study are available within the article.

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Short Communication

Simple approximation of sample size for precise estimates of SARS-CoV-2 infection from point-seroprevalence studies

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ABSTRACT

Objective: This study aimed to model the precision of SARS-CoV-2 seroprevalence estimates.
Methods: Sample size and precision estimates were calculated using the normal approximation to the binomial distribution. The relationship between sample size and precision was visualized across a range of assumed SARS-CoV-2 seroprevalence from 2% to 75%.
Results: The calculation found that 2% precision was attainable by taking moderately sized sample sets when the expected seroprevalence of SARS-CoV-2 infection exceeds 2%. In populations with a low incidence of SARS-CoV-2 infection and an expected seroprevalence of less than 2%, larger samples are required for precise estimates.
Conclusions: Taking a sample of 177–1000 participants can provide precise prevalence estimates of SARS-CoV-2 infection in vaccinated and unvaccinated populations. Larger sample sizes are only necessary in low prevalence settings.

Surveillance of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections has evolved throughout the COVID-19 pandemic but remains a critical public health tool to estimate risk and inform containment, mitigation, and treatment strategies.[1] In the first year of the pandemic, many countries used nucleic acid amplification tests for routine surveillance of SARS-CoV-2 infection counts in their populations.[2] Overtime, the use of molecular tests was scaled down in many jurisdictions due to a combination of factors, including cost, patient hesitancy, and availability of take-home rapid antigen tests. In the second year of the pandemic, surveillance programs transitioned to using serological testing and novel methods such as environmental sampling of wastewater to estimate SARS-CoV-2 infection rates.[3] Going forward, the use of serological testing for surveillance is likely to increase, as it can be used to estimate SARS-CoV-2 point-prevalence and measure antibody responses post COVID-19 vaccination and fluctuations in anti-SARS-CoV-2 antibody levels over time.[4]

In response to the increased need to design and implement SARS-CoV-2 serosurveillance studies, we provide a simple approximation of the sample size required for precise estimates.

Accurately estimating the point prevalence of a disease in a population requires a precision-based sample size calculation. The precision of an estimate refers to half the width of the desired confidence interval (CI).[5] For example, if the CI equals five units, then the precision would equal two and a half units. Calculating the desired precision in the design stage of the study has several benefits, as it requires that the investigators think about the width of the CI and whether it exceeds the expected prevalence value. For example, if a disease has an expected prevalence of 3%, then a study with a CI of 10% lacks sufficient precision to observe the true prevalence in the population of interest: Prevalence = 3%, 95% CI: −2% to 8%, the CI includes zero. Therefore, precision should be derived from the expected prevalence estimate, and studies should not be conducted before making a precision-based sample size calculation.

The simplest (frequentist) methods to perform a precision-based sample size calculation assume that the test being used to classify disease or evidence of infection possesses perfect sensitivity and specificity. This assumption is not impractical, as many studies use a test with high diagnostic accuracy, reporting 95% CIs accommodates for error and corrections for instrument bias can be made postestimation by the Rogan-Gladen method.[6] Biological confounders of test results should also be taken into consideration,

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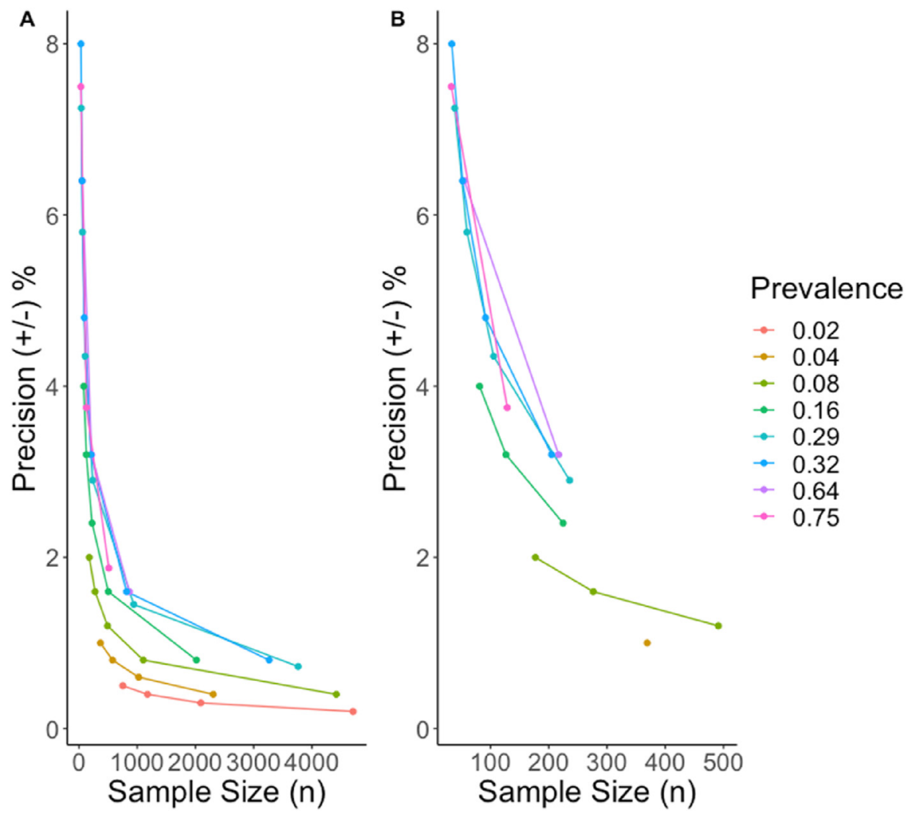

Fig. 1. Calculated estimates of precision by sample size assuming varying prevalence. (A) X-axis is scaled from 0 to 5000; (B) X-axis is scaled from 0 to 500.

for example, interpretation of serological test results should always be done in reference to the time of infection and disease severity, as antibodies wane overtime and those with mild symptoms may have a less robust serological response. We used a sample size formula derived from the normal approximation of the binomial distribution to estimate the required sample size for precise SARS-CoV-2 serological surveys.[7] Notation of formula to estimate precision is as follows:

$$n = \frac{(z^2 * N * p * (1-p))}{(N-1) * \left(h^2 * p^2\right) + z^2 * p * (1-p)}$$

where n is the sample size, N represents population size*, p represents prevalence, h represents precision, and z is Z-score[†]. A population* of one million and Z-score[†] of 1.96 was specified.

We used the above formula to calculate the necessary sample size to achieve precise estimates across a range of expected SARS-CoV-2 prevalence from 2% to 75% (Fig. 1; Table S1).

The precision curve (Fig. 1) shows that sample sizes ranging from 177 to 1000 possess adequate precision even when the expected prevalence equals 2% (Fig. 1, Table S1). In the fall of 2021, during the fourth epidemiological phase of the COVID-19 pandemic, high seroprevalence estimates were observed in unvaccinated persons living in South Africa, anti-spike 68.4% (95% CI, 67.2–69.6%), and antinucleocapsid 39.7% (95% CI, 38.4–41.0%).[8] In the United States, similar trends were reported with anti-nucleocapsid seroprevalence increasing from 2021 to 2022 from 33.5% (95% CI, 33.1–34.0%) to 57.7% (95% CI, 57.1–58.3%).[9] Assuming that, early 2022 seroprevalence rates exceed approximately 30%, a sample of 817 provides an estimate with <2% precision (Table S1). In health-based research, a precision of 2–5% is recommended for most applications, we recommend that the investigator select the appropriate precision on a case-to-case basis.[10] Of note, if a serosurvey is planning to use multiple antigenic targets in its study design, the estimated sample size for high precision results should be calculated using the assay target that is expected to yield lower seroprevalence estimates (e.g. such as the antinucleocapsid antibodies in the case of SARS-CoV-2, that are known to wane over time).[11]

Investigators should consider the precision afforded by their sample size in the design phase of a SARS-CoV-2 seroprevalence study (or any other pathogen of interest), samples size greater than 1000 are only necessary in low prevalence settings. In a high prevalence but low incidence environment, a smaller sample size can be used to estimate the number of people infected but may not reliably measure changes overtime. We recommend taking several randomly selected stratified samples overtime to reduce bias and observe longitudinal trends.

Author statements

Ethical approval

No ethical approval was sought for the study, as it does not involve the recruitment of participants, data collection, or measurement of an intervention. The analysis describes calculations, which does not rely on observational or experimental data of any kind.

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Competing interests

The authors have no conflicts of interest to declare.

Author contributions

A.M.N., I.S., and A.N.J. conceived and designed the study. Data analysis was performed by A.M.N. A.M.N., I.S., and A.N.J. responded to the peer review. All authors interpreted the data, contributed to writing and editing the manuscript, and provided their approval for publication.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.08.008.

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Short Communication

Trajectories of loneliness, depressive symptoms, and anxiety symptoms during the COVID-19 pandemic in Austria

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ABSTRACT

Objective: There is considerable heterogeneity within populations regarding the effects of the COVID-19 pandemic on mental health. This study aimed at identifying latent groups of individuals within the older Austrian population that differ in their mental health trajectories across three phases of the pandemic.
Study design: Data were gathered from a longitudinal survey study among a sample of older adults in Austria. The survey was carried out in May 2020 ($N_1 = 556$), March 2021 ($N_2 = 462$), and December 2021 ($N_3 = 370$) via either computer-assisted web or telephone interviewing.
Methods: Latent class growth analysis was conducted to explore different homogenous groups in terms of non-linear trajectories of loneliness, depressive symptoms, and anxiety symptoms as well as potential correlates thereof.
Results: We identified four latent classes. The vast majority of individuals belong to two classes that are either resilient (71%) or that have recovered relatively quickly from an initial COVID-19 shock (10.2%). Deterioration in mental health after the first phase of the pandemic (13.4%) or a generally high mental health burden (5.4%) characterizes the other two classes.
Conclusions: About 19% of individuals showed increasing or elevated levels in loneliness, depressive symptoms, and anxiety symptoms across the COVID-19 pandemic. The feeling of being socially supported and in control over one's own life emerged as potentially protective factors.

Introduction

With the onset of the COVID-19 pandemic in late 2019, people's lives changed considerably nearly all over the world. Next to the perceived and real health threat from COVID-19, individuals have faced challenges, such as social disconnectedness, lifestyle changes, or financial losses, all of which may have negatively affected mental health and well-being.[1] A meta-analysis comparing mental health before and during the pandemic however suggested that deterioration was small and that populations adapted quite well to the new situation.[2] This finding may be due to the fact that most studies focus on mean changes and disregarded potential heterogeneity within populations. Ahrens et al.,[3] for instance, identified three subgroups of German adults that considerably differed in their mental health responses to the first lockdown phase, with most individuals being resilient and two smaller groups showing symptoms either in the first or later weeks. Yet, longitudinal studies that explore interindividual differences in mental health trajectories across the COVID-19 pandemic are still rare.[4]

This study thus aimed at identifying latent groups of individuals within the older Austrian population that differ in their trajectories in terms of loneliness, depressive symptoms, and anxiety symptoms across three measurement occasions during the COVID-19 pandemic. Moreover, we explored protective and risk factors for latent group membership.

Methods

Data and sample

We gathered data from three waves of a COVID-19 panel survey among the Austrian population of older adults aged ≥60 years.[5] The data were collected in May 2020, March 2021, and December 2021 (supplemental materials A) via either computer-assisted web or telephone interviewing. Participant selection was based on a

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random sampling procedure from an online and offline participant pool for the web interviews and on a randomized last digit procedure for the telephone interviews. After excluding one participant (who did not provide any data for the main variables of interest), the sample size at baseline was $N_1 = 556$ individuals, of which $N_2 = 462$ (83%) and $N_3 = 370$ (67%) individuals also participated in waves 2 and 3, respectively.

Measures

At each wave, feelings of loneliness were measured with the UCLA three-item loneliness scale,[6] and symptoms of depression and anxiety were assessed with the Brief Symptom Inventory[7] (supplemental tables B.1.–B.2.). As regards loneliness, older adults had to indicate on a four-point scale ranging from “0 = never” to “3 = often” how often they felt (1) “a lack of companionship,” (2) “left out,” or (3) “isolated.” To measure depressive and anxiety symptoms, older adults had to indicate on a 5-point scale, ranging from “0 = not at all” to “4 = very strongly” how much they suffered from six depressive (e.g. “feeling no interest in things”) and six anxiety (e.g. “feeling fearful”) symptoms within the last 2 weeks. We summed up the respective item scores to obtain total scale scores for loneliness (range: 0–9) and for depressive and anxiety symptoms (range: 0–24).

The predictor variables of latent group membership (supplemental materials B. and D.) were based on a single item on the perceived threat from COVID-19 (no threat/threat), a self-constructed COVID-19–related social restrictions scale, an external locus of control subscale, the Oslo social support scale, age (years), sex (male/female), educational level (low/high), financial poverty risk (yes/no), living status (alone/not alone), and self-perceived health ([very] bad or fair/[very] good).

Statistical analysis

We performed latent class growth analysis using Mplus version 8.4.[11] Non-linear growth curves were estimated for loneliness, depressive symptoms, and anxiety symptoms. Non-linearity was specified by fixing the slope factor loadings of the first and second waves to 0 and 1, respectively, while freely estimating the slope factor loadings of the third wave. We estimated models with up to six latent classes and decided on the number of classes based on both statistical and substantive grounds. To examine the relationship between latent class membership and the predictor variables, we used the three-step approach.[8] After the latent class growth analysis (step 1) and classifying cases into the most likely latent class (step 2), the variable created in step 2 was regressed on the predictor variables while accounting for the uncertainty in latent class assignment (step 3).

Results

At baseline, participants were aged between 60 and 89 years (mean = 70.0 years, standard deviation = 6.6), and 53% of participants were female (supplemental Table A.7).

We found the 4-class solution to provide the best trade-off between model fit and interpretability (supplemental material D.2.). Fig. 1 shows the latent trajectories for loneliness and for depressive and anxiety symptoms based on the estimated means for each class. Most older adults (71.0%) belong to the resilient class, which shows generally low levels for each of the three constructs. The second largest class (13.4%)—the increasing burden class—is characterized by an increase in depressive and anxiety symptoms from wave 1 to wave 2, which remains elevated in wave 3. Loneliness, in turn, is stable on a relatively high level. The third class (10.2%) is called the recovered class and shows decreasing levels in depressive and anxiety symptoms from wave 1 to wave 2, and no significant change thereafter. Loneliness is stable on a low to mediocre level. The smallest class (5.4%)—the high burden class—does not show considerable changes across waves, but the estimates for all three constructs are on a generally high level.

Greater perceived COVID-19–related social restrictions at wave 1 were related to a higher chance of belonging to the increasing burden class than to the resilient class. Higher levels of an external locus of control went along with a higher chance of belonging to the recovered and the high burden classes than to the resilient class. More perceived social support was related to a lower chance of belonging to the increasing and the high burden classes. Increasing age went along with a lower chance of belonging to the increasing burden (vs the resilient) class. Interestingly, poverty risk (vs no poverty risk) was related to a lower chance of belonging to the recovered class than to the resilient class. (Very) bad or fair (vs [very] good) self-perceived health was associated with a lower chance of belonging to the resilient class than to the other three classes (supplemental Table A.9).

Discussion

In this study, we identified four latent groups of mental health trajectories in terms of loneliness and of depressive and anxiety symptoms during the COVID-19 pandemic in Austria. Most older adults seemed to be resilient against the pandemic-related burden across the entire period of observation. A second smaller group showed elevated levels of mental strain only in the initial phase of the pandemic but appear to have recovered later on. The remaining two groups can be considered the two risk groups, with a combined population share of about 19%. One of these groups showed a considerable increase in depressive and anxiety symptoms from spring 2020 to spring 2021. Given the relatively high level of loneliness and the fact that more perceived COVID-19–related social restrictions and a lack of social support were associated with a higher chance of belonging to this group, it is likely that individuals within this group may be particularly at risk to suffer from the social effects of the pandemic.[5] The other risk group, in turn, demonstrated generally high levels in all three constructs across the entire period, with poor self-perceived health, high external locus of control, and low social support as important predictors of belonging to this group. Because prepandemic levels of mental health are lacking and because the perceived threat from COVID-19 as well as the experienced COVID-19–related social restrictions did not predict membership to this high burden group, the direct impact of the pandemic however remains unclear. Nevertheless, the two risk groups require special attention to prevent and tackle long-term suffering. Future interventions may focus on strengthening both social and psychological resources[3] because we found the feeling of being socially supported and of being in control over one's own life to be protective factors in this context.

Despite considerable differences in study design and data, our findings are comparable to those of previous studies.[3,4,9,10] These studies also found the vast majority of individuals to be either resilient or to have recovered relatively quickly from the initial COVID-19 shock. But, there are also smaller vulnerable groups that show elevated levels of mental health burden. As our and other studies[10] found a similar pattern of mental health trajectories in the specific subgroup of older adults as was revealed in other samples spanning the entire range of adulthood,[3,4,9] it seems that the

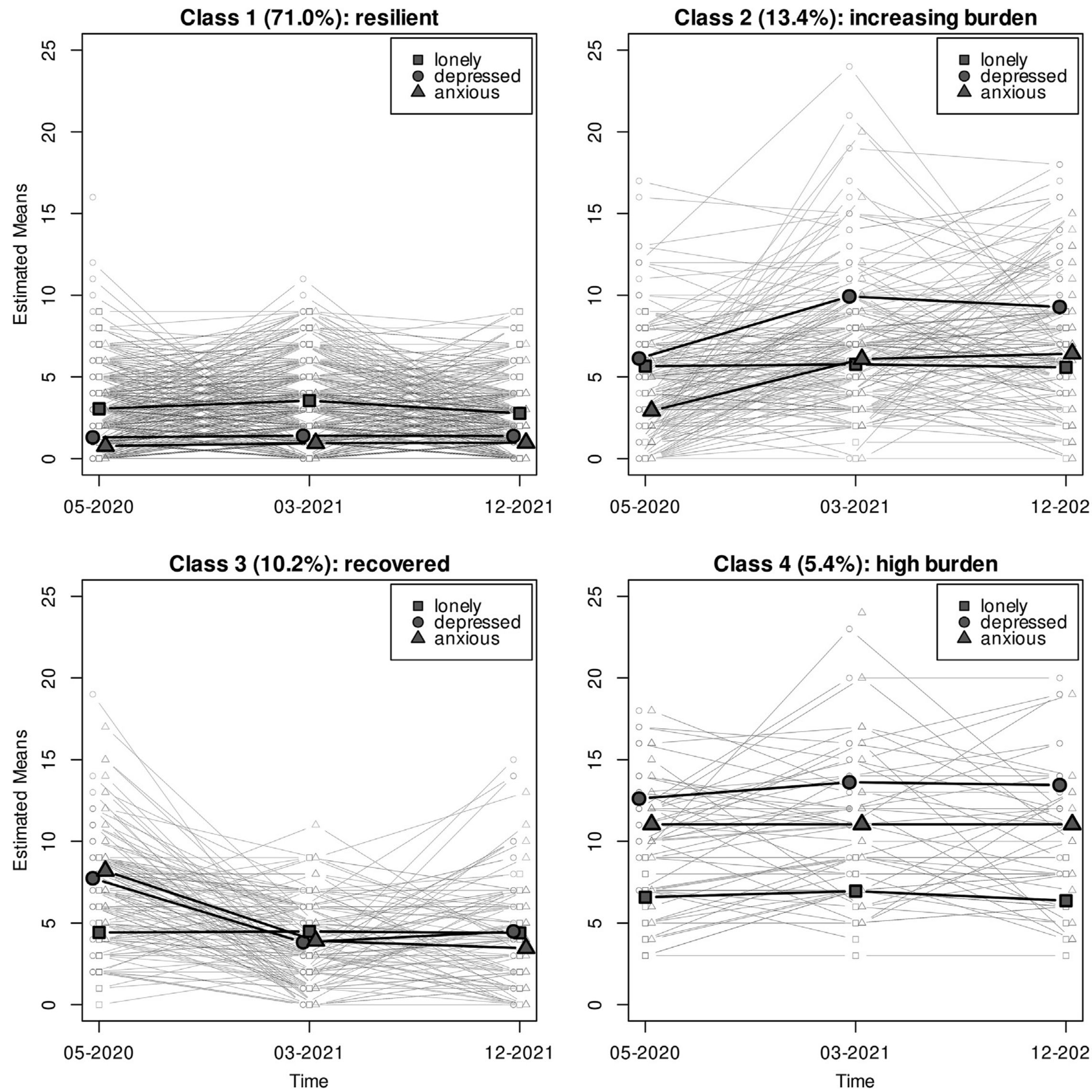

Fig. 1. The black trajectories show the estimated means of the loneliness, the depressive symptoms, and the anxiety symptoms scale scores for each of the four latent classes. The gray trajectories in the background illustrate the repeated observations for each individual after latent class assignment. The symbols are slightly shifted along the x-axis for better visibility.

pattern of mental health responses to the pandemic is quite comparable across age. Although older groups were initially expected to be at high risk for experiencing the negative effects of the pandemic, we even found older age to go along with a higher chance of belonging to the resilient group than to the other groups. However, the effect was rather small and statistically significant only for the increasing burden group.

Future research is encouraged to further monitor the long-term and prolonged effects of the pandemic on mental health of the identified risk groups and to explore strategies and interventions for specific public health measures.

Author statements

Ethical approval

The study was approved by the Ethics Committee of an Austrian University (32-368 ex 19/20; 33-226 ex 20/21).

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Competing interests

None declared.

Data availability

The survey data are available on request. Data will be also made available for scientific use via the Austrian Social Science Data Archive.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.08.004.

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Short Communication

Trends in negative emotions throughout the COVID-19 pandemic in the United States

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ABSTRACT

Objectives: This study aimed to identify trends in the prevalence of negative emotions in the United States throughout the COVID-19 pandemic between March 2020 and November 2021.
Study design: This was a descriptive, repeated cross-sectional analysis of nationally representative survey data.
Methods: Data originated from Gallup's COVID-19 web survey, encompassing 156,684 observations. Prevalence estimates for self-reported prior-day experience of sadness, worry, stress, anger, loneliness, depression, and anxiety were computed, plotted using descriptive trend graphs, and compared with 2019 estimates from the Gallup World Poll. Differences between estimates were evaluated by inspecting confidence intervals.
Results: Stress and worry were the most commonly experienced negative emotions between March 2020 and November 2021; worry and anger were significantly more prevalent than prepandemic. The prevalence of sadness, worry, stress, and anger fluctuated considerably over time and declined steadily to prepandemic levels by mid-2021. Distinctive spikes in the prevalence of several negative emotions, especially sadness and anger, were observed following the murder of George Floyd.
Conclusions: Several negative emotions exhibited excess prevalence during the pandemic, especially in spring/summer 2020. Despite recent reductions to prepandemic levels, continued monitoring is necessary to inform policies and interventions to promote population well-being.

Introduction

Since the beginning of the COVID-19 pandemic, the United States has experienced numerous challenges, including approximately 1 million deaths due to COVID-19 (as of early 2022), stark social and racial disparities in mortality from COVID-19, historically high levels of unemployment, a rise in hate-related events directed at Asian Americans, and ongoing incidents of police brutality against African Americans. Studies have detected a substantially elevated burden of depressive, anxiety, and other symptoms of psychological distress compared with prepandemic data, suggesting that the events of the prior 2 years have had a considerable impact on public mental health.[1–4] According to the US Census Bureau Household Pulse Survey (HPS), the prevalence of current probable anxiety or depressive disorder was 36% in August 2020 and 42% in January 2021, compared with prepandemic (2019) estimates based on the National Health Interview Survey of 11%;[5] in early 2022, the estimated prevalence remained elevated at 31.5%.[6] This study adds a fine-grained analysis of trends in the experience of various negative emotions among US adults between March 2020 and November 2021, based on nationally representative, repeated cross-sectional data. Elucidating temporal dimensions of how this disaster has been experienced emotionally over time complements our understanding of the pandemic's effect on public mental health.

Methods

Respondent data originated from Gallup's COVID-19 web survey, which used a probability-based, nationally representative panel of approximately 80,000 US adults residing in all 50 states and the District of Columbia,[7] with data collection starting March 13, 2020.

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A simple random sample of approximately 1200 panel members was interviewed daily until April 26, 2020; subsequently, about 500 individuals were interviewed each day between April 27, 2020, and August 17, 2020, and approximately 3000 individuals per month thereafter. Starting on March 23, 2020, respondents were asked if they had experienced each of the following negative emotions during "a lot of the prior day" (yes/no): sadness, worry, stress, anger, and loneliness; between May 11, 2020, and August 22, 2021, respondents were also asked about the experience of "depression" and "anxiety." This analysis was based on 156,684 observations collected from 54,530 participants between March 23, 2020, and November 24, 2021. Because this study involved secondary analyses of deidentified data, it did not qualify as Human Subjects Research, and no ethical review was required.

Given the varying frequency of data collection and the reinvitation of panel members to participate in the Gallup COVID-19 web survey, data were analyzed in 36 intervals covering between 4 and 20 (median: 7) days of data collection and including between 2714 and 9353 (median: 3765) respondents. As respondents were not allowed to take the survey more than once every 2 weeks, these data could be analyzed as repeated cross-sectional. For each of the 7 negative emotions, the median, minimum, and maximum prevalence between March 23, 2020, and November 24, 2021 (depression and anxiety: between May 11, 2020, and August 22, 2021) were computed, along with 95% confidence intervals (CIs). For comparison, nationally representative prepandemic data were retrieved from the Gallup World Poll, encompassing data from 1026 US respondents interviewed in April 2019. In addition, descriptive trend graphs were created to plot the US-wide prevalence of each of the seven emotions throughout the COVID-19 pandemic, along with 95% CIs and, for sadness, worry, stress, and anger, prepandemic estimates. Differences between estimates were evaluated by inspecting CIs.

Results

Median, minimum, and maximum prevalence estimates are presented in Table 1. Throughout the period covered by this analysis, stress (52.0%) and worry (46.6%) were the most commonly reported emotions, followed by anxiety (38.7%), sadness (27.6%), anger (23.9%), loneliness (21.9%), and depression (19.9%). The prevalence of sadness, worry, stress, and anger varied considerably across the study period, with lowest prevalence estimates obtained for June and July 2021 and highest estimates for the data collection intervals starting in late March or early June 2020. Loneliness, depression, and anxiety peaked slightly later, in late July and mid-August 2020, respectively. Compared with 2019, the point estimates for the prevalence of worry and anger were significantly higher (by 11.3 and 9.1 percentage points, respectively).

Trends in the prevalence of these emotions, along with the prepandemic prevalence of sadness, worry, stress, and anger based on data from April 2019, are shown in Supplemental Figures 1 to 7. These figures reveal elevated prevalence of sadness, worry, stress, and anger in spring 2020 compared with prepandemic measures. After mid-2020, sadness and stress were either similarly or significantly less prevalent than prepandemic; anger and worry had reached prepandemic levels by early or mid-2021, respectively, with elevated levels once again being observed in early fall 2021. For loneliness, depression, and anxiety, for which no prepandemic data were available, no clear trajectory could be observed. Moreover, the trend graphs show distinct spikes in the prevalence of several of these emotions in summer 2020, which were most pronounced for sadness and anger during the data collection period June 1–7, 2020.

Discussion

These results suggest a substantially elevated prevalence of several negative emotions during the COVID-19 pandemic in the United States, particularly during the first two waves in spring and summer 2020. There were also noticeable spikes in the prevalence of sadness and anger specifically that coincide with protests across the country in response to the May 25, 2020, murder of George Floyd. By mid-2021, the prevalence of negative emotions for which prepandemic data were available (sadness, worry, stress, anger) had declined to levels of 2019 or below, which may be due to psychological adaptation to the pandemic;[2] however, a renewed uptick was observed in the second half of 2021, which may have been driven by concern about the rising delta variant.

These results largely correspond to those from prior studies that highlight elevated psychological distress in the early pandemic period,[1–4,8] sadness as a relatively common emotional response to disaster,[9] and a fairly rapid return to prepandemic levels of emotional well-being over time.[3] The fact that stress, worry, and anxiety emerged as the most commonly reported negative emotions, particularly in the early pandemic period, may be a result of increased experience of daily stressors such as job loss, caregiving responsibilities, and financial strain.[10] At the same time, the

Table 1
Prevalence estimates for seven negative emotions in the United States, March 23, 2020, to November 24, 2021[a].

Emotion	Median, Prev (%) [95% CI]	Minimum, Prev (%) [95% CI] {Date}[b]	Maximum, Prev (%) [95% CI] {Date}[b]	April 2019, Prev (%) [95% CI]
Sadness	27.6 [26.1; 29.1]	20.8 [18.9; 22.6] {July 19, 2021}	38.1 [34.9; 41.3] {June 1, 2020}	23.1 [19.7; 26.8]
Worry	46.6 [44.7; 48.6]	37.6 [35.8; 39.4] {June 14, 2021}	59.7 [57.6; 61.8] {Mar 30, 2020}	35.3 [31.5; 39.3]
Stress	52.0 [49.5; 54.5]	42.6 [40.4; 44.9] {July 19, 2021}	60.2 [58.2; 62.3] {Mar 30, 2020}	50.5 [46.5; 54.4]
Anger	23.9 [22.0; 25.7]	15.4 [14.0; 16.8] {June 14, 2021}	38.4 [35.2; 41.6] {June 1, 2020}	14.8 [12.0; 18.1]
Loneliness	21.9 [20.7; 23.1]	16.6 [15.1; 18.2] {July 19, 2021}	27.4 [24.2; 30.3] {Aug 10, 2020}	N/A
Depression	19.9 [18.9; 20.9]	16.8 [14.3; 19.3] {June 29, 2020}	24.5 [21.6; 27.4] {Aug 10, 2020}	N/A
Anxiety	38.7 [37.3; 40.1]	34.4 [32.6; 36.2] {July 19, 2021}	44.3 [40.6; 48.0] {July 20, 2020}	N/A

CI, confidence interval; N/A, not available; Prev, prevalence.
[a] Depression and anxiety: May 11, 2020, to August 22, 2021.
[b] Beginning of data collection interval (daily and aggregated by week until Aug 16, 2020; monthly from August 17, 2020).

increase in sadness and anger may reflect feelings of loss and emotional processing of the pandemic's immediate impact on almost every facet of daily life.[11] The findings of this study also mirror previously reported evidence of elevated sadness and anger (also using Gallup data) and probable depression or anxiety disorder (using HPS data) in the period directly following George Floyd's murder.[12] Unfortunately, disaggregation by sociodemographic characteristics such as race/ethnicity was precluded in this analysis by the limited sample size; other limitations included the use of binary self-report items that are not psychometrically validated.

In sum, there is evidence to suggest that the COVID-19 pandemic and associated social and economic challenges in the United States have manifested in measurably elevated levels of negative emotions, although their prevalence appears to have abated to pre-pandemic levels by late 2021. While the temporary experience of negative emotions does not necessarily indicate poor mental health or clinical need, the persistently high prevalence of depressive or anxiety symptoms in the HPS suggests ongoing challenges to public mental health, which calls for continued monitoring and should inform policies and interventions to promote population well-being and resilience.

Author statements

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Ethical approval

This research did not qualify as Human Subjects Research as per the US regulations for the protection of human subjects in research, thus no ethics approval was required.

Competing interests

The authors have no competing interests to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.08.009.

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