Adherence to mask wearing and social distancing following vaccination and use of lateral flow testing during the COVID-19 pandemic in England and Wales: Results from a cross-sectional study nested within the prospective Virus Watch household community cohort study

Vivi Antonopoulou
v.antonopoulou@ucl.ac.uk
University College London
Madeline Ong
University College London
Carly Meyer
University College London
Sarah Beale
University College London
Fabiana Lorencatto
University College London
Susan Michie
University College London
Robert W. Aldridge
University College London
Andrew Hayward
University College London

Research Article

Keywords: personal protective behaviours, public health interventions, pandemic, rapid lateral flow tests, lateral flow device (LFD), behavioural science

Posted Date: January 29th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-3875563/v1

Additional Declarations: No competing interests reported.

Abstract

Background

Personal protective behaviours (PPBs) played a crucial role in limiting the spread of infection during the COVID-19 pandemic, yet adherence to these behaviours varied at population level. Understanding the factors influencing adherence to protective behaviours is important, as PPBs will be a critical part of the response in future pandemics. Using behavioural science, we investigated the influences on adherence to PPBs, focusing on face mask wearing, social distancing, and lateral flow testing (LFT).

Methods

Two online surveys, the first gathering data on mask wearing and social distancing, and the second on lateral flow testing, were conducted in July and August 2021 with a sample from England and Wales (N = 20,488 (survey 1) and N = 26,613 (survey 2)). The survey questions were designed based on the Capability, Opportunity, Motivation (COM-B) model of Behavior. Multivariate models were used to examine associations between identified influences and adoption of these protective behaviours.

Results Most respondents reported wearing a face mask in public indoor places (88.5%) and maintaining a 1+ metre distance (86.8%) all or most of the time. After two doses of COVID-19 vaccine, social distancing decreased with 48.3% reporting meeting friends or family and 38.3% visiting indoor places more frequently. Motivation, Opportunity and Capability factors were significantly associated with increased odds of wearing a face covering and social distancing.

Among individuals who indicated using an LFT (comprising 68% of the total sample), 50.4% reported engaging in routine testing. For those who had never used an LFT, the predominant reason cited was a perceived lack of necessity for testing (55.3%). Statistically significant associations were found between routine testing and accurate interpretation of test results across all LFT belief-based statements ($p < 0.05$).

Conclusions

Findings indicated high levels of adherence to face masks, social distancing, and lateral flow testing, even amid reduced restrictions and high vaccination rates. Utilising a behavioural science framework, factors related to capability, opportunity, and motivation were found to significantly influence the use of these protective behaviours. Our recommendations can inform public health intervention design and guide the selection of implementation strategies for public health emergencies preparedness.

Background

Throughout the COVID-19 pandemic, governments worldwide implemented various public health and social measures to control the spread of the virus, especially before the development of vaccines [1, 2]. These measures included travel bans, lockdowns (school, non-essential shop, and workplace closures), restrictions on social interactions, isolation and quarantine protocols, social distancing guidelines, mandatory mask-wearing, and cancellation of public events. In countries with testing capabilities, population-wide testing and contact tracing were also implemented [3]. However, it has been widely recognised that the introduction of such measures alone is not enough to limit disease transmission. Behaviours such as compliance with public health guidance, adherence to restrictions, and the adoption of personal protective measures (PPBs) (e.g., hand washing and use of face masks) are crucial factors for the successful prevention of infectious diseases at the population level [4–9].

Even after the development of effective vaccines [10–13], with new strains of the virus, waning immunity, and a proportion of the population remaining unvaccinated for COVID-19, PPBs continued to be valuable in managing the spread of the disease [10, 13, 14]. However, as vaccination was promoted as the most effective public health intervention to control the virus and return to normalcy, there were concerns that adherence to preventive behaviours might decline after vaccination due to a false

sense of reduced infection risk [15, 16]. Previous studies on vaccine rollouts for other diseases (e.g. Lyme disease, influenza) indicated reduced adherence [17, 18], and early evidence from COVID-19 antibody testing studies also suggested lower intention to engage in protective behaviours among individuals with antibodies [19–21]. Studies conducted during the early stages of the COVID-19 pandemic yielded mixed results with some studies suggesting a decrease in PPB use (e.g. [22–26], while others indicated a consistent use of PPBs regardless of vaccination status [15, 27].

Mask wearing and social distancing are important PPBs to mitigate COVID-19 infection, particularly as mask wearing and social distancing are the most visible and hence socially impactful [28–30]. A number of international studies examining adoption of mask wearing and social distancing during the COVID-19 pandemic indicated that PPB use can vary depending on the specific behaviour, country, and time ([31, 32]. Evidence regarding sociodemographic factors influencing mask wearing and social distancing including age [33–37], gender [34, 38–42], level of education [43], employment and income [44], ethnicity [34, 35, 39], and perceived susceptibility to the disease [43] was mixed and varied across contexts. In a similar vein, an evidence review of interventions to increase PPBs for respiratory viruses, including COVID-19, found unclear results for interventions targeting face mask use and highlighted the lack of evidence about intervention effectiveness for the majority of PPBs [45].

Self-testing using a rapid Lateral Flow Test (LFTs) (also known as rapid diagnostic test (RDT)) was also a preventative measure that contributed to the management of the COVID-19 virus and was a cost-effective alternative to Polymerase Chain Reaction (PCR) testing [46, 47]. LFTs were initially introduced as a form of asymptomatic screening and not recommended for use when symptomatic, and while this guidance later changed, LFTs were still primarily about preventing the spread of the virus by rapidly identifying those individuals who were carrying high levels of the virus so they may self-isolate, rather than for monitoring one's own health [48]. The evidence-base for the uptake of LFT is still limited, but early evidence pointed to low uptake among the public in UK-based studies, although some improvement was found over time [49–51]. Moreover, the coexistence of both PCR and LFT options for the general public led to considerable confusion regarding the appropriate test for different situations [50, 51].

As we are now transitioning out of the acute phase of the COVID-19 pandemic, we need to better understand the evidence from the COVID-19 pandemic to plan for future epidemics/pandemics, particularly as adoption of personal protective measures (PPBs) to protect oneself and others in our communities will undoubtedly be a critical part of any public health response. Using behavioural science theories and frameworks can be very helpful for guiding investigation of the factors influencing the enactment (or maintenance) of PPBs and for designing effective public health interventions [52]. An example of an integrated model of behaviour change which is widely used to conceptualise possible influences on behaviour is the COM-B model [53]. The COM-B model states that to enact a behaviour one needs to have the Capability (psychological or physical), Opportunity (social or physical) and Motivation (the reflective and automatic processes that direct behaviour) to perform the Behaviour [54]. One major benefit of the COM-B is that it is mapped to the Behaviour Change Wheel, enabling systematic progression from identifying influences to generating suggestions for interventions [53]. Therefore, we sought to identify and classify behavioural influences on mask-wearing, social distancing and lateral flow testing during the COVID-19 pandemic with a view to generate recommendations that can inform public health interventions for future epidemics and pandemics.

Aims of the current study

In this context, the present study aimed to assess a) changes to use of wearing of face masks and social distancing, following vaccination compared to baseline, and b) the factors associated with use of face masks and social distancing, and the uptake of lateral flow testing, using a behavioural science approach. Specifically, this study addressed the following research questions (RQs):

RQ1a. To what extent did participants adhere to wearing face masks and observing social distancing rules?

RQ1b. Was there a change in reported use of mask wearing and/or social distancing post-vaccination?

RQ1c. Which influences (capability, opportunity, and motivational factors) are associated with wearing of face masks post-vaccination?

RQ 1d. Which influences (capability, opportunity, and motivational factors) are associated with social distancing post-vaccination?

RQ2a. To what extent did participants use LFT and what were the reasons for using LFT?

RQ2b. Were there any differences in understanding the test result between those who routinely test and those who test opportunistically?

RQ2c. Which influences (capability, opportunity, and motivational factors) are associated with lack of (LF) testing?

Methods

Design

This is a cross-sectional study nested within the prospective Virus Watch community cohort study which comprised over 50,000 participants from households across England and Wales. The Virus Watch study was run by University College London (UCL) in conjunction with NHS and was aiming to investigate transmission of COVID-19 in relation to population movement and behaviours and to provide evidence on which public health approaches are most likely to be effective in reducing transmission of the virus [55]. Virus Watch included weekly online surveys regarding infection symptoms, COVID-19 testing, and vaccinations, as well as monthly surveys on psychosocial and clinical topics beyond the scope of the weekly surveys and tailored to the phase of the pandemic.

Data for this study were collected in two one-off surveys with households sampled from the Royal Mail post office address file and through social media advertising. Data on face mask wearing and social distancing were collected from a survey conducted in July 2021 (survey 1). Data on lateral flow testing were collected from a survey carried out in August 2021 (survey 2). In addition, survey 2 included a screening question about use of LFT and directed participants in two branches based on their responses. If they had used LFT, they were asked questions about routine and non-routine use and their understanding of the test result. If they had never taken a LFT, they were asked about the reasons for never having self-tested using a LFT along with COM-B questions. Data for both surveys were collected using REDCap electronic data capture tools hosted on University College London (UCL) Data Safe Haven.

Sample

For representativeness, the sample was stratified by age, gender, ethnicity and geographical regions across England and Wales (for more information on the Virus Watch recruitment strategy see [56]). Entire households were recruited, and the lead householder was asked to complete two online surveys.

Mask wearing and social distancing (Survey 1): Participants were included if they had received one or two doses of a COVID-19 vaccine at the point of data collection. By the time of the data collection for this study, the vaccine had been offered to all individuals in the first nine priority groups in the UK which included residents of care homes for older adults and their carers, those 50 years old and older, and clinically extremely vulnerable individuals. The UK government anticipated that by the end of July 2021, all 18–49 year-old people from the general population would have been offered a vaccine. At the time of the survey, 69,932,565 doses had been administered, with 38,890,375 individuals having received at least one dose [57].

LFT (Survey 2): We included responses from people who had and had not done LFT previously. At the time of data collection, lateral flow devices were available to everyone in England for symptomatic or for regular asymptomatic testing at no cost to the individual [58].

Materials and Measures

Survey 1

RQ1. Mask wearing and social distancing measures

a) Frequency of mask wearing and social distancing measures

b) Changes in frequency of mask wearing and social distancing

Frequency of mask wearing and social distancing was measured with the statements '*I wear a face covering in public, indoor places*' and '*I keep a 1 + metre distance from people I don't live with*'. Response options were measured on a 5-point Likert Scale and ranged from 'Never' to 'All of the time'. Changes in frequency of mask wearing and social distancing after receiving the vaccine were measured with statements such as '*Have you changed any of the following as a result of having had one/two doses of the vaccine - Visiting public indoor places (e.g., restaurant, café, cinema) with people you don't live with*'. Responses were measured on a 3-point Likert scale ('More frequently', 'No change', 'Less frequently'). (See Table S1 in the Supplementary Material file)

c) Influences on Mask wearing and social distancing measures - COM-B factors

Influences on mask wearing and social distancing behaviours were measured with agreement to statements structured around the COM-B domains, for example "*The elderly and vulnerable are protected from Covid-19 now that vaccination is available*" (reflective motivation statement). Responses were measured on a 5-point Likert scale from 'Strongly disagree' to 'Strongly agree'. (See Table S2)

Survey 2

RQ2. LFT measures

a) Frequency of testing

Participants were initially asked two screening questions to assess use of LFT. The first screening question assessed whether they had ever done a test ('Have you ever done a lateral flow test? with response options 'Yes/No/Don't know'); the second question asked about frequency of use ('Do you routinely have lateral flow tests? Response options included Yes/No/Don't know').' Based on reported frequency of LFT (regular, non-regular testing, never used), participants were directed to either answer questions related to the reported use and understanding of a test result, or to indicate the reasons for never having done a test.

b) Reasons for testing and understanding of a test result

Non-regular testing. Of those who reported having done LFT, those who reported non-regular testing were asked to indicate on which of the following occasions they did a test (option of multiple response): a) Before visiting friends or relatives, b) To get into a venue, c) When I'm feeling poorly, d) Because I have symptoms that might be Covid-19, e) Because I'm required to for work/education, f) So that I can travel, g) Because someone told me to, h) Because I've been in contact with someone I think might have Covid-19, i) Other [free text]

This group of participants was also asked questions related to their understanding of the LFT result.

Regular testing. Participants who reported regular testing were only asked questions related to their understanding of the LFT result.

Understanding of a positive/negative LFT result (for participants indicating regular as well as for participants indicating non-regular testing) was measured with agreement to statements such as *'If you get a positive result from a lateral flow test, it means: I'm infected with COVID-19'* on a 5-point Likert scale (from 'Definitely not' to 'Definitely'). (See Table S3)

c) *Influences on testing - COM-B factors*

Participants who reported never having done a LFT test were asked to indicate their level of agreement with statements citing possible reasons for never having done an LFT. These statements were structured around the COM-B model including capability, opportunity, and motivational factors, for example, '*I don't want to have to report my test result'* (reflective motivation). The response options were measured on a 5-point Likert scale ranging from 'Strongly disagree' to 'Strongly agree'. (See Table S4)

Statistical Analysis

For frequency of use, frequency responses for wearing face masks, social distancing, and lateral flow testing were analysed and reported as percentages. Logistic regression models were used to identify those COM-B factors associated with mask wearing and social distancing (maintaining a 1 + metre distance) among those fully vaccinated controlling for age, ethnic group, income, gender, and health status (assessed by having received an NHS risk letter). Subscale factors (capability, opportunity, and motivational factors) were used in the model. Cronbach's alpha for each subscale was calculated to assess the internal consistency of the sub-scales (see Table S5). Univariate associations were examined to screen for variables to include in the model ($p < 0.1$). Multicollinearity between predictor variables were checked using the Variance Inflation Factor (VIF) (see Table S6). Frequencies of reported reasons for testing and interpretations of LFT results were analysed and reported as percentages. The reasons for never having done LFT were also analysed and reported as percentages and mean scores. A chi-square test was performed to measure the differences in interpretations of LFT results among those who do and do not routinely test.

Results

Participant Characteristics

The sociodemographic characteristics of the respondents for both surveys are presented in Table 1. In survey 1 (July 2021), a total of 20,488 responses on social distancing and wearing a face mask were included in the final sample.1 In survey 2 (August 2021), a total of 26,613 responses on LFT were included in the final sample. In both surveys, 56% of participants were female and 60 years old and older. The majority of participants belonged to White ethnic groups.

Table 1
Baseline participant characteristics for survey 1 (N = 20,488) and survey 2 (N = 26,613)

	Participants (Survey 1: mask wearing and social distancing)			Participants (Survey 2: Lateral Flow Testing*)		
	Overall	After one dose	After two doses	Overall	Used an LFT	Never used LFT
Age in years	*% (n)*	*% (n)*	*% (n)*	*% (n)*	*% (n)*	*% (n)*
<30	2.5 (519)	59.3 (118)	2.0 (401)	3.6 (952)	4.4 (802)	1.8 (150)
30–39	2.4 (493)	5.0 (10)	2.4 (483)	4.1 (1084)	5.1 (931)	1.8 (153)
40–49	4.1 (848)	11.1 (22)	4.1 (826)	7.2 (1925)	8.9 (1623)	3.5 (302)
50–59	15.3 (3127)	7.0 (14)	15.3 (3113)	16.3 (4372)	18.8 (3432)	11.0 (940)
60+	75.7 (15501)	17.6 (35)	76.2 (15466)	68.9 (18431)	62.7 (11422)	81.9 (7009)
Number of people in the household	**Mean (SD)**					
	1.9 (0.6)	2.6 (1.1)	1.8 (0.6)	2.0 (0.8)	2.0 (0.9)	2.0 (0.7)
Gender at birth	**% (n)**					
Male	43.2 (8803)	48.5 (96)	43.1 (8707)	43.2 (11500)	40.9 (7393)	48.3 (4103)
Female	56.6 (11536)	51.5 (102)	56.6 (11434)	56.5 (15036)	58.9 (10666)	51.5 (4370)
Intersex	0.1 (30)	0 (0)	0.1 (30)	0.1 (34)	0.1 (26)	0.1 (8)
Prefer not to say	0.1 (16)	0 (0)	0.1 (16)	0.1 (21)	0.1 (10)	0.1 (11)
Ethnic Group	**% (n)**					
White-English/Welsh/Scottish/Northern Irish/British	91.7 (18653)	85.3 (168)	91.8 (18485)	90.0 (23887)	89.9 (16245)	90.2 (7642)
Any other white background	5 (1012)	8.6 (17)	4.9 (995)	5.5 (1474)	5.8 (1053)	5.0 (421)
Mixed/ multiple ethnic groups	0.8 (167)	1.5 (3)	0.8 (164)	1.0 (252)	1.0 (181)	0.8 (71)
Asian/Asian British background	1.7 (348)	4.0 (8)	1.9 (340)	2.4 (625)	2.1 (383)	2.8 (242)
Black British/African/Caribbean/Any other Black background	0.4 (72)	0 (0)	0.1 (72)	0.6 (167)	0.7 (115)	0.6 (52)
Any other ethnic group	0.3 (66)	0 (0)	0.4 (66)	0.4 (99)	0.4 (70)	0.4 (29)
Prefer not to say	0.1 (26)	0.5 (1)	0.1 (25)	0.1 (35)	0.1 (20)	0.2 (15)
Received an NHS risk letter	**% (n)**					
Yes	13.6 (2574)	9.0 (15)	13.6 (2559)	13.0 (3205)	12.9 (2155)	13.4 (1050)
No	86.4	91.0	86.4	87.0	87.1	86.6

*NB: Lateral Flow Testing (LFT)

	Participants (Survey 1: mask wearing and social distancing)			Participants (Survey 2: Lateral Flow Testing*)		
	Overall	After one dose	After two doses	Overall	Used an LFT	Never used LFT
Age in years	*% (n)*	*% (n)*	*% (n)*	*% (n)*	*% (n)*	*% (n)*
	(16391)	(152)	(16239)	(21428)	(14614)	(6814)
Combined Household Income	**% (n)**					
0–9,999	5.9 (1117)	9.9 (18)	5.8 (1099)	5.4 (1331)	5.1 (863)	5.9 (468)
10,000–24,999	28.2 (5362)	15.9 (29)	28.3 (5333)	26.5 (6552)	24.9 (4187)	29.8 (2365)
25,000–49,999	37.3 (7076)	33.5 (61)	37.3 (7015)	35.7 (8826)	34.4 (5782)	38.3 (3044)
50,000–74,999	12.7 (2421)	18.7 (34)	12.7 (2387)	14.3 (3537)	15.4 (2590)	11.9 (947)
75,000–99,999	5.0 (942)	8.2 (15)	4.9 (927)	5.9 (1470)	6.7 (1134)	4.2 (336)
100,000-124,999	2.3 (440)	3.3 (6)	2.3 (434)	3.1 (762)	3.6 (601)	2.0 (161)
125,000-149,999	0.6 (122)	4.4 (8)	0.6 (114)	0.9 (234)	1.2 (196)	0.5 (38)
150,000-174,999	0.5 (99)	0.5 (1)	0.5 (98)	0.7 (173)	0.9 (145)	0.4 (28)
175,000-199,999	0.3 (60)	0.5 (1)	0.3 (59)	0.4 (93)	0.5 (78)	0.2 (15)
200,000 or more	0.5 (91)	1.6 (3)	0.5 (88)	0.8 (192)	1.0 (167)	0.3 (25)
Prefer not to say	6.7 (1264)	3.3 (6)	6.7 (1258)	6.4 (1582)	6.4 (1068)	6.5 (514)
*NB: Lateral Flow Testing (LFT)						

Survey 1

RQ1a. Frequency of mask wearing and social distancing

Of 20,488 participants who received one or two doses of the COVID-19 vaccine, 99% (20289) completed two doses. The majority of the respondents reported that they would wear a face mask in public indoor places (88.5%) and maintain a 1 + metre distance (86.8%) all or most of the time, as shown in Table 2.

Table 2
Reported levels of use of protective behaviour among participants with two doses of COVID-19 vaccine.

Response options	I wear a face mask in public indoor places (n = 20,135)	I keep a 1 + metre distance from people I don't live with (n = 20,057)
	% (n)	*% (n)*
Never	1.1 (218)	0.5 (91)
Rarely	2.1 (413)	2.0 (400)
Sometimes	8.4 (1685)	10.7 (2147)
Most of the time	31.7 (6375)	49.2 (9870)
All of the time	56.8 (11444)	37.6 (7549)

RQ1b. Changes in reported frequency of mask wearing and social distancing post-vaccination

Although the majority of participants reported no change following vaccination for wearing a face mask, social distancing, visiting public indoor and outdoor places and using public transport, there was still a proportion of participants reporting changes in their behaviour. Specifically, 48.3% participants reported meeting with friends or family more frequently, while 38.3% participants reported increasing the frequency of visiting indoor places and 27.8% increasing the frequency of visiting outdoor places. Conversely, 14.5% reported wearing a face mask less frequently and 16.1% reported maintaining social distance less frequently (see Table 3).

Table 3
Changes in mask wearing and social distancing after two doses of COVID-19 vaccine

	Less frequently	More frequently	No change
	% (n)	*% (n)*	*% (n)*
Wearing a face mask in public indoor spaces (n = 20,127)	14.5 (2912)	3.0 (606)	82.5 (16609)
Maintaining a 1m + distance from people you don't live with (n = 20,020)	16.1 (3231)	5.1 (1027)	78.7 (15762)
Meeting friends or family you don't live with, either at your home or their home (n = 20,035)	3.7 (748)	48.3 (9681)	47.9 (9606)
Visiting public indoor places (e.g. restaurant, café, cinema) with people you don't live with (n = 19,784)	5.7 (1123)	38.3 (7584)	56.0 (11077)
Visiting public outdoor places (e.g. parks) with people you don't live with (n = 19568)	3.9 (761)	27.8 (5431)	68.4 (13376)
Using public transport (n = 17,990)	5.8 (1037)	14.3 (2566)	80.0 (14387)

Women were more likely than men to wear masks all or most of the time (OR 1.43 [1.28, 1.59], $p < 0.001$) and keep a 1 + metre distance from others all or most of the time (OR 1.16 [1.05, 1.30], $p < 0.01$). Being white decreased the odds of keeping a 1 + metre distance from others all or most of the time (OR 0.73 [0.54, 0.98], $p < 0.05$). Participants older than 40 years were more likely than those younger than 30 years to keep a 1 + metre distance from others all or most of the time, and these odds were higher as age increased (40–49 years: OR 1.68 [1.15, 2.46], $p > 0.01$; 50–59 years: OR 1.77 [1.28, 2.46], $p < 0.001$; 60 + years: OR 2.13 [1.56, 2.91], $p < 0.001$). Those with an income > 50,000GBP compared to < 25,000 were less likely to keep a 1 + metre

distance from others all or most of the time (OR 0.73 [0.64, 0.84], p < 0.001). Participants who received an NHS risk letter were more likely to keep a 1 + metre distance from others all or most of the time (OR 1.78 [1.49, 2.12], p < 0.001).

RQ 1c. COM-B influences on mask wearing and social distancing post-vaccination

Overall, results from the logistic regression models indicated that all COM-B predictor variables significantly contributed to wearing a face mask in public indoor spaces (model 1) and keeping a 1 + metre distance all or most of the time (model 2), as shown in Table 8. For both models, the Hosmer and Lemeshow goodness of fit test was not significant (p < 0.001) indicating they were correctly specified. Additionally, the Cox and Snell was 0.092 and 0.100 for models 1 and 2, respectively; and the Nagelkerke R squared was 0.179 and 0.186 for models 1 and 2, respectively indicating that approx. 20% of the variance was accounted for in each of the models. Specifically:

Mask wearing

The estimated adjusted odds ratio for the COM-B domain of automatic motivation showed an increase of 2.20 times for mask wearing for every unit of increase in participants' reported agreement score (aOR = 2.20, 95% CI 2.02–2.39); for social opportunity an increase of 1.7 times the odds (aOR = 1.70, 95% CI 1.61–1.79); and for psychological capability an increase of 1.3 times the odds (aOR = 1.31, 95% CI 1.23–1.39). In contrast, the estimated odds ratio for reflective motivation showed a decrease in the odds of about 0.6 times (aOR = 0.58, 95% CI 0.53–0.63) for mask wearing for every unit of increase in participants' reported agreement score. Essentially this findings suggests that people who had higher scores on reflective motivation, indicating they thought they could no longer catch or pass on COVID-19 post-vaccination, were at decreased odds of wearing a face mask.

Social distancing

The estimated odds ratio for the COM-B domain of automatic motivation for social distancing showed an increase of 2.5 times for every unit of increase in participants' reported agreement score (aOR = 2.46, 95% CI 2.27–2.67),; for social opportunity an increase of 1.8 times the odds (aOR = 1.77, 95% CI 1.68–1.87); and for psychological capability an increase of 1.3 times the odds (aOR = 1.29, 95% CI 1.22–1.37). In contrast, the estimated odds ratio for reflective motivation showed a decrease in the odds of 0.7 times (aOR = 0.74, 95% CI 0.683, 0.81). A high reflective motivation score for these items would suggest thinking that one can no longer catch or pass on COVID-19 post-vaccination or that the risks of COVID-19 are exaggerated.

All results for both mask wearing and social distancing per COM-B domain are presented in Table 4.

Table 4
Multivariable logistic regression results for face mask wearing and social distancing (survey 1) among those with two doses of COVID-19 vaccine (n = 18,873)

	Wearing of face mask in public indoor spaces	**Keeping a 1 + metre distance from others**	
	Always/Most of the time OR (95% CI)	Always/Most of the time OR (95% CI)	
Reflective motivation		0.58*** (0.53, 0.63)	0.74*** (0.683, 0.81)
Automatic motivation		2.20*** (2.02, 2.39)	2.46*** (2.27, 2.67)
Social opportunity		1.70*** (1.61, 1.79)	1.77*** (1.68, 1.87)
Psychological capability		1.31*** (1.23, 1.39)	1.29*** (1.22, 1.37)
Age	30–39 (vs < 30)	1.54 (0.97, 2.46)	1.19 (0.80, 1.76)
	40–49 (vs < 30)	0.74 (0.50, 1.11)	1.68** (1.15, 2.46)
	50–59 (vs < 30)	1.04 (0.73, 1.50)	1.77*** (1.28, 2.46)
	60+ (< 30)	1.48* (1.05, 2.10)	2.13*** (1.56, 2.91)
Ethnic Group	White (vs. Non-White)	1.14 (0.87, 1.49)	0.73* (0.54, 0.98)
Combined Income	25,000–49,999 (vs. 0–24,999)	1.15* (1.02, 1.30)	1.01 (0.90, 1.14)
	> 50,000 (vs. 0–24,999)	1.11 (0.97, 1.28)	0.73*** (0.64, 0.84)
Gender	Male (vs. Female)	0.70*** (0.63, 0.78)	0.856** (0.77, 0.95)
Received an NHS risk letter (vs. Did not receive an NHS risk letter)		1.07 (0.91, 1.25)	1.78*** (1.49, 2.12)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$			
Reference category: Sometimes/Rarely/Never			
Wearing of face mask Cox and Snell 0.092, Nagelkerke 0.179, Hosmer and Lemeshow p < 0.001			
Keeping a 1 + metre distance Cox and Snell 0.100, Nagelkerke 0.186, Hosmer and Lemeshow p < 0.001			

Survey 2

RQ2a. Frequency of lateral flow testing

Of 26,613 respondents, 32.1% had never done an LFT. Of the 67.9% who had done an LFT, 50.4% tested routinely, while the remaining 49.6% tested non-routinely.

RQ2b. Non-routine testing: Reasons for testing and understanding the test result

Among those who tested non-routinely, the most frequently reported reason or occasion for testing was before visiting friends and family (40.2%). In contrast, the least cited reasons for testing included personal health or illness-related issues—16.7% when feeling poorly, 12.9% because of having been in contact with someone who might have COVID-19, and 10.8% because of having symptoms that might be COVID-19. An even smaller minority tested for other reasons such as travel and getting into venues (see Table 5).

Table 5
Reasons for testing among those who do not routinely take a LFT (n = 8,953)

	Yes	No
	% (n)	*% (n)*
Before visiting friends or relatives	40.2 (3602)	59.8 (5351)
To get into a venue	4.9 (443)	95.1 (8510)
When I'm feeling poorly	16.7 (1491)	83.3 (7462)
Because I have symptoms that might be Covid-19	10.8 (968)	89.2 (7985)
Because I'm required to for work/education	7.4 (664)	92.6 (8289)
So that I can travel	6.5 (585)	93.5 (8368)
Because someone told me to	9.2 (825)	90.8 (8128)
Because I've been in contact with someone I think might have Covid-19	12.9 (1156)	87.1 (7797)
Had other reasons	18.8 (1684)	

Most people thought that a positive test meant they probably had COVID-19 (76.2%) with only a minority thinking a positive test definitely indicated COVID-19 infection (20.4%). The majority thought that a positive test meant they could definitely or probably infect others (97.3%).

RQ2c. Routine testing.

Those who tested routinely were more likely to think that a positive test needed to be followed up with a PCR test than those who did not test routinely (90.7% vs. 81.3%). The majority thought that if they tested positive they definitely needed to self-isolate (80.3%) and most thought that their household contacts would need to self-isolate (61.6%). Those who regularly tested were more likely than those who did not regularly test to think that positive tests needed to be reported (92.6% vs. 81.1%). A summary of these results as well significant differences in the interpretation of LFT results between those who routinely and do not routinely test are shown in Table 6.

Table 6
Differences in interpretation of LFT results among those who routinely and do not routinely take a LFT

		Definitely don't have COVID-19 % (n)	Probably don't have COVID-19 % (n)	May still have COVID-19 % (n)	Don't know % (n)		Chi-square (c^2) Sig.
Overall	Routinely have LFT (n = 9059)	7.1 (635)	71.5 (6368)	20.6 (1830)	0.8 (68)		$c^2(3) = 154.556$, $p < .001$
	Do not routinely have LFT (n = 8901)	6.1 (549)	79.3 (7181)	14.2 (1288)	0.5 (41)		
		Definitely not % (n)	**Probably not % (n)**	**Don't know % (n)**	**Probably % (n)**	**Definitely % (n)**	
Do you think you could have a negative test result today from a lateral flow test but a positive test result tomorrow?	Routinely have LFT (n = 9066)	1.1 (98)	4.7 (425)	7.9 (716)	36.5 (3309)	49.8 (4518)	$c^2(4) = 59.861$, $p < .001$
	Do not routinely have LFT (n = 8898)	1.4 (122)	5.6 (494)	9.9 (882)	38.5 (3423)	44.7 (3977)	
If you get a negative result from a lateral flow test, it means:							
It's safe to mix with people from outside your household	Routinely have LFT (n = 8990)	5.3 (475)	7.1 (637)	2.4 (218)	67.8 (6098)	17.4 (1562)	$c^2(4) = 73.905$, $p < .001$
	Do not routinely have LFT (n = 8110)	4.2 (369)	8.8 (776)	3.8 (334)	68.5 (6031)	14.8 (1300)	
I need to get a PCR test	Routinely have LFT (n = 8549)	43.4 (3706)	46.3 (3960)	2.8 (240)	2.1 (179)	5.4 (464)	$c^2(4) = 517.788$, $p < .001$
	Do not routinely have LFT (n = 8297)	31.3 (2600)	50.2 (4168)	7.4 (615)	5.1 (422)	5.9 (492)	
I need to report my test result	Routinely have LFT (n = 8819)	11.0 (969)	7.5 (660)	3.6 (321)	8.3 (733)	69.6 (6136)	$c^2(4) = 517.788$, $p < .001$

		Definitely don't have COVID-19 % (n)	Probably don't have COVID-19 % (n)	May still have COVID-19 % (n)	Don't know % (n)		Chi-square (c^2) Sig.
	Do not routinely have LFT (n = 8489)	19.5 (1657)	14.9 (1261)	8.4 (713)	10.5 (888)	46.8 (3970)	
If I test positive on LFT:							
I'm infected with Covid-19	Routinely have LFT (n = 8709)	0.6 (52)	0.6 (49)	1.7 (152)	76.2 (6640)	19.9 (1816)	$c^2(4) = 15.045$, $p = .005$
	Do not routinely have LFT (n = 8487)	0.8 (67)	0.8 (72)	2.3 (194)	76.1 (6456)	20.0 (1698)	
I might infect others	Routinely have LFT (n = 8680)	0.5 (41)	0.3 (27)	1.5 (131)	59.0 (5122)	38.7 (3359)	$c^2(4) = 16.921$, $p = .002$
	Do not routinely have LFT (n = 8427)	0.7 (58)	0.6 (48)	1.8 (149)	60.2 (5073)	36.8 (3099)	
I need to get a PCR test	Routinely have LFT (n = 8821)	0.8 (71)	0.8 (71)	2.3 (204)	5.4 (475)	90.7 (8000)	$c^2(4) = 327.444$, $p < .001$
	Do not routinely have LFT (n = 8389)	1.2 (97)	1.8 (147)	5.4 (455)	10.4 (873)	81.3 (6817)	
I need to self-isolate	Routinely have LFT (n = 8823)	0.8 (71)	0.6 (50)	1.5 (129)	13.6 (1200)	83.6 (7373)	$c^2(4) = 122.234$, $p < .001$
	Do not routinely have LFT (n = 8495)	0.9 (74)	1.0 (86)	2.3 (194)	18.8 (1597)	77.0 (6544)	
Others who live with me will need to self-isolate	Routinely have LFT (n = 8641)	2.3 (196)	5.3 (461)	6.0 (516)	21.0 (1817)	65.4 (5651)	$c^2(4) = 114.960$, $p < .001$
	Do not routinely have LFT (n = 8262)	2.7 (224)	6.5 (539)	8.4 (693)	24.8 (2045)	57.6 (4761)	

		Definitely don't have COVID-19 % (n)	Probably don't have COVID-19 % (n)	May still have COVID-19 % (n)	Don't know % (n)		Chi-square (c^2) Sig.
I need to report my test result	Routinely have LFT (n = 8821)	0.8 (70)	0.6 (54)	1.9 (167)	4.1 (364)	92.6 (8166)	$c^2(4) = 517.788$, $p < .001$
	Do not routinely have LFT (n = 8456)	1.8 (152)	2.1 (181)	6.2 (521)	8.8 (744)	81.1 (6858)	

Overall, only a small minority of participants thought that a negative LFT test meant that they definitely did not have COVID-19 (6.6%) with 92.8% thinking they 'probably did not have COVID-19' or 'may still have COVID-19'. Most people thought that a negative LFT result today could definitely or probably turn positive the next day (84.8%). The great majority thought that a negative test meant it is probably safe to mix with people from outside their households (70.9%). Those who tested routinely were more likely to think that they do not need to follow up a negative test with a PCR test than those who did not test routinely (43.4% vs. 31.3%). Those who tested routinely were also more likely to think that they needed to report their negative test result compared to those who did not test routinely (69.6% vs 46.8%).

RQ2d. Non-testing: Influences on testing – COM-B factors

Table 7 depicts the reasons reported by those who have never taken an LFT categorised into capability, opportunity, and motivational factors. Participants' responses indicated that the highest level of agreement (mean M = 4.3, SD = 0.97) was obtained for the statement 'I have not needed to test' (Social opportunity).

Table 7
Mean and SDs of reasons for never having taken a LFT

	Mean (SD)	Answered Definitely % (n)	Answered Probably % (n)	Answered Don't know % (n)	Answered Probably not % (n)	Answered Definitely not % (n)
Capability Factor						
I don't know where to get tested or where to get a hold of tests (n = 6351)	2.02 (1.153)	4.1 (262)	8.9 (564)	16.2 (1030)	26.7 (1695)	44.1 (2801)
Opportunity Factor (social)						
I have not needed to (n = 8294)	4.33 (0.966)	55.3 (4588)	31.9 (2642)	7.9 (653)	0.7 (57)	4.3 (354)
Opportunity Factor (physical)						
I can't afford to self-isolate for practical or financial reasons (n = 6261)	1.64 (0.916)	1.7 (108)	2.6 (163)	12.3 (767)	24.6 (1538)	58.9 (3685)
Motivation Factors (reflective)	*Cronbach's Alpha = 0.815*					
I don't believe it is accurate (n = 6325)	2.41 (1.022)	3.3 (207)	8.3 (528)	36.7 (2324)	29.7 (1876)	22.0 (1390)
I don't want to have to report my test result (n = 6253)	1.78 (0.955)	1.4 (87)	2.4 (148)	19.4 (1215)	27.0 (1686)	49.8 (3117)
I don't want to or am unable to self-isolate (n = 6271)	1.74 (0.955)	1.5 (92)	3.7 (233)	16.1 (1011)	25.0 (1570)	53.7 (3365)
I don't believe in testing (n = 6263)	1.49 (0.835)	1.7 (104)	0.7 (45)	10.3 (644)	19.4 (1218)	67.9 (4252)
I don't think Covid-19 poses a risk to me (n = 6281)	1.57 (0.914)	1.8 (113)	2.8 (176)	10.3 (646)	20.9 (1310)	64.3 (4036)
I'm vaccinated so I can't catch Covid-19 (n = 6356)	1.70 (0.902)	1.5 (93)	2.5 (156)	14.0 (889)	28.4 (1805)	53.7 (3413)
Motivation Factors (automatic)						
It is unpleasant or uncomfortable	2.69 (1.080)	4.5 (283)	15.6 (985)	43.0 (2712)	18.4 (1160)	18.6 (1172)

**Responses: Definitely, Probably, Don't know, Probably not, Definitely not*

	Mean (SD)	Answered Definitely % (n)	Answered Probably % (n)	Answered Don't know % (n)	Answered Probably not % (n)	Answered Definitely not % (n)
Capability Factor						
(n = 6312)						
It's a hassle (n = 6290)	2.36 1.058)	2.2(137)	10.0 (628)	37.4 (2352)	22.5 (1415)	27.9 (1758)
**Responses: Definitely, Probably, Don't know, Probably not, Definitely not*						

Conversely, participants' low mean scores for the statements which were categorised as 'reflective motivation' statements, which mostly conveyed negative meanings (e.g. 'I don't think Covid-19 poses a risk to me'), indicated that participants did not agree with these statements. The lowest mean score (denoting a disagreement) was found for the statement 'I don't believe in testing' (M = 1.49, SD = 0.84) signifying that the majority of participants did believe in testing, despite never having done a LFT.

Table 8
COM-B influences mapped to proposed interventions using the Behaviour Change Wheel

Behaviour	COM-B factors	Intervention types	Policy options	Example Behaviour Change Techniques	Examples of how these could be designed and delivered
Mask wearing/ Social distancing/ Testing	Psychological Capability	Education Enablement Persuasion	Communications/marketing Guidelines	- Information about social and environmental consequences - Information on health consequences - Salience of consequences - Action planning - Credible source	-Raise awareness about the importance of minimising risk/stop virus transmission through the use of PPBs -Raise awareness of importance of testing following contact with someone who had Covid-19 -Provide details of where to locate scientifically robust evidence about the benefits of mask wearing, social distancing and testing - Community support, targeted media campaigns, apps, and websites to assist households, especially those with vulnerable people to establish new living arrangements and routines and to remember the guidance
Mask wearing/ Social distancing/ Testing	Reflective Motivation	Education Persuasion Modelling Enablement	Communications/marketing Guidelines	- Pros and cons - Credible source - Framing /reframing - Information about health consequences	- Address misleading informational sources about mask wearing, social distancing and testing accuracy (e.g., social media) -Provide testimonials from medical experts about the importance of mask wearing, social distancing and testing -Targeted ads and comms campaigns about the significance

Behaviour	COM-B factors	Intervention types	Policy options	Example Behaviour Change Techniques	Examples of how these could be designed and delivered
					of testing and likely unwanted consequences before meeting vulnerable individuals
Mask wearing/ Social distancing	Automatic Motivation	Persuasion Modelling Incentivisation/ Coercion	Communications/marketing Service provision Fiscal measures	- Habit formation -Information about consequences - Anticipated regret, - Social support (Emotional) - Salience of consequences	- Prompt rehearsal and repetition of mask wearing and social distancing in public spaces (context) so that the context elicits the behaviour (e.g. prompt individuals before taking public transport, or offer free masks) so that it becomes a habit -Testimonials from individuals at high risk about their experiences/fears -Create an expectation of a fine if not adhering to government guidance
Testing/ Mask wearing/ Social distancing	Social Opportunity	Persuasion Modelling Environmental restructuring Enablement	Service provision Guidelines Regulation Environmental/ social planning	- Credible source - Social support (Practical) - Social comparison	- Workplaces (all public-facing industries) should provide testing programmes for their workers to increase uptake/make it an expectation - Make it a pre-requisite for admission in certain settings like public transport, public places and healthcare settings - Offer masks or LFTs in a variety of designated locations in the community (e.g. schools, hospitals) - Community champions to

Behaviour	COM-B factors	Intervention types	Policy options	Example Behaviour Change Techniques	Examples of how these could be designed and delivered
					model behaviour (e.g. testing, mask wearing) - Community support, clear messaging and promotion of strong social identity and shared responsibility

Discussion

The results of our study indicate that a significant portion of fully vaccinated individuals maintained high adherence to wearing face masks in public indoor spaces (88.5% of the sample) and practicing social distancing (keeping at least 1 meter from others) (86.8% of the sample) most of the time. At the time of the data collection, there was no legal requirement in England and Wales to wear a face mask or maintain social distancing, with only general government advice that people should continue to wear a face mask and maintain a social distance considering the risks of close contact with others, particularly those who were clinically extremely vulnerable or not yet fully vaccinated [59]. It is noteworthy that while some participants reported minor changes in the frequency of mask-wearing and social distancing after vaccination, the majority reported no change in these behaviors. In contrast, a substantial portion of respondents (32.1% of the sample) had never used a lateral flow test (LFT), a percentage that appears considerably high, especially considering that the study was conducted during the peak of the pandemic when LFTs were widely available and often free or low-cost for asymptomatic testing. However, among those who had used LFTs, half of them (50.4%) reported testing regularly.

High level of adherence for face mask wearing is consistent with other UK studies which were conducted at later stages of the pandemic documenting that the overall levels of adherence were relatively high throughout the pandemic until the government mandate ended. A cross-sectional study investigating adherence to PPBs, including face mask wearing over the course of the pandemic, found that engagement with protective behaviours increased at the start of the pandemic and remained high throughout and that the greatest variations in behaviour reflected changes to Government guidance [50]. Similarly, another study found that adherence to PPBs ranged between 50–95%, with higher adherence during the period of stricter government measures and with the highest level of adherence for wearing masks indoors [60].

The reported level of adherence to social distancing in this study is notably higher compared to findings in other studies, where adherence rates ranged from as low as 31% [61] to 70% [60]. Conversely, in a separate study, non-adherence, whether intentional or unintentional, was reported at a much higher rate of 92.8% [62], though we noted the smaller sample size of that particular study and that follow up analyses showed that the odds of not adhering to rules increased if a participant was not identified as highly vulnerable to COVID-19 [43]. In comparison, the majority of participants in this study were aged 60 years and above and had received two doses of the vaccine indicating a specific demographic represented in this research. The variation in age distribution between those who received one versus two doses of the vaccine can be attributed to the initial vaccination campaign's emphasis on prioritising older adults due to elevated risk of infection and severe illness. This likely contributed to a heightened awareness of health precautions among older adults during the COVID-19 pandemic. This is also in line with other studies in the UK which show that being less vulnerable and less worried about COVID-19 increased the odds of non-adherence to social distancing and isolation. [43, 63] This, to a degree, also reflects the effectiveness of COVID-19 risk communication targeted at the vulnerable population, particularly the older population.

In relation to changes in reported compliance for mask wearing and social distancing, our finding that the majority reported no change in behaviour is in line with the findings in the COVID-19 Social Study which comprised of 70,000 adults in the UK and did not yield any significant differences in compliance with COVID-19 measures between those who were vaccinated and those non-vaccinated [15, 64]. A smaller study in the UK also shows similar findings of no significant differences in decrease of PBBs among the fully, partially, and non-vaccinated [65].

Identified influences on face mask wearing and social distancing post-vaccination

After adjusting for age, sex, income, ethnicity, and receipt of NHS risk letter, capability, opportunity, and motivation factors were associated with higher compliance to mask wearing and social distancing [66]. In relation to automatic motivation which was the strongest predictor for both mask wearing and social distancing, this finding is in line with other studies which reveal that automatic motivation factors such as habit and fear are associated with increased compliance to protective behaviours [35, 67]. Associations between these PPBs and social opportunity factors have also been previously documented. In several studies, adherence to social distancing decreased when one had less control over others' distancing or when coming in contact with others was unavoidable [43, 68]. Another study in the US showed that the perceived social norm was a predictor of mask wearing behaviour. [35] Finally, capability factors such as having access to COVID-19 information and being knowledgeable about the threat of COVID-19 have also been shown to increase the likelihood of adherence to public health measures [69].

The reflective motivation factor assessed risk perception post vaccination in this study - specifically, agreement with the statement that COVID-19 poses low to no risk after vaccination - signifying that participants did not think that the risk of infection was lower post vaccination. This finding is consistent with existing evidence showing that perceived high risk to COVID-19 promotes vaccine uptake as a means of protection and risk aversion [64, 70, 71], and it is therefore, possible that the same risk aversion could promote PPBs irrespective of vaccination status [72]. Conversely, being less worried about COVID-19 decreases the likelihood of compliance to PPBs [63]. In a similar vein, other reflective motivation factors such as self-efficacy and action planning have been shown to increase compliance to PPBs [68, 73, 74].

Identified influences on LFT

Of the 67.9% who had done an LFT, participants reported primarily using LFTs only before social gatherings with friends and family. They rarely tested themselves in response to any symptoms that may be COVID-19 or after potential exposure to COVID-19 and a very small proportion of our participants responded that they tested for work-related purposes or to travel. In contrast, in a study conducted in two English local authority areas, 60% of participants reported getting tested primarily for work-related reasons [48]. This finding may be explained by the government's advice at the time of the survey to take a PCR test for those experiencing symptoms. Furthermore, this finding highlights the importance of social relations and the sense of social responsibility towards others, which are fundamental human needs, especially during times of isolation. This is particularly relevant in the context of meeting friends and family from different households, which showed the most significant increase after vaccination in our study. This also emphasises the complex interplay between public health guidance, testing behaviours and the need to maintain social connections during these challenging times [75].

In the context of interpreting test results, the key difference between individuals who test regularly being more inclined to report a positive test and self-isolate than those who do not test regularly, can be attributed to differences in their overall understanding of the disease and risk attitudes of each group. While there is a lack of specific studies exploring the association between COVID-19 testing behaviors and risk attitudes, existing research indicates that being risk-averse can serve a protective function. Risk-averse individuals tend to engage in more proactive health information seeking and a perception of utility of public health measures, such as adhering to lockdown protocols [70]. Those in the habit of routine testing may exhibit a higher risk aversion, leading them to be more cautious and therefore, reporting a positive result and isolating promptly, thereby reducing the risk of spreading the virus to others. Conversely, individuals with a higher tolerance for risk might adopt a more relaxed approach even in the event of a positive test result, assuming that transmission might not

necessarily occur. This leniency could result from their willingness to accept a certain level of risk or uncertainty in their daily activities.

Among individuals who have never taken an LFT, the highest mean (agreement) score pertained to the social opportunity factor that they did not need to test indicating a perceived lack of need for testing. This finding coupled with high disagreement scores for negative statements about the utility and accuracy of testing (reflective motivation) suggest a likely absence of conditions such as work requirements, social interactions or contact with infected individuals that would necessitate the use of LFT rather than negative beliefs about the value of testing. Alternatively, this could also be attributed to a limited understanding about when to take the LFT test (psychological capability). This finding aligns with other research, where limited face-to-face interactions with others emerged as a common justification for not testing [76]. Moreover, another study revealed that a prevalent reason for not engaging in LFTs, despite the recommended bi-weekly testing, was the belief that testing was only necessary after exposure to someone with COVID-19 [44].

Policy implications

While the COVID-19 is no longer classified as a public health emergency of international concern [77], the findings of this study can be useful for future pandemic preparedness and critical response strategies. It is noteworthy that the findings of our study suggest that at a time when there were few restrictions in the UK, many participants reported still wearing a face mask and keeping the recommended distance. This indicates that adherence to these behaviours was mostly a personal decision, rather than merely a response to official guidance, to protect themselves and others around them [78]. This is supported by studies conducted during the COVID-19 and influenza (e.g. H1N1 in 2009) pandemics which show that greater sense of social responsibility and the belief in protecting others promoted compliance to protective behaviours [79–81]. Similarly, LFTs which enable access to testing beyond healthcare settings were reportedly used by the majority of our participants. However, our results suggest that there was still a significant proportion of our participants (about a third of our sample) who had never used an LFT at a time when the pandemic was still ongoing and when LFTs were widely available - although not free for most people apart from those meeting eligibility criteria (i.e. being clinically vulnerable and working as a key worker).

Based on our findings, health communications and messaging campaigns in the UK are recommended to focus on shared responsibility and social consciousness principles since the population appears to relate and respond well to these [82]. Importantly, given that the LFTs could also play an important part in the detection of other infectious diseases of epidemic potential and antimicrobial resistance [46], public health planning should also focus on increasing social opportunity by addressing systemic factors that influence LFT uptake for COVID-19 and other infectious respiratory diseases. It is important, however, to consider the ethical implications of any interventions especially in light of substantial evidence pointing to intervention-induced inequalities during the pandemic [83]. Failing to address these ethical considerations may exacerbate existing disparities and disproportionately impact vulnerable populations, emphasising the need for a conscientious and equitable approach in implementing intervention strategies to ensure fair outcomes across diverse communities [84, 85].

Recommendations for intervention design

To generate recommendations for interventions to increase the uptake of mask wearing, social distancing, and LFT, we consulted the BCW matrix for intervention strategies that are likely to be effective in addressing the different types of behavioural influences. The BCW is a published matrix that pairs the COM-B to BCW interventions and policy options for intervention implementation [53, 86]. Factors found to be significantly associated with the target behaviours were mapped to Intervention Types (ITs) and then onto relevant policy options using the BCW matrix and generated descriptions as to how these could potentially be operationalised and delivered using frequently used Behaviour Change Techniques taxonomy BCTTv1 [87].

Significant influences for mask wearing and social distancing were found to be associated with capability, social opportunity and motivation, with (automatic) motivation having the highest odds for uptake of mask wearing and social distancing. These factors could be targeted with a wide range of interventions such as education and persuasion, delivered via policy options such as communication, regulation, or environmental and social planning in a way that resonates with the community's values

and concerns. For example, a tailored public health messaging campaign could include a series of posters or digital graphics conveying persuasive messages about the benefits of face masks or social distancing in protecting both oneself and others and encourage regular mask wearing and social distancing as a habit in public spaces. For testing, the primary COM-B domain underpinning lack of testing was social opportunity followed by psychological capability. Factors related to social opportunity can be targeted through interventions using modelling, environmental restructuring, and enablement. For example, public health (government or community) campaigns should aim to convey the importance of testing as a community-wide responsibility to curb the virus and can encourage regular testing through video advertisements featuring prominent public figures and/or healthcare professionals. A list of other potential intervention strategies and policy options as well as examples of how these could be delivered, in the form of behavior change techniques, are shown in Table 8.

Strengths and Limitations

Strengths of the study include the large sample size and the use of a theoretically-informed behavioural science framework to structure the questionnaire items and interpret the data. This allows for a systematic analysis and identification of influences on the behaviours of interest and to generate recommendations for future public health interventions. However, despite the large sample size, non-white ethnic groups were under-represented in this study and most participants were older adults (60+). It is also likely that participants may have been more self-aware of adherence to PPBs and responses may have been influenced by a degree of social-desirability bias. These limitations may have led to an overreporting of PPBs compared to the general population.

Conclusions

The findings of this study show that, overall, there is a high level of adherence to mask wearing and social distancing, despite fewer restrictions and high rates of vaccination. However, there is still a proportion of people (about 10%) who do not use these protective measures and a higher proportion of people who had never used the LFT (about 30%) to check themselves. After two doses of the vaccine, people reported visited friends and relatives more frequently compared to other activities and visiting family and friends was also the most reported reason for testing. Therefore, targeted interventions and public health initiatives fostering a sense of social responsibility and promoting safe social interactions can be effective in managing new COVID-19 variants and new viruses in future public health emergencies.

Declarations

Ethics approval and consent to participate- The Virus Watch Study was approved by the Hampstead NHS Health Research Authority Ethics Committee (Ethics approval number 20/HRA/2320). Informed consent was obtained from all participants involved in the study.

Consent for publication- Not applicable

Availability of data and materials – All materials used are included in the Appendices andthe data presented in this study are available upon reasonable request from the corresponding author.

Competing interests – The authors declare no competing interests.

Funding – This study has received funding from the following funders:

1. UKRI Medical Research Council Grant: MC_PC 19070 & MR/V028375/1
2. Department of Health & Social Care
3. European Commission Horizon Health 2021 Grant: 101046314

Authors' contributions – Conceptualisation, SM, FL, SB, RA, AH, CM, VA; Design, SM, FL, SB, AH, RA, CM, VA, Funding acquisition, SM, FL, SB, RA, AH; Methodology, SM, FL, SB, AH, RA, CM, VA; Data curation, MO; Formal analysis, MO, CM, VA;

Investigation and Interpretation, MO, VA, CM; Writing – original draft, OM, VA; Writing – review & editing, VA, OM, CM, FL, SM, SB, AH, RA. All authors have approved the submitted version of the study

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