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OFFICIAL SENSITIVE

Reducing false reassurance following negative results from asymptomatic coronavirus (Covid-19) testing: an online experiment

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Abstract

Objectives. Individuals who receive a negative lateral flow coronavirus (Covid-19) test result may misunderstand it as meaning 'no risk of infectiousness', giving false reassurance. This experiment tested the impact of adding information to negative test result messages about (a) residual risk and (b) need to continue protective behaviours.

Design. 4 (residual risk) x 2 (post-test result behaviours) between-subjects design.

Setting. Online.

Participants. 1200 adults from a representative UK sample recruited via Prolific (12-15 March 2021).

Interventions. Participants were randomly allocated to one of eight messages. Residual risk messages were: 1) 'Your coronavirus test result is negative' (control); 2) Message 1 plus 'It's likely you were not infectious when the test was done' (Current NHS Test & Trace); 3) Message 2 plus 'But there is still a chance you may be infectious' (Elaborated NHS T&T); 4) Message 3 plus infographic depicting residual risk (Elaborated NHS T&T + infographic). Each message contained either no additional information or information about behaviour, i.e. the need to continue following guidelines and protective behaviours.

Outcome measures. (i) proportion understanding residual risk of infectiousness and (ii) likelihood of engaging in protective behaviours (score range 0-7).

Results. The control message decreased understanding relative to the current NHS T&T message: 54% vs 71% (AOR=0.37 95% CI [0.22, 0.61], p<.001). Understanding increased with the elaborated NHS T&T (89%; AOR=3.27 95% CI [1.78, 6.02], p<.001) and elaborated NHS T&T + infographic (91%; AOR=4.03 95% CI [2.14, 7.58], p<.001) compared to current NHS T&T message. Likelihood of engaging in protective behaviours was unaffected by information (F(1,1192)=0.43, p=.513), being high (M=6.4, SD=0.9) across the sample.

Conclusions. The addition of a single sentence ('But there is still a chance you may be infectious') to current NHS Test & Trace wording increased understanding of the residual risk of infection.

Trial registration. Open Science Framework: https://osf.io/byfz3/

Keywords: Covid-19; Public health

Strengths and limitations

- Participants from a representative sample of UK adults imagined taking part in asymptomatic lateral flow Covid-19 testing and were randomly allocated to one of eight negative test result messages.
- Information currently delivered by NHS Test and Trace about the residual risk of infectiousness following a negative test result was compared to two interventions which elaborated on the residual risk and a control with no information.
- Expectations of engaging in protective behaviours were measured during a period of national lockdown.

Introduction

As part of the global effort to reduce the transmission of coronavirus (Covid-19), asymptomatic testing via rapid antigen tests such as lateral flow devices (LFDs) has become widespread[1]. LFDs have high specificity (over 99%), meaning they are highly likely to correctly identify people who are not infectious[2]. However, they have lower sensitivity and can incorrectly provide a negative test result in up to 50% of asymptomatic positive Covid-19 cases[2], either due to lower viral load[3] or improper sampling techniques, which are more likely when tests are conducted unsupervised[3]. This means individuals could be told they are not infectious when in fact they are. Given this, individuals who receive a negative test result (i.e. the majority) need to understand the residual risk of infectiousness and the need to continue following government guidelines.

The extent to which people understand the residual risk of infection after a negative asymptomatic Covid-19 test result is not known. Research on negative test results in cancer screening suggests that just 52% of people have a correct understanding of residual risk[4]. This can produce false reassurance and detrimental changes to behaviour[5], where individuals may be less concerned if they experience symptoms of an infection or disease in the future or may reduce their engagement in protective behaviours[6-9]. This is akin to the 'health certificate effect' whereby a negative result can reduce motivation to protect oneself against a health threat[6]. In the context of Covid-19, if people take a negative test result to mean no risk of infection, this could lead to reduced adherence to Covid-19 guidelines[10].

Importantly, the way in which negative test results are communicated can affect understanding and behaviour. For example, communicating that there is still a risk of cervical cancer after a negative screening result increases understanding compared to communicating that the residual risk is lower than for the average person (OR 5.46)[5]. In the context of Covid-19, communicating residual risk with a negative PCR test result makes people more likely to agree that a symptomatic individual should continue to self-isolate, compared to not communicating it (96% vs 83)[11]. Furthermore, graphical representations of risk have been found to increase understanding in healthcare contexts[12,13]. For example, the addition of an icon array to numerical risk information can improve the accuracy of risk estimates in medical scenarios (medium effect size)[12]. This shows that emphasising residual risk in negative test results both visually and verbally could increase understanding that a risk remains.

Test result messages also offer an opportunity to communicate the need to continue adhering to protective behaviours after a negative result, which might not be immediately clear if individuals are given a negative result but told that they could still be infectious. Unambiguous behavioural instructions and guidelines in Covid-19 messaging are encouraged by The British Psychological Society[14] and can provide the knowledge and capability people need to engage in protective

behaviours[15]. It is also likely to be valuable given that responses to a health threat are influenced by whether an individual believes there are behaviours they can engage in to reduce or alleviate the risk[16].

At the time of writing, the NHS Test and Trace (T&T) negative result messaging communicates some residual risk which is positively framed (see Box 1). However, perceptions of risk or uncertainty have been shown to increase when messages contain negative framing or if positive and negative framing are combined, compared to positive framing alone[17-19]. The addition of a negatively framed sentence to the existing NHS T&T messaging could therefore improve understanding. Post-test result behaviours are also included in existing messaging[20], but to our knowledge have not been evaluated.

Given the dearth of research examining the understanding of residual risk and behaviours following a negative Covid-19 LFD test, we conducted an online experiment examining the impact of communicating about residual risk and protective behaviours following a negative test result. The protocol was preregistered on Open Science Framework (OSF) (https://osf.io/byfz3/) and hypotheses were as follows:

Hypothesis 1: Understanding of residual risk is (a) increased by adding existing NHS T&T messaging compared to no information about residual risk (control) and (b) increased further by adding an elaborated message and an infographic.

Hypothesis 2: Expectations to follow coronavirus guidelines are higher when messages contain information about the need for continued engagement in protective behaviours.

Method

Design. Participants were randomly allocated to a message in a 4 (residual risk) x 2 (post-test result behaviours) between-subjects design (see Box 1).

Participants. A cross-stratified quota sample of 1207 UK adults representative of the UK population based on sex, age and ethnicity was recruited via the online platform Prolific (https://www.prolific.co/) between 12-15 March 2021, during the third national lockdown in England. A quota sample fills predetermined targets so that demographic characteristics are representative of the general population. Participants are prevented from completing the experiment if they belong to a quota that has already been filled.

Power. The power analyses conducted with G*Power (version 3.1) indicated that a sample of 1095 was needed to test the hypotheses. For Hypothesis 1, given the lack of prior data, a power analysis for a logistic regression could not be conducted and was based on a chi-square test instead. A sample of 547 can detect a difference between two groups with a small effect size (w=0.12), using a chi-square test with α=0.05 and power >.80. For 4 groups, it was estimated that double the sample size was needed, i.e. 1094 participants. For Hypothesis 2, 1095 participants can detect a small effect size (f=0.10) using a between-subjects ANOVA with α=0.05 and power >.80. We planned to exclude participants who failed an attention check (see Supplementary Material). As 10% of participants were expected to fail it, 1205 participants were needed to ensure 1095 participants could be included in the analysis.

Messages. Participants imagined they had taken a lateral flow test and received one of 8 messages (see Box 1 and Supplementary Material). The messages incrementally varied the level of residual risk communicated. The control condition provided no information about residual risk, the current NHS T&T[1] condition adds positively framed information about residual risk to the control message, the elaborated NHS T&T condition adds negatively framed information about residual risk to the existing NHS T&T messaging, and the elaborated NHS T&T and infographic condition adds an infographic with numerical residual risk information to the elaborated NHS T&T message. The infographic is based on 1% prevalence, 99% specificity and 50% sensitivity and includes a) a flow chart illustrating among a given population the number of positive and negative test results within

[1] Messages are provided by NHS T&T when communicating test results to those who have taken a lateral flow test at a test site or reported their home test result to NHS T&T. The message communicated by NHS T&T after a negative test result includes further information that we did not include in the messages in this study. The NHS T&T wording tested here is the residual risk sentence 'It's likely you were not infectious when the test was done' which follows the statement of the negative test result, as in this study.

individuals who are infected and those who are not and b) an icon array demonstrating the proportion of those receiving a negative result who are actually infected.

The message also contained either none or some information about the need to maintain adherence to protective behaviours following a negative test result, as listed on UK government guidance under national lockdown in March 2021[21]. This information indicates that people should continue to follow all government guidance and reminds them of key protective behaviours (hands, face, space).

Residual risk messages

No residual risk information:

'Your coronavirus test result is negative.'

Current NHS Test & Trace:

'Your coronavirus test result is negative. It's likely you were not infectious when the test was done.'

Elaborated NHS Test & Trace:

'Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.'

Elaborated NHS Test & Trace + infographic:

'Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.' + infographic (see Supplementary Material)

Post-test result behaviours

This means you should continue to follow all government guidance to reduce transmission of the virus. You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- *hands – wash your hands regularly and for at least 20 seconds*
- *face – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet*
- *space – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)*

Box 1: Residual risk and post-test result behaviours.

Primary outcome measures. Primary outcome measures were understanding of residual risk and behavioural expectations to follow Covid-19 guidelines (see Supplementary Material). Understanding of residual risk was measured by asking participants to identify the correct statement from four options: 'I am not infectious with coronavirus', 'I am most likely not infectious with coronavirus' (correct), 'I am most likely infectious with coronavirus', 'I am infectious with coronavirus'.

Behavioural expectations to follow Covid-19 guidelines were measured with specific protective behaviour questions and a general question. Six protective behaviours were measured with a 7-point scale question: 'After receiving this test result, how likely is it that you would engage in the following behaviours because of coronavirus?' (behaviours: social distancing, hand washing, wearing a face covering, avoiding meeting others, working from home, avoiding public transport; 1-very unlikely to 7-very likely), taken from a previous study[22]. There was good reliability between questions (Cronbach's α = .86) which were averaged to provide an overall score of behavioural expectation. The general question was adapted from previous studies[22,23]: 'Having received this test result, how strictly would you follow coronavirus guidelines now compared to before taking the test?' (1-a lot less strictly; 7-a lot more strictly).

Secondary outcome measures. Secondary outcome measures were confidence in understanding, perceived test accuracy and testing uptake expectations (see Supplementary Material). Participants were asked how confident they were in their understanding of residual risk (1-not at all confident; 5-extremely confident). They were asked how accurate they thought rapid lateral flow tests were (1-very inaccurate; 7-very accurate) and how likely they were to take a rapid lateral flow test in the future (1-very unlikely; 7-very likely) as there is a risk that communicating residual risk could give the impression that antigen tests are inaccurate and not worth taking.

Other measures. Participants were asked about their previous testing experience, including the last time they took a coronavirus test and what type of test it was (see Supplementary Material). A frequently used numeracy question was administered to assess their understanding of proportions[24]. Those who received the message containing the infographic were asked how easy it was to understand (1-very difficult; 5-very easy) and any suggestions for improvements (text box). An attention check (a multiple choice question asking participants not to select an option) and a recognition question (asking participants to select the test result they received) were included to evaluate participant attention throughout the study. Finally, participants were asked demographic questions (gender, age, ethnicity, UK region, highest level of education).

Procedure. Participants were recruited via Prolific and then directed to the study on Qualtrics. They were asked to imagine they had taken a lateral flow test as part of a local mass asymptomatic testing programme, similar to those taking place in the UK[25]. They then received a message about the result of their test, to which they were randomised using the Qualtrics randomisation function, and answered a series of questions (see Supplementary Material). Participants were unaware of the condition they were allocated to and paid at a rate of £25 per hour (i.e. £2.10 for a 5-minute experiment).

Patient and public involvement. Patients and/or the public were not involved in the development of the study due to the rapid nature of this research. However, the experiment was piloted with 16 participants to ensure it ran smoothly and that there were no errors. Those who took part in the pilot were able to provide feedback to researchers on the study.

Analysis. Pre-registered analyses were conducted using SPSS (version 27) with a significance level of $p<.05$. To test Hypothesis 1, a binomial logistic regression was conducted with residual risk, post-test result behaviour and an interaction term as predictors of understanding (coded as correct: 'I am most likely not infectious with coronavirus', or incorrect: all other responses). Group 2 (current NHS T&T) was used as the reference category for the residual risk predictor. Age, gender, ethnicity, education, location and numeracy were added to the model as covariates. To test hypothesis 2, a 4 (residual risk) x 2 (post-test result behaviour) between-subjects ANOVA was conducted on specific protective behaviours. Expected engagement in specific behaviours was negatively skewed, which was corrected with pre-planned logarithmic transformation. Other analyses reported are exploratory.

Results

Of the 1207 participants who completed the study, 7 (0.6%) failed the attention check and were excluded from the analysis. A breakdown of the demographic characteristics of the remaining 1200 participants can be found in Table 1.

Table 1: Participant demographic characteristics

Demographic characteristic	n	%
Gender		
Male	582	48.5%
Female	615	51.2%
Non-binary	1	0.1%
Prefer not to say	2	0.2%
Age		
18-24	127	10.6%
25-64	902	75.2%
65+	171	14.2%
Education		
GCSE or equivalent	221	18.4%
A level or equivalent	298	24.8%
Undergraduate degree	482	40.2%
Postgraduate degree	199	16.6%
Ethnicity		
White - British	906	75.5%

White - Other	113	9.4%
Asian	98	8.2%
Black	41	3.4%
Mixed	32	2.7%
Other	10	0.9%
UK region		
NI/Scotland/Wales	162	13.4%
England – South	316	26.3%
England – London	155	12.9%
England – Midlands	268	22.3%
England – North	299	24.9%
Testing experience		
Yes – PCR	235	19.6%
Yes – LFT	281	23.4%
Yes – Other (e.g. antibody)	33	2.8%
Yes – Don't know	44	3.7%
None	607	50.6%

Table 2: Primary and secondary outcomes (%(n); mean (SD)) by experimental group

	Residual risk				Post-test result behaviours	
	Control (n=300)	NHS T&T (n=298)	Elaborated (n=302)	Infographic (n=300)	None (n=602)	Included (n=598)
Primary measures						
Understanding						
I am not infectious	45.3% (n=136)	28.2% (n=84)	9.6% (n=29)	7.7% (n=23)	19.6% (n=118)	25.8% (n=154)
I am most likely not infectious*	54.3% (n=163)	71.1% (n=212)	88.7% (n=268)	90.7% (n=272)	79.7% (n=480)	72.7% (n=435)
I am most likely infectious	0% (n=0)	0.3% (n=1)	1.3% (n=4)	0.7% (n=2)	0.5% (n=3)	0.7% (n=4)
I am infectious	0.3% (n=1)	0.3% (n=1)	0.3% (n=1)	1.0% (n=3)	0.2% (n=1)	0.8% (n=5)
Specific behaviours						
Average	6.40 (0.9)	6.46 (0.8)	6.42 (0.9)	6.33 (1.1)	6.39 (0.9)	6.41 (0.9)
Social distancing	6.52 (1.0)	6.55 (1.0)	6.53 (1.0)	6.46 (1.2)	6.53 (1.0)	6.50 (1.1)
Hand washing	6.45 (1.0)	6.50 (1.0)	6.46 (1.1)	6.41 (1.2)	6.48 (1.1)	6.44 (1.1)
Face covering	6.70 (0.8)	6.71 (0.9)	6.71 (0.9)	6.55 (1.3)	6.70 (0.9)	6.63 (1.1)
Avoid meeting others	6.20 (1.3)	6.21 (1.3)	6.15 (1.3)	6.00 (1.5)	6.09 (1.3)	6.18 (1.3)
Work from home	6.19 (1.5)	6.32 (1.4)	6.24 (1.4)	6.21 (1.4)	6.20 (1.5)	6.28 (1.4)
Avoid public transport	6.28 (1.4)	6.47 (1.2)	6.44 (1.2)	6.34 (1.3)	6.35 (1.3)	6.43 (1.2)
Secondary measures						
Expectations to follow guidelines	4.23 (0.9)	4.18 (0.8)	4.25 (0.9)	4.32 (0.9)	4.19 (0.8)	4.30 (0.8)
Confidence in understanding	4.17 (0.8)	4.35 (0.8)	4.23 (0.8)	4.32 (0.8)	4.24 (0.8)	4.29 (0.8)
Perceived testing accuracy	5.71 (1.1)	5.71 (1.1)	5.61 (1.1)	5.95 (1.0)	5.75 (1.1)	5.74 (1.1)

Future testing expectations	5.90 (1.6)	5.92 (1.6)	5.88 (1.6)	5.99 (1.6)	5.90 (1.6)	5.95 (1.6)

Notes: * refers to a correct understanding of residual risk. Confidence is on a 5-point scale and other continuous variables on a 7-point scale.

Understanding of residual risk. Understanding varied by residual risk message as outlined in Hypothesis 1 (see Table 2), as shown by a binomial logistic regression in Table 3. Those who saw the existing NHS T&T message were more likely to have a correct understanding of residual risk (71.1%) than those in the control group who received no information about residual risk (54.3%) (AOR=0.58 95% CI [0.35, 0.97], $\chi^2(1)=4.32$, $p=.038$) (see Figure 1). Those who saw the elaborated NHS T&T message were more likely to have a correct understanding (88.7%) than those who saw the existing NHS T&T message (AOR=3.31 95% CI [1.68, 6.51], $\chi^2(1)=11.95$, $p<.001$). This was also the case for the elaborated NHS T&T message with the infographic (90.7%) (AOR=5.31 95% CI [2.54, 11.10], $\chi^2(1)=19.73$, $p<.001$). However, understanding in this condition was not significantly higher than the elaborated NHS T&T message alone ($\chi^2(1)=0.60$, $p=.437$). Understanding was lower among those with lower education, those with lower numeracy and those from Black and Mixed ethnicity compared to White British ethnicity (see Table 3). The model correctly classified 78.9% of cases and was a good fit to the data according to the Hosmer–Lemeshow test ($\chi^2(8)=4.77$, $p=.782$).

Confidence in understanding. As planned, we explored whether residual risk messages affected confidence in understanding among those who were correct (76.3%), to assess the effectiveness of messages beyond understanding. Residual risk information affected confidence ($F(3,907)=10.94$, $p<.001$, $\eta 2=.04$), with the control group being less confident ($M=3.93$, $SD=0.77$) than existing NHS T&T ($M=4.36$, $SD=0.73$, $p<.001$), elaborated NHS T&T ($M=4.24$, $SD=0.81$, $p<.001$) and elaborated NHS T&T with the infographic ($M=4.32$, $SD=0.80$, $p<.001$) according to post-hoc tests (Tukey). There were no significant differences between other groups. Neither post-test result behaviours ($F(1,907)=1.06$, $p=.304$, $\eta 2<.01$) nor the interaction between residual risk and post-test result behaviours ($F(3,907)=0.53$, $p=.664$, $\eta 2<.01$) had a significant effect on confidence.

Table 3: Logistic regression predicting correct understanding of residual risk.

	AOR	95% CI	Wald	p
Intercept	1.26	0.49, 3.19	0.23	.633
Residual risk				
Control	0.58	0.35, 0.97	4.32	**.038**
NHS T&T (reference)				
Elaborated T&T	3.31	1.68, 6.51	11.95	**<.001**
Elaborated T&T + infographic	5.31	2.54, 11.10	19.73	**<.001**
Post-test result behaviours				

Without (reference)				
With	0.82	0.49, 1.38	0.58	.447
*Residual risk * Post-test result behaviours*				
NHS T&T * With (reference)				
Control * With	0.64	0.31, 1.31	1.50	.220
Elaborated T&T * With	0.95	0.38, 2.38	0.01	.919
Elaborated T&T + infographic * With	0.73	0.28, 1.92	0.40	.525
Gender[2]				
Male (reference)				
Female	1.06	0.79, 1.43	0.15	.698
Age	0.99	0.98, 1.00	1.62	.204
Education				
GCSE or equivalent (reference)				
A-level or equivalent	1.84	1.20, 2.83	7.72	**.005**
Undergraduate	2.70	1.80, 4.06	23.01	**<.001**
Postgraduate	4.83	2.79, 8.34	31.55	**<.001**
Ethnicity				
White British (reference)				
White Other	0.79	0.46, 1.38	0.68	.411
Asian	0.60	0.34, 1.07	2.98	.084
Black	0.34	0.16, 0.74	7.45	**.006**
Mixed	0.36	0.15, 0.90	4.77	**.029**
Other	0.66	0.12, 3.60	0.23	.633
Location				
London (reference)				
Northern Ireland	1.09	0.27, 4.46	0.01	.907
Scotland	0.81	0.41, 1.60	0.37	.541
Wales	0.64	0.29, 1.42	1.21	.271
South England	1.10	0.64, 1.86	0.11	.738
Midlands	1.47	0.85, 2.56	1.89	.169
North England	0.87	0.51, 1.47	0.23	.596
Numeracy				
Incorrect (reference)				
Correct	1.67	1.12, 2.42	7.49	**.006**

Post-test result behaviours. Communicating about the need to maintain protective behaviours following a negative test result did not significantly increase expected engagement in protective behaviours ($F(1,1192)=0.38$, $p=.536$, $\eta 2<.01$), which does not support Hypothesis 2. Neither residual

[2] To ensure meaningful comparisons between genders, participants who reported their gender as 'non-binary' (n=1) or 'prefer not to say' (n=2) were excluded from the logistic regression analysis given low numbers in each group. When included in the analysis, their understanding of residual risk was not significantly different from the reference category (male) nor did this alter the significance or direction of the other effects or analyses.

risk (F(3,1192)=0.83, p=.476, η2<.01) nor the interaction between residual risk and post-test result behaviours (F(3,1192)=0.66, p=.579, η2<.01) had a significant effect on expected engagement in protective behaviours.

Those who received information on the need to maintain protective behaviours had higher expectations that they would follow guidelines (M=4.30, SD=0.80) than those who did not (M=4.19, SD=0.80) (F(1,1192)=5.26, p=.022, η2=.004), in line with Hypothesis 2. Neither residual risk (F(3,1192)=1.56, p=.199, η2<.01) nor the interaction between residual risk and post-test result behaviours (F(3,1192)=0.56, p=.644, η2<.01) had a significant effect on expectations of following coronavirus guidelines.

Perceived accuracy. Perceived accuracy of lateral flow tests (see Table 2) was influenced by residual risk condition (F(3,1192)=5.38, p=.001, η2=.01). Those who saw the infographic perceived lateral flow tests as more accurate (M=5.95, SD=1.00) than those who saw no residual risk information (M=5.71, SD=1.10; p=.034), existing NHS T&T messaging (M=5.71, SD=1.10; p=.029) and elaborated NHS T&T messaging (M=5.61, SD=1.1; p=.001) according to post-hoc tests (Tukey). There were no significant differences between other groups. Neither post-test result behaviours (F(1,1192)=0.06, p=.809, η2<.01) nor their interaction with residual risk (F(3,1192)=0.45, p=.714, η2<.01) affected perceived accuracy.

Uptake expectations. Expectations to engage in asymptomatic lateral flow testing in the future (see Table 2) were not affected by residual risk information (F(3,1192)=0.27, p=.849, η2<.01), post-test result behaviours (F(1,1192)=0.37, p=.545, η2<.01) or their interaction (F(3,1992)=1.30, p=.272, η2<.01).

Association between understanding and behavioural expectations. We explored whether those who had a correct understanding (n=915) were more likely to engage in protective behaviours compared to those who reported that there was no residual risk (n=272), bearing in mind participants were not randomised to each group. Those with a correct understanding did not have higher expected engagement in protective behaviours (M=6.40, SD=0.95) than those who believed there was no residual risk (M=6.38, SD=0.87) (t=0.47, df=1185, p=.641). Those with a correct understanding had lower expectations that they would follow guidelines (M=4.19, SD=0.73) than those who believed there was no residual risk (M=4.35, SD=1.07) (t=2.24, df=349.37, p=.026).

Discussion

Enhanced communication of residual risk information in negative asymptomatic coronavirus test results improved understanding of residual risk, without evidence that it decreased the perceived accuracy of LFDs or testing uptake expectations. The elaborated NHS T&T message was better understood than the current NHS T&T message (89% vs 71% correct), which itself was more effective than giving no residual risk information (54% correct). The elaborated NHS T&T message added residual risk information which was negatively framed ('But there is still a chance you may be infectious') to the current NHS T&T message, which was positively framed ('It's likely you were not infectious when the test was done'). This study therefore echoes previous findings on negatively framed communications of residual risk[5], to which it adds that combining positive and negative framing is also effective, as has been found in other health contexts[19].

Adding an infographic with an icon array of residual risk did not significantly improve understanding relative to the elaborated NHS T&T message. This may be due to a ceiling effect given that the elaborated NHS T&T message increased understanding to nearly 90%. Although it contrasts with previous findings on the effectiveness of infographics[12, 13], there is a precedent for them not increasing understanding of residual risk relative to verbal communications[4]. The infographic increased perceptions of testing accuracy, which could be because it includes numerical information which participants associated with accuracy. Indeed, this seems akin to the 'seductive allure effect' whereby people find psychological explanations more convincing when presented alongside irrelevant neuroscience information[26]. Furthermore, this did not result in differences on other measures, suggesting it is not a meaningful effect in terms of understanding, behavioural expectations or uptake expectations.

Demographic factors affected understanding of residual risk. Understanding was lower as education level and numeracy decreased and lower in groups self-classifying as Black and Mixed ethnicity compared to White British. This mirrors findings in other risk communication trials, where higher understanding is associated with higher education[4,27,28], higher numeracy[27] and White British ethnicity[27].

Communicating the need to maintain adherence to protective behaviours following a negative test result did not increase expectations of engaging in protective behaviours, although these may have been subject to ceiling effects given the high reported likelihood of engaging in protective behaviours across the sample (M=6.4, SD=0.9). This finding is akin to other similar Covid-19 vaccine communications tested during lockdown[22]. Information about post-test result behaviours did increase expectations to follow coronavirus guidelines, although this was a very small effect ($\eta 2$=.004) whereby both those who did and did not receive information about protective behaviours indicated they would

follow guidelines as strictly as before. Participants who believe there to be no residual risk of infectiousness following a negative test result were more likely to report they expect to follow guidelines than those who correctly understood residual risk. This exploratory result is difficult to explain and would warrant replication as a pre-planned hypothesis before discussing further.

Strengths and weaknesses of the study

This study provides the first experimental evidence that some misunderstand there to be no residual risk of infectiousness following a negative asymptomatic Covid-19 test result, while demonstrating the effectiveness of simple, low-cost interventions to increase understanding. Implementing these interventions would be a valuable step in ensuring that the implications of asymptomatic LFD testing are more often understood by the public.

The study has several limitations. First, participants were responding to a hypothetical test result. The interventions would benefit from being tested in a real world setting to check that the increase in understanding is maintained. Second, expectations of engaging in protective behaviours were high. This could have been due to national lockdown restrictions being in place at the time, as in previous studies[22,29]. As restrictions ease, there might be more variability in the propensity to follow guidelines and more pronounced effects of messaging on behaviour. Third, a quota sample was used. Although it was broadly demographically representative of the UK population, it was limited to internet users and could have been subject to bias[30]. A quota sample was favoured as it enables rapid data collection and can therefore meet the demands of a crisis[31]. Participants were randomly allocated to each message, meaning their effects can be experimentally compared and any issues about representativeness are unlikely to affect the interpretation of the findings.

Implications for policymakers

The results of this study suggest that adding one sentence to a pre-existing single sentence can increase understanding of the meaning of a negative test result. Including the need to continue engaging in protective behaviours following a negative test result, as in current NHS T&T messaging, may also prevent lowering adherence to guidelines. These findings merit implementation with a nested evaluation to check that the effects observed in this hypothetical study are replicated in a real-world setting. However, stronger messages may be needed in contexts where residual risk of infectiousness is higher than in asymptomatic community testing programmes. Messages which include only negatively framed residual risk information could be more effective than the combined positive and negative framing used in this study[19].

Unanswered questions and future research

The effects of education, numeracy and ethnicity on understanding of residual risk were consistent with prior studies on risk communication[4, 27, 28] and suggest there are additional barriers to understanding in those with low education, low numeracy and Black and Mixed ethnicity. Future research should seek to identify and tackle them, to which end co-producing messages with these populations could be a useful approach[32, 33]. Finally, future research should evaluate the effectiveness of the messages that people receive after a positive LFD test result, in terms of encouraging self-isolation or following up with a PCR test. Ensuring people do self-isolate after a test-positive result is important given recent findings that fewer than 50% of symptomatic individuals fully self-isolate[34].

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Contributors

TMM framed the broad research question. All authors contributed to conceptualising and designing the study. EB and SB completed the data collection and analysis and drafted the manuscript. All authors contributed to, and approved, the final manuscript.

Ethics approval

The study was reviewed and approved by Public Health England's Research and Ethics Governance Group (RD432).

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Competing interests

The authors have no competing interests to declare.

Transparency statement

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned have been explained.

Dissemination to participants and related patient and public communities

Participants took part in the study anonymously, meaning the authors do not have the necessary details to send participants the results of the study. These findings have been disseminated to relevant stakeholders across government.

Data sharing

The data will be made available upon acceptance of the manuscript for publication from Open Science Framework: https://osf.io/byfz3/

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Figure legends

Figure 1: Percentage of participants with a correct understanding of residual risk by residual risk experimental group. Error bars represent 95% confidence intervals. Significance levels are based on the logistic regression in Table 3). * refers to p<.05, ** refers to p<.01, *** refers to p<.001.

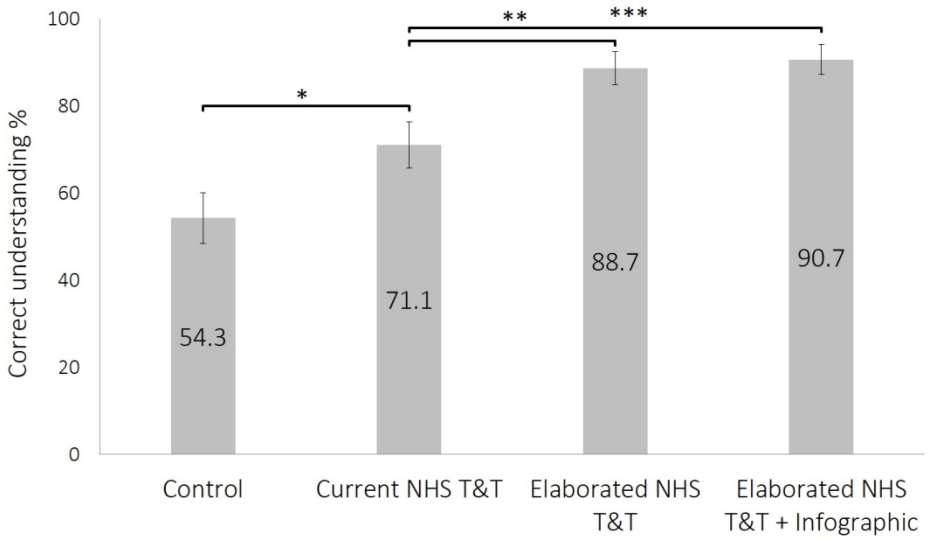


Figure 1: Percentage of participants with a correct understanding of residual risk by residual risk experimental group. Error bars represent 95% confidence intervals. Significance levels are based on the logistic regression in Table 3). * refers to p<.05, ** refers to p<.01, *** refers to p<.001.

260x176mm (150 x 150 DPI)

Supplementary material

Instructions

You will be asked to imagine that you have participated in a mass testing programme for coronavirus. You will be presented with test results and answer a series of questions about this.

Please read the information carefully as afterwards we will ask you some questions about it, including testing if you remember what the information was.

Scenario

Imagine that you have agreed to take part in a mass testing programme for coronavirus in your local area. The programme intends to test as many people as possible who are not currently experiencing symptoms using rapid lateral flow tests.

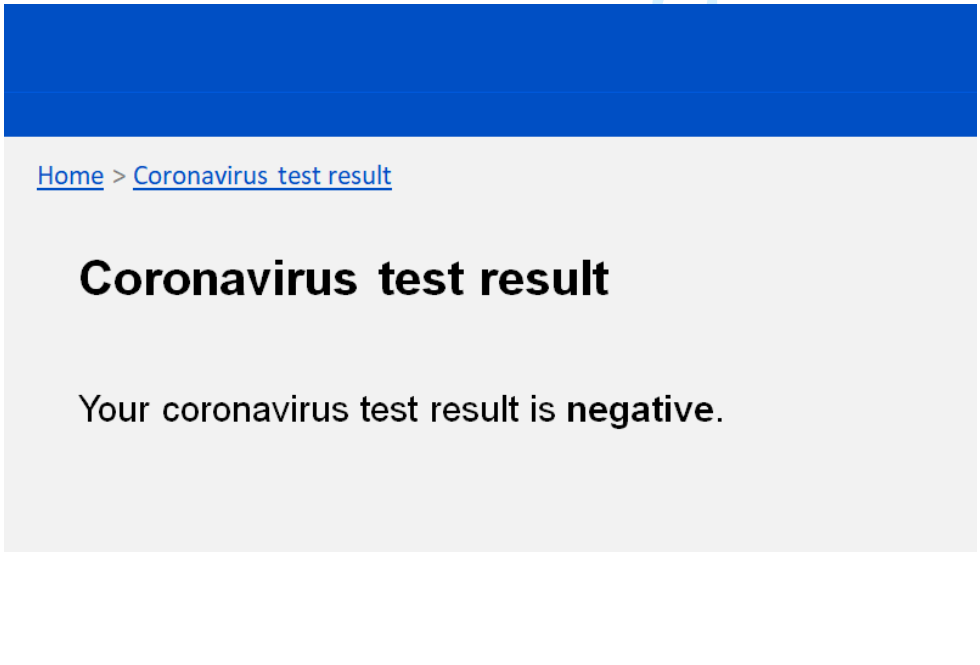
You arrive at the test site and are tested using a lateral flow test which involves taking a swab from the back of the throat or the nose. You then leave the test site and are told you will be sent results in approximately 30 minutes.

Half an hour later, you receive your test results.

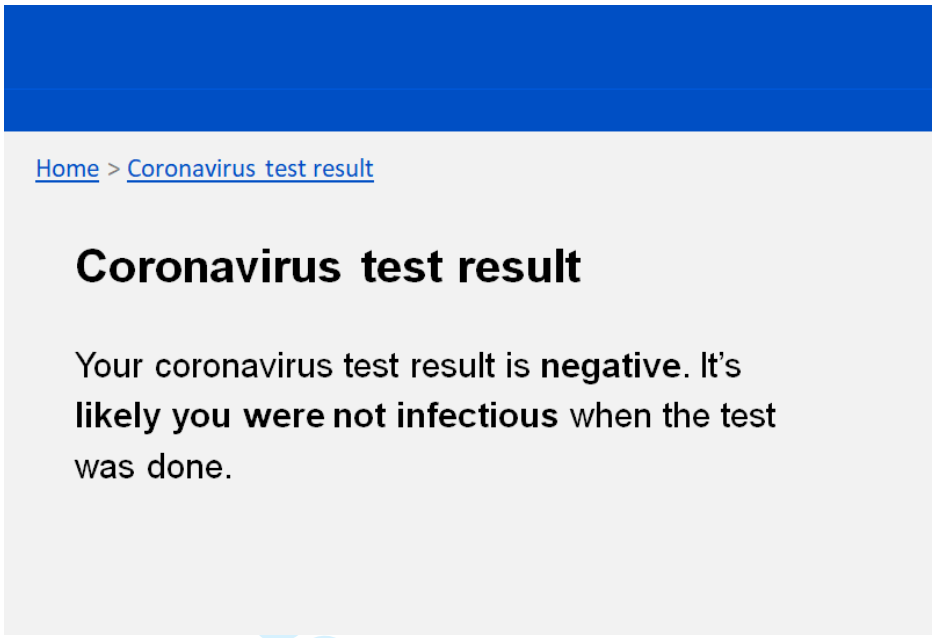
Messages

Note all messages were displayed with the same font size.

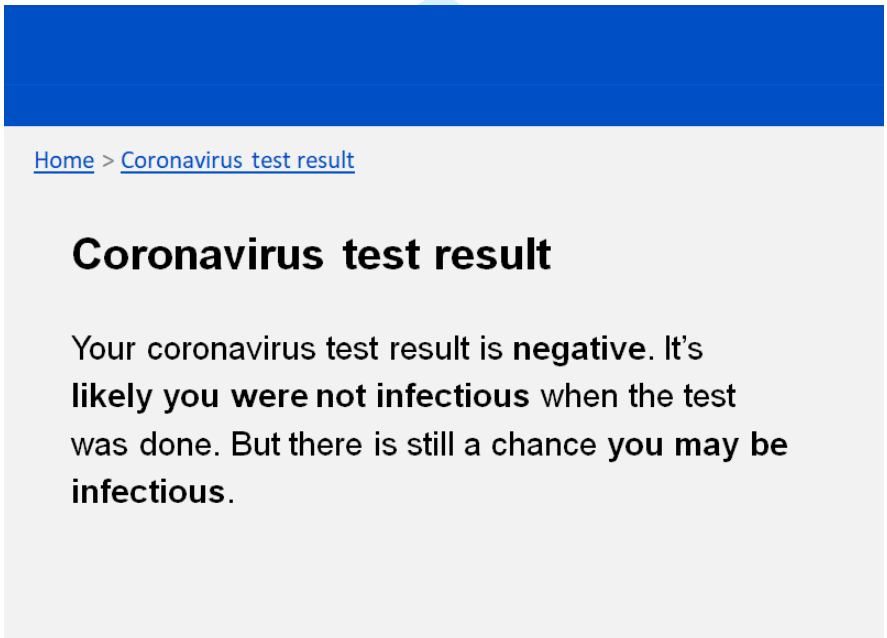
Condition 1 – No residual risk information, no behavioural implications



Condition 2 – Current NHS Test & Trace message, no behavioural implications



Condition 3 – Elaborated NHS Test & Trace message, no behavioural implications



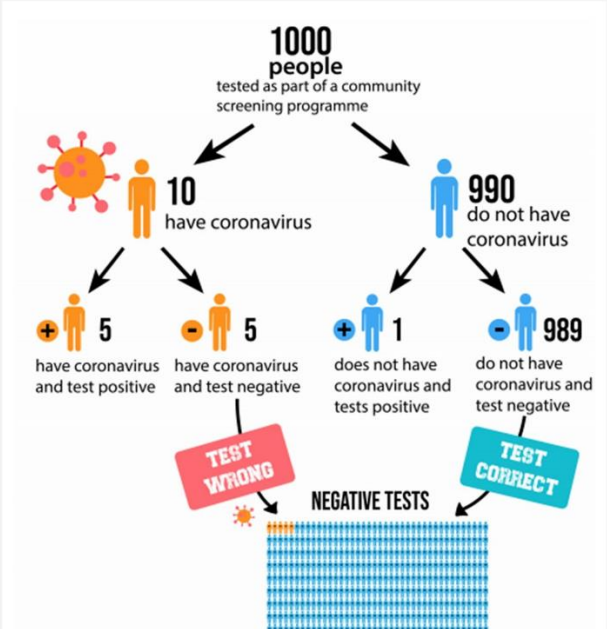
Condition 4 – Elaborated NHS Test & Trace message with infographic, no behavioural implications

Home > Coronavirus test result

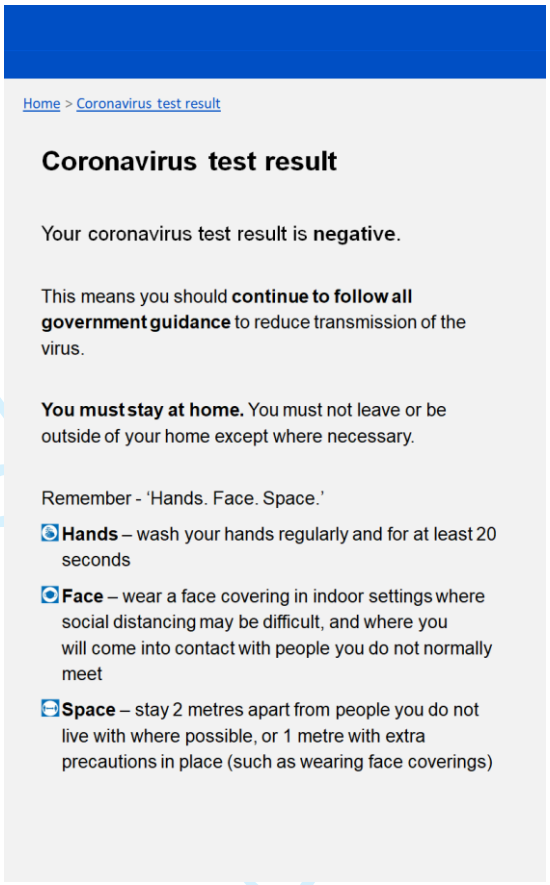
Coronavirus test result

Your coronavirus test result is **negative**. It's **likely you were not infectious** when the test was done. But there is still a chance **you may be infectious**.

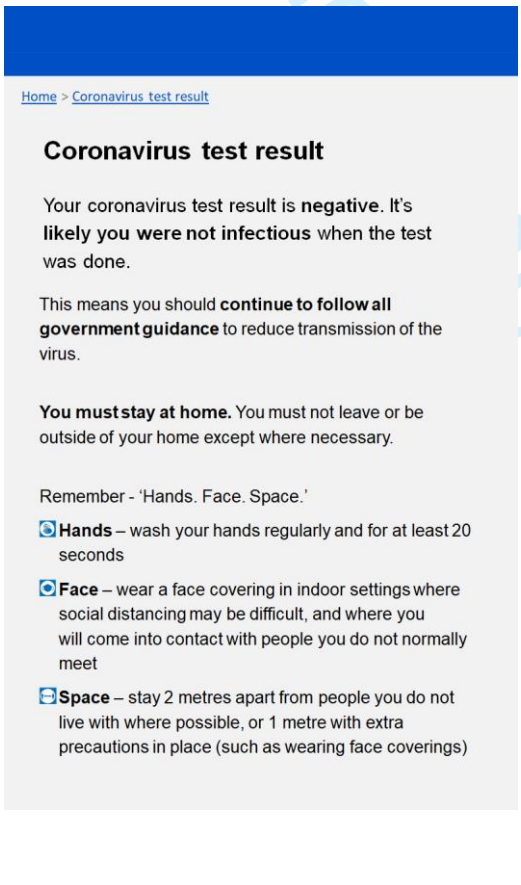
The infographic shows you how likely it is that you are infectious.



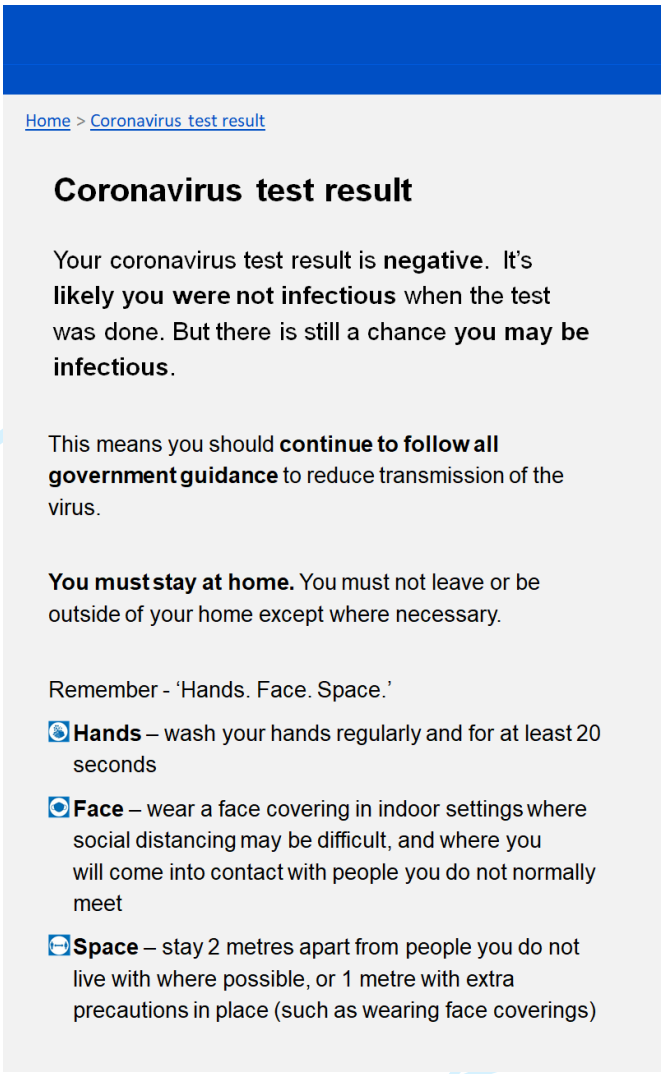
Condition 5 – No residual risk information, with behavioural implications



Condition 6 – Current NHS Test & Trace message, with behavioural implications



Condition 7 – Elaborated NHS Test & Trace message, with behavioural implications



Home > Coronavirus test result

Coronavirus test result

Your coronavirus test result is **negative**. It's **likely you were not infectious** when the test was done. But there is still a chance **you may be infectious**.

This means you should **continue to follow all government guidance** to reduce transmission of the virus.

You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- **Hands** – wash your hands regularly and for at least 20 seconds
- **Face** – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet
- **Space** – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)

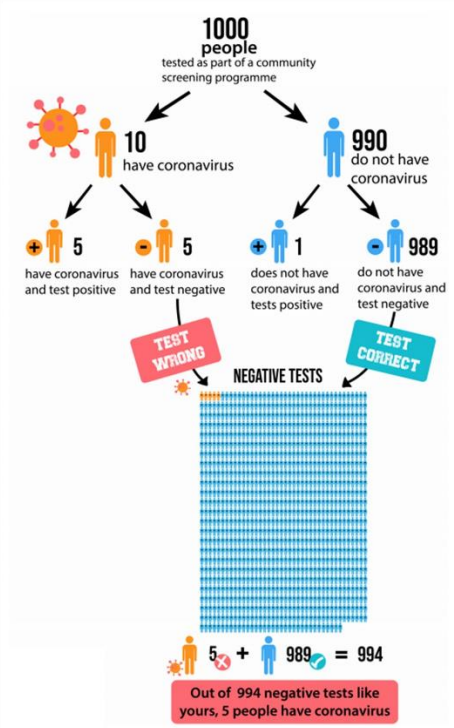
Condition 8 – Elaborated NHS Test & Trace message with infographic and behavioural implications

Home > Coronavirus test result

Coronavirus test result

Your coronavirus test result is **negative**. It's **likely you were not infectious** when the test was done. But there is still a chance **you may be infectious**.

The infographic shows you how likely it is that you are infectious.



This means you should **continue to follow all government guidance** to reduce transmission of the virus.

You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- **Hands** – wash your hands regularly and for at least 20 seconds
- **Face** – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet
- **Space** – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)

Question set

Primary outcome measures and attention check

Understanding of residual risk

Having received this test result, which one of the following statements is true?

1. I am not infectious with coronavirus
2. I am most likely not infectious with coronavirus
3. I am most likely infectious with coronavirus
4. I am infectious with coronavirus

Confidence in understanding

How confident are you that you have answered the previous question correctly?

5- Extremely confident
4- Very confident
3- Moderately confident
2- Slightly confident
1- Not at all confident

Attention check question

How worried would we be if you didn't pay attention? To check that you are paying attention, please do not select an answer below.

a. Strongly agree
b. Somewhat agree
c. Neither agree nor disagree
d. Somewhat disagree
e. Strongly disagree
f. Don't know

Behavioural intention - general behaviours

Having received this test result, how strictly would you follow coronavirus guidelines now compared to before taking the test?

7. A lot more strictly
6. More strictly
5. Slightly more strictly
4. The same as before
3. Slightly less strictly
2. Less strictly
1. A lot less strictly

Behavioural intention - Specific protective behaviours

After receiving this test result, how likely is it that you would engage in the following behaviours because of coronavirus?

> Social distancing - staying more than 1m from people not in your bubble
> Washing your hands carefully and frequently
> Wearing a face covering in indoor public spaces
> Avoiding meeting with others
> Working from home whenever possible
> Avoiding public transport whenever possible

7 - Very likely
6 - Moderately likely

5 - Slightly likely
4 - Neither likely nor unlikely
3 - Slightly unlikely
2 - Moderately unlikely
1 - Very unlikely

Secondary outcome measures

Perceived test accuracy
How accurate do you think rapid lateral flow tests for coronavirus are? (The test you imagined doing in this study was a rapid lateral flow test)
7 - Very accurate
6 - Moderately accurate
5 - Slightly accurate
4 - Neither accurate nor inaccurate
3 - Slightly inaccurate
2 - Moderately inaccurate
1 - Very inaccurate

Testing uptake intentions
If available to you, how likely are you to take a rapid lateral flow test in the future?
7. Very likely
6. Moderately likely
5. Slightly likely
4. Neither likely nor unlikely
3. Slightly unlikely
2. Moderately unlikely
1. Very unlikely

Previous testing behaviour
When was the last time you took any type of test for coronavirus?
a. In the last 2 weeks
b. In the last month
c. In the last 3 months
d. In the last year
e. Never

If answer is a/b/c/d:
What type of test was the one you took most recently?
a. Lateral Flow Test (LFT) - commonly used for individuals who are asymptomatic and provides results in approximately 30 minutes
b. Polymerase Chain Reaction (PCR) test – commonly booked through the NHS website and used to test individuals who are showing symptoms. Results take between 1-3 days.
c. Other
d. I don't know what type of test it was

Numeracy and recognition questions

Numeracy question
Which of the following numbers represents the biggest risk of getting a disease?

a. 1 in 100
b. 1 in 1000
c. 1 in 10

Recognition question

In this study, what were you told when you received your test result?

a. Your coronavirus test result is inconclusive
b. Your coronavirus test result is positive
c. Your coronavirus test result is negative

Infographic questions (for those in infographic conditions only)

To what extent did you find the infographic (the diagram of what a negative test result means) easy or difficult to understand?

5 - Very easy
4 - Somewhat easy
3 - Neither easy nor difficult
2 - Somewhat difficult
1 - Very difficult

Do you have any suggestions for how the infographic could be improved? Text box

Demographic questions

What is your gender? Male/Female/Non-binary/Prefer not to say/Other

How old are you? Text box (restricted to numbers between 18 and 100)

What is your ethnicity? White British/White other/Asian/Black/Arab/Mixed/Other

In which part of the UK are you currently based? Northern Ireland/Scotland/Wales/ England-South East/England-South West/ England – London/ England-East of England/ England – East Midlands/ England West Midlands/ England – North West/ England – North East/ England – Yorkshire and Humber

What is the highest level of education you have completed? GCSE or equivalent, A levels or equivalent, undergraduate degree, post graduate master's level, postgraduate PhD level

End of study questions

Do you have any comments or feedback about the study (e.g. your experience, how it could be improved)?

Protocol: Reducing false reassurance following negative results from asymptomatic coronavirus (Covid-19) testing: an online experiment

Introduction

Mass Covid-19 testing programmes aim to test large numbers of asymptomatic individuals to reduce the transmission of the virus. Programmes typically utilise lateral flow tests (LFTs) which require a swab taken from the back of the nose or throat and produce results within 30 minutes. Recent data suggest that the sensitivity of LFTs is 50% and the specificity is 99.93%. This means that in a given population, only half of those who are infected with the virus will receive a positive test result. Consequently, among those who receive a negative test result, some individuals will in fact be infected with the COVID-19.

The effectiveness of asymptomatic testing in reducing rates of COVID-19 depends in part on the behavioural responses of those receiving a test-negative result, the great majority of those undergoing such tests. Of concern is that receiving such test results may decrease engagement with behaviours that reduce transmission, including social distancing, wearing face-coverings and hand-washing.

A recent survey by the Winton Centre investigated the impact of messages containing different levels of uncertainty on interpretations of a negative PCR test result. They found that that those who saw a New Zealand based message containing uncertainty were more likely to agree that a symptomatic individual should continue to self-isolate after receiving a negative test than individuals who saw a UK based message that mentioned no uncertainty. This suggests that the influence of test result messages needs to be further explored to understand how behavioural responses to a negative Covid-19 result can be improved in asymptomatic testing.

The current study aims to identify whether communicating residual risk of infection following a negative test can mitigate any unintended consequences on behaviour, i.e. being less likely to follow coronavirus guidelines following a negative test. We will test various methods of communicating uncertainty relating to residual risk to identify which are more effective. We will test messages that are currently communicated to people in the UK as well as more evidence-based messages which should increase understanding of residual risk. We will also examine the influence of messages that contain information about behavioural implications on behavioural intentions.

Aims

To investigate whether understanding and behavioural responses to receiving negative test results can be improved by (a) communicating the residual risk of COVID-19 inherent in a test-negative result using verbal and visual explanations and (b) information about the behavioural implications of a test-negative result.

Methods

Design

An online experiment with a between-subjects design. Participants will read one of several possible messages about receiving a negative Covid-19 test result. The message will contain a) some or no information about residual risk (4 levels) and b) some or no information about the behavioural implications of the test result (2 levels). See Appendix for details of the messages.

a. Residual risk information

1. None

Your coronavirus test result is negative.

2. Uncertainty – positive framing

Your coronavirus test result is negative. It's likely you were not infectious when the test was done. [Wording used by NHS T&T]

3. Uncertainty – positive framing + negative framing

Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.

4. Uncertainty – positive framing + negative framing + infographic

Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.

b. Behavioural implications

i. None

ii. Described

This means you should continue to follow all government guidance to reduce transmission of the virus. You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- hands – wash your hands regularly and for at least 20 seconds
- face – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet
- space – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)

[listed as current government guidance under national lockdown (excluding first sentence): [https://www.gov.uk/guidance/national-lockdown-stay-at-home]

The study is expected to last approximately 6 minutes and will be run on Qualtrics with participant recruitment done using Prolific.

Participants

We will recruit 1205 adults. Gender, age, ethnicity, level of education and UK region will be recorded. Participants who fail the attention check will be excluded and will not be compensated.

Sample size estimate

The two primary outcomes (dependent variables):

(a) understanding of residual risk.

(b) intentions to follow covid-19 rules and regulations.

We will recruit 1205 participants. Based on previous studies, we expect 10% of participants (N=110) to fail the attention check, which leaves 1095 participants in total. We used G*Power (version 3.1) to conduct our power analyses.
For Hypothesis 1, given the lack of prior data we are unable to conduct a power analysis for a logistic regression. We base our power calculation on a chi-square test instead. A sample of 547 allows us to detect a difference with a small effect size (w=0.12) between two groups, using a chi-square test with α=0.05 and power >.80. As we have 4 groups, we estimate that we need double the sample size, i.e. 1094 participants.
For Hypothesis 2, 1095 participants allows us to detect a small effect size (f=0.10) using a between-subjects ANOVA with α=0.05 and power >.80.

Recruitment

A representative sample of the UK adult population (based on age, gender and ethnicity) will be recruited via the online platform Prolific (https://www.prolific.co/).

Measures

Two primary endpoints:

- *Understanding of residual risk (understanding and confidence)*
- *Behavioural intention (general intention and specific behaviours)*

Other measures

- *Perceived test accuracy*
- *Testing uptake intentions*
- *Previous testing behaviour*

Hypotheses

Hypothesis 1: The positive framing message (NHS T&T; group 2) increases understanding of residual risk compared to no message about residual risk (group 1) but reduces understanding compared to adding a negative framing message (group 3) and an infographic (group 4).

Hypothesis 2: Intentions to follow Covid-19 guidelines are higher when the message contains information about continuing to follow Covid-19 rules and regulations after receiving a negative test result.

Analysis

Preregistered analyses (as per the OSF form)

To test Hypothesis 1, we will conduct a binomial logistic regression with residual risk communication, behavioural implications and an interaction term as predictors of understanding of residual risk (coded as correct: 'I am most likely not infectious with coronavirus', or incorrect: all other responses). Group 2 (positive framing) will be used as the reference category for the residual risk communication predictor. Age, gender, ethnicity, education, location and numeracy will be added to the model as covariates.

To test Hypothesis 2, we will conduct a 4 (residual risk communication) x 2 (behavioural implications) between-subjects ANOVA on specific protective behaviours (average score across the 6 questions). If the outcome variable is skewed, we will use transformations to ensure it is normally distributed.

Procedure

After consenting to take part in the study, participants will be asked to imagine that they have taken part in a mass testing programme and received a message about the outcome of the test. They will be randomly allocated to view one of eight possible messages containing a) some or no residual risk information (4 levels) b) some or no information about the behavioural implications of a negative test result (2 levels).

After reading the message, participants will be asked questions that measure their behavioural intentions and understanding of residual risk. These will be informed by the behaviour and intention literature and adapted from previous research by Waller et al. 2020 and the Winton Centre.

Participants will also be asked to answer demographic questions, a numeracy question to assess their understanding of proportions and attention checks to ensure they are paying attention.

Ethical considerations

The study will ask participants about their behaviours and intentions. Informed consent will be obtained from all participants before they participate in the study. The study will be submitted and reviewed by the PHE Research Ethics and Governance Group. Data will be stored in line with GDPR requirements, and no identifiable information will be recorded. The study will be preregistered on the Open Science Framework.

Data handling

Survey responses will remain anonymous, will be stored on secure PHE servers and will not be shared outside of the working group, in line with GDPR regulations.

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	3-4
	2b	Specific objectives or hypotheses	5
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	6
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	NA
Participants	4a	Eligibility criteria for participants	6
	4b	Settings and locations where the data were collected	8
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	6-7
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	7-8
	6b	Any changes to trial outcomes after the trial commenced, with reasons	NA
Sample size	7a	How sample size was determined	6
	7b	When applicable, explanation of any interim analyses and stopping guidelines	NA
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	8
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	8
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	8
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	8
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	8

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	7
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	9
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	9
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	9-10
	13b	For each group, losses and exclusions after randomisation, together with reasons	9
Recruitment	14a	Dates defining the periods of recruitment and follow-up	6
	14b	Why the trial ended or was stopped	6
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	9-10
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	9-14
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	10-14
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	11-13
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	13-14
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	13-14
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	16
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	16
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	15-16
Other information			
Registration	23	Registration number and name of trial registry	5
Protocol	24	Where the full trial protocol can be accessed, if available	5
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	18

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

BMJ Open

Impact of residual risk messaging to reduce false reassurance following test-negative results from asymptomatic coronavirus (SARS-CoV-2) testing: an online experimental study of a hypothetical test

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OFFICIAL SENSITIVE

Impact of residual risk messaging to reduce false reassurance following test-negative results from asymptomatic coronavirus (SARS-CoV-2) testing: an online experimental study of a hypothetical test

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Abstract

Objectives. Individuals who receive a negative lateral flow coronavirus test result may misunderstand it as meaning 'no risk of infectiousness', giving false reassurance. This experiment tested the impact of adding information to negative test result messages about residual risk and the need to continue protective behaviours.

Design. 4 (residual risk) x 2 (post-test result behaviours) between-subjects design.

Setting. Online.

Participants. 1200 adults from a representative UK sample recruited via Prolific (12-15 March 2021).

Interventions. Participants were randomly allocated to one of eight messages. Residual risk messages were: 1) 'Your coronavirus test result is negative' (Control); 2) Message 1 plus 'It's likely you were not infectious when the test was done' (Current NHS Test & Trace); 3) Message 2 plus 'But there is still a chance you may be infectious' (Elaborated NHS T&T); 4) Message 3 plus infographic depicting residual risk (Elaborated NHS T&T + infographic). Each message contained either no additional information or information about the need to continue following guidelines and protective behaviours.

Outcome measures. (i) proportion understanding residual risk of infectiousness and (ii) likelihood of engaging in protective behaviours (scale 1-7).

Results. The control message decreased understanding relative to the current NHS T&T message: 54% vs 71% (AOR=0.56 95%CI [0.34,0.95], p=.030). Understanding increased with the elaborated NHS T&T (89%; AOR=3.25 95%CI [1.64,6.42], p=.001) and elaborated NHS T&T + infographic (91%; AOR=5.16 95%CI [2.47,10.82], p<.001) compared to current NHS T&T message. Likelihood of engaging in protective behaviours was unaffected by information (AOR=1.11 95%CI [0.69,1.80] $\chi^2(1)=0.18$, p=.669), being high (M=6.4,SD=0.9) across the sample.

Conclusions. A considerable proportion of participants misunderstood the residual risk following a negative test result. The addition of a single sentence ('But there is still a chance you may be infectious') to current NHS Test & Trace wording increased understanding of residual risk.

Trial registration. OSF: https://osf.io/byfz3/

Keywords: Covid-19; Public health

Strengths and limitations

- A well-powered, representative sample of UK adults imagined taking part in asymptomatic lateral flow coronavirus testing.
- Participants were randomly allocated to read one of eight test-negative result messages.
- Information currently delivered by NHS Test and Trace was compared to a control message and two intervention messages.
- Expectations of engaging in protective behaviours were measured during a period of national lockdown.

Introduction

As part of the global effort to reduce the transmission of coronavirus (Covid-19), asymptomatic testing via rapid antigen tests such as lateral flow devices (LFDs) has become widespread.[1] LFDs have high specificity (over 99%), meaning they are highly likely to correctly identify people who are not infectious.[2] However, they have lower sensitivity and can incorrectly provide a negative test result in up to 50% of asymptomatic positive Covid-19 cases,[2] either due to lower viral load or improper sampling techniques, which are more likely when tests are conducted unsupervised.[3] This means individuals could be told they are not infectious when in fact they are. Given this, individuals who receive a negative test result (i.e. the majority) need to understand the residual risk of infectiousness and the need to continue following government guidelines.

The extent to which people understand the residual risk of infection after a negative asymptomatic Covid-19 test result is not known. Research in cancer screening suggests that 43% of people believe they definitely do not have cervical cancer following a normal smear test result.[4] This can produce false reassurance and detrimental changes to behaviour,[5] where individuals may be less concerned if they experience symptoms of an infection or disease in the future or may reduce their engagement in protective behaviours.[6-9] This is akin to the 'health certificate effect' whereby a negative result can reduce motivation to protect oneself against a health threat.[6] In the context of Covid-19, if people take a negative test result to mean no risk of infection, this could lead to reduced adherence to Covid-19 guidelines.[10]

Importantly, the way in which negative test results are communicated can affect understanding and behaviour. For example, communicating that there is still a risk of cervical cancer after a negative screening result increases understanding that having cancer is unlikely or very unlikely compared to communicating that the residual risk is lower than for the average person (OR 5.46).[5] In the context of Covid-19, communicating residual risk with a negative PCR test result makes people more likely to agree that a symptomatic individual should continue to self-isolate, compared to not communicating it (96% vs 83).[11] Furthermore, graphical representations of risk have been found to increase understanding in healthcare contexts.[12,13] For example, the addition of an icon array to numerical risk information can improve the accuracy of numerical risk estimates in medical scenarios (medium effect size).[12] This shows that emphasising residual risk in negative test results both visually and verbally could increase understanding that a risk remains.

Test result messages also offer an opportunity to communicate the need to continue adhering to protective behaviours after a negative result, which might not be immediately clear if individuals are given a negative result but told that they could still be infectious. Unambiguous behavioural instructions and guidelines in Covid-19 messaging are encouraged by The British Psychological Society

and can provide the knowledge and capability people need to engage in protective behaviours.[14,15] It is also likely to be valuable given that responses to a health threat are influenced by whether an individual believes there are behaviours they can engage in to reduce or alleviate the risk.[16]

At the time the study was conducted, the NHS Test and Trace (T&T) negative result messaging communicated some residual risk which was positively framed (see Box 1). However, perceptions of risk or uncertainty have been shown to increase when messages contain negative framing or if positive and negative framing are combined, compared to positive framing alone.[17-19] The addition of a negatively framed sentence to the existing NHS T&T messaging could therefore improve understanding. Post-test result behaviours are also included in existing messaging,[20] but to our knowledge have not been evaluated.

Given the dearth of research examining the understanding of residual risk and behaviours following a negative Covid-19 LFD test, we conducted an online experiment examining the impact of communicating about residual risk and protective behaviours following a negative test result. The protocol was preregistered on Open Science Framework (OSF) (https://osf.io/byfz3/) and hypotheses were as follows:

Hypothesis 1: Understanding of residual risk is (a) increased by adding existing NHS T&T messaging compared to no information about residual risk (control) and (b) increased further by adding an elaborated message and an infographic.

Hypothesis 2: Expectations to follow coronavirus guidelines are higher when messages contain information about the need for continued engagement in protective behaviours.

Method

Design. Participants were randomly allocated to a message in a 4 (residual risk) x 2 (post-test result behaviours) between-subjects design (see Box 1).

Participants. A cross-stratified quota sample of 1207 UK adults representative of the UK population based on sex, age and ethnicity was recruited via the online platform Prolific (https://www.prolific.co/) between 12-15 March 2021, during the third national lockdown in England. A quota sample fills predetermined targets so that demographic characteristics are representative of the general population. Participants are prevented from completing the experiment if they belong to a quota that has already been filled.

Power. The power analyses conducted with G*Power (version 3.1) indicated that a sample of 1095 was needed to test the hypotheses. For Hypothesis 1, given the lack of prior data, a power analysis for a logistic regression could not be conducted and was based on a chi-square test instead. A sample of 547 can detect a difference between two groups with a small effect size (w=0.12), using a chi-square test with α=0.05 and power >.80. For 4 groups, it was estimated that double the sample size was needed, i.e. 1094 participants. For Hypothesis 2, 1095 participants can detect a small effect size (f=0.10) using a between-subjects ANOVA with α=0.05 and power >.80. We planned to exclude participants who failed an attention check (see Supplementary Material). As 10% of participants were expected to fail it, 1205 participants were needed to ensure 1095 participants could be included in the analysis.

Messages. Participants imagined they had taken a lateral flow test and received one of 8 messages in a 4 (residual risk) x 2 (post-test result behaviour) factorial design (see Box 1 and Supplementary Material). The messages incrementally varied the level of residual risk communicated. The control condition provided no information about residual risk, the current NHS T&T[1] condition adds positively framed information about residual risk to the control message, the elaborated NHS T&T condition adds negatively framed information about residual risk to the existing NHS T&T messaging, and the elaborated NHS T&T and infographic condition adds an infographic with numerical residual risk information to the elaborated NHS T&T message. The infographic is based on 1% prevalence, 99% specificity and 50% sensitivity and includes a) a flow chart illustrating among a given population the number of positive and negative test results within individuals who are infected and

[1] Messages are provided by NHS T&T when communicating test results to those who have taken a lateral flow test at a test site or reported their home test result to NHS T&T. At the time of the study, the message communicated by NHS T&T after a negative test result included further information that we did not include in the messages in this study. The NHS T&T wording tested here is the residual risk sentence 'It's likely you were not infectious when the test was done' which follows the statement of the negative test result, as in this study.

those who are not and b) an icon array demonstrating the proportion of those receiving a negative result who are actually infected.

The message also contained either none or some information about the need to maintain adherence to protective behaviours following a negative test result, as listed on UK government guidance under national lockdown in March 2021.[21] This information indicates that people should continue to follow all government guidance and reminds them of key protective behaviours (hands, face, space).

Residual risk messages

No residual risk information:

'Your coronavirus test result is negative.'

Current NHS Test & Trace:

'Your coronavirus test result is negative. It's likely you were not infectious when the test was done.'

Elaborated NHS Test & Trace:

'Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.'

Elaborated NHS Test & Trace + infographic:

'Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.' + infographic (see Supplementary Material)

Post-test result behaviours

This means you should continue to follow all government guidance to reduce transmission of the virus. You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- *hands – wash your hands regularly and for at least 20 seconds*
- *face – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet*
- *space – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)*

Box 1: Intervention messages (a) Residual risk and (b) post-test result behaviours.

Primary outcome measures. Primary outcome measures were understanding of residual risk and behavioural expectations to follow Covid-19 guidelines after receiving a hypothetical negative test result (see Supplementary Material). Understanding of residual risk was measured by asking participants to identify the correct statement from four options: 'I am not infectious with coronavirus',

'I am most likely not infectious with coronavirus' (correct), 'I am most likely infectious with coronavirus', 'I am infectious with coronavirus'.

Behavioural expectations to follow Covid-19 guidelines were measured with specific protective behaviour questions and a general question. Six protective behaviours were measured with a 7-point scale question: 'After receiving this test result, how likely is it that you would engage in the following behaviours because of coronavirus?' (behaviours: social distancing, hand washing, wearing a face covering, avoiding meeting others, working from home, avoiding public transport; 1-very unlikely to 7-very likely), taken from a previous study.[22] There was good reliability between questions (Cronbach's $\alpha = .86$) which were averaged to provide an overall score of behavioural expectation. The general question was adapted from previous studies: 'Having received this test result, how strictly would you follow coronavirus guidelines now compared to before taking the test?' (1-a lot less strictly; 7-a lot more strictly).[22,23]

Secondary outcome measures. Secondary outcome measures were confidence in understanding, perceived test accuracy and testing uptake expectations (see Supplementary Material). Participants were asked how confident they were in their understanding of residual risk (1-not at all confident; 5-extremely confident). They were asked how accurate they thought rapid lateral flow tests were (1-very inaccurate; 7-very accurate) and how likely they were to take a rapid lateral flow test in the future (1-very unlikely; 7-very likely) as there is a risk that communicating residual risk could give the impression that antigen tests are inaccurate and not worth taking.

Other measures. Participants were asked about their previous testing experience, including the last time they took a coronavirus test and what type of test it was (see Supplementary Material). A frequently used numeracy question was administered to assess their understanding of proportions.[24] Those who received the message containing the infographic were asked how easy it was to understand (1-very difficult; 5-very easy) and any suggestions for improvements (text box). An attention check (a multiple-choice question asking participants not to select an option) and a recognition question (asking participants to select the test result they received) were included to evaluate participant attention throughout the study. Finally, participants were asked demographic questions (gender, age, ethnicity, UK region, highest level of education).

Procedure. Participants were recruited via Prolific and then directed to the study on Qualtrics. They were asked to imagine they had taken a lateral flow test as part of a local mass asymptomatic testing programme, similar to those taking place in the UK.[25] They then received a message about the result of their test, to which they were randomised using the Qualtrics randomisation function, and answered a series of questions (see Supplementary Material). Participants were unaware of the

condition they were allocated to and paid at a rate of £25 per hour (i.e. £2.10 for a 5-minute experiment). See Supplementary file for study protocol.

Patient and public involvement. Patients and/or the public were not involved in the development of the study due to the rapid nature of this research. However, the experiment was piloted with 16 participants to ensure it ran smoothly and that there were no errors. Those who took part in the pilot were able to provide feedback to researchers on the study.

Analysis. Pre-registered analyses were conducted using Stata (version 15) with a significance level of $p<.05$. To test Hypothesis 1, a binomial logistic regression was conducted with residual risk, post-test result behaviour and an interaction term as predictors of understanding (coded as correct: 'I am most likely not infectious with coronavirus', or incorrect: all other responses). Group 2 (current NHS T&T) was used as the reference category for the residual risk predictor. Age, gender, ethnicity, education, location and numeracy were added to the model as covariates. Expected engagement in specific behaviours was negatively skewed and remained in violation of the assumption of normality following logarithmic transformation. The pre-planned 4 (residual risk) x 2 (post-test result behaviour) between-subjects ANOVA on specific protective behaviours was therefore unsuitable and an ordinal regression was conducted to test Hypothesis 2. Other analyses reported are exploratory. The dataset is publicly available.[26]

Results

Of the 1207 participants who completed the study, 7 (0.6%) failed the attention check and were excluded from the analysis. A breakdown of the demographic characteristics of the remaining 1200 participants can be found in Table 1. There were no demographic differences between participants in each condition (see Supplementary File, Table 1).

Table 1: Participant demographic characteristics

Demographic characteristic	n	%
Gender		
Male	582	48.5%
Female	615	51.2%
Non-binary	1	0.1%
Prefer not to say	2	0.2%
Age		
18-24	127	10.6%
25-34	205	17.1%
35-44	206	17.2%
45-54	217	18.1%
55-64	274	22.8%
65+	171	14.3%
Education		
GCSE or equivalent	221	18.4%
A level or equivalent	298	24.8%
Undergraduate degree	482	40.2%
Postgraduate degree	199	16.6%
Ethnicity		
White - British	906	75.5%
White - Other	113	9.4%
Asian	98	8.2%
Black	41	3.4%
Mixed	32	2.7%
Other	10	0.9%
UK region		
NI/Scotland/Wales	162	13.4%
England – South	316	26.3%
England – London	155	12.9%
England – Midlands	268	22.3%
England – North	299	24.9%
Testing experience		
Yes – PCR	235	19.6%
Yes – LFT	281	23.4%

Yes – Other (e.g. antibody)	33	2.8%
Yes – Don't know	44	3.7%
None	607	50.6%

Table 2: Primary and secondary outcomes (%(n); mean (SD)) by experimental group

	Residual risk				Post-test result behaviours	
	Control (n=300)	NHS T&T (n=298)	Elaborated (n=302)	Infographic (n=300)	None (n=602)	Included (n=598)
Primary measures						
Understanding						
I am not infectious	45.3% (n=136)	28.2% (n=84)	9.6% (n=29)	7.7% (n=23)	19.6% (n=118)	25.8% (n=154)
I am most likely not infectious*	54.3% (n=163)	71.1% (n=212)	88.7% (n=268)	90.7% (n=272)	79.7% (n=480)	72.7% (n=435)
I am most likely infectious	0% (n=0)	0.3% (n=1)	1.3% (n=4)	0.7% (n=2)	0.5% (n=3)	0.7% (n=4)
I am infectious	0.3% (n=1)	0.3% (n=1)	0.3% (n=1)	1.0% (n=3)	0.2% (n=1)	0.8% (n=5)
Specific behaviours						
Average	6.40 (0.9)	6.46 (0.8)	6.42 (0.9)	6.33 (1.1)	6.39 (0.9)	6.41 (0.9)
Social distancing	6.52 (1.0)	6.55 (1.0)	6.53 (1.0)	6.46 (1.2)	6.53 (1.0)	6.50 (1.1)
Hand washing	6.45 (1.0)	6.50 (1.0)	6.46 (1.1)	6.41 (1.2)	6.48 (1.1)	6.44 (1.1)
Face covering	6.70 (0.8)	6.71 (0.9)	6.71 (0.9)	6.55 (1.3)	6.70 (0.9)	6.63 (1.1)
Avoid meeting others	6.20 (1.3)	6.21 (1.3)	6.15 (1.3)	6.00 (1.5)	6.09 (1.3)	6.18 (1.3)
Work from home	6.19 (1.5)	6.32 (1.4)	6.24 (1.4)	6.21 (1.4)	6.20 (1.5)	6.28 (1.4)
Avoid public transport	6.28 (1.4)	6.47 (1.2)	6.44 (1.2)	6.34 (1.3)	6.35 (1.3)	6.43 (1.2)
Secondary measures						
Expectations to follow guidelines	4.23 (0.9)	4.18 (0.8)	4.25 (0.9)	4.32 (0.9)	4.19 (0.8)	4.30 (0.8)
Confidence in understanding	4.17 (0.8)	4.35 (0.8)	4.23 (0.8)	4.32 (0.8)	4.24 (0.8)	4.29 (0.8)
Perceived testing accuracy	5.71 (1.1)	5.71 (1.1)	5.61 (1.1)	5.95 (1.0)	5.75 (1.1)	5.74 (1.1)
Future testing expectations	5.90 (1.6)	5.92 (1.6)	5.88 (1.6)	5.99 (1.6)	5.90 (1.6)	5.95 (1.6)

Notes: * refers to a correct understanding of residual risk. Confidence is on a 5-point scale and other continuous variables on a 7-point scale.

Understanding of residual risk. Understanding varied by residual risk message as outlined in Hypothesis 1 (see Table 2), as shown by a binomial logistic regression in Table 3. Those who saw the existing NHS T&T message were more likely to have a correct understanding of residual risk (71.1%) than those in the control group who received no information about residual risk (54.3%) (AOR=0.56 95%CI [0.34, 0.95], $\chi^2(1)=4.70$, $p=.030$) (see Figure 1). Those who saw the elaborated NHS T&T message were more likely to have a correct understanding (88.7%) than those who saw the existing NHS T&T message (AOR=3.25 95%CI [1.64, 6.42], $\chi^2(1)=11.50$, $p=.001$). This was also the case for the elaborated

NHS T&T message with the infographic (90.7%) (AOR=5.16 95%CI [2.47, 10.82], $\chi^2(1)=18.94$, $p<.001$). However, understanding in this condition was not significantly higher than the elaborated NHS T&T message alone ($\chi^2(1)=1.14$, $p=.286$). Understanding was lower among those with lower education, those aged 65+ compared to those aged 45-64, those with lower numeracy and those from Black and Mixed ethnicity compared to White British ethnicity (see Table 3). The model correctly classified 78.9% of cases and was a good fit to the data according to the Hosmer–Lemeshow test ($\chi^2(8)=3.36$, $p=.910$). In a separate exploratory analysis, previous testing experience (coded as Yes: PCR, LFT, Other, Don't know, coded as No: None (ref category)), was added to the pre-planned logistic regression model as a covariate. This did not significantly predict understanding of residual risk, nor did it alter any other effects (See Supplementary File, Table 2).

Confidence in understanding. As planned, we explored whether residual risk messages affected confidence in understanding among those who were correct (76.3%), to assess the effectiveness of messages beyond understanding. Residual risk information affected confidence ($F(3,907)=10.94$, $p<.001$, $\eta 2=.04$), with the control group being less confident ($M=3.93$, $SD=0.77$) than existing NHS T&T ($M=4.36$, $SD=0.73$, $p<.001$), elaborated NHS T&T ($M=4.24$, $SD=0.81$, $p<.001$) and elaborated NHS T&T with the infographic ($M=4.32$, $SD=0.80$, $p<.001$) according to post-hoc tests (Tukey). There were no significant differences between other groups. Neither post-test result behaviours ($F(1,907)=1.06$, $p=.304$, $\eta 2<.01$) nor the interaction between residual risk and post-test result behaviours ($F(3,907)=0.53$, $p=.664$, $\eta 2<.01$) had a significant effect on confidence.

Table 3: Logistic regression predicting correct understanding of residual risk.

	AOR	95% CI	Wald	*p**
Intercept	0.61	0.29, 1.31	1.58	.209
Residual risk				
Control	0.56	0.34, 0.95	4.70	**.030**
NHS T&T (reference)				
Elaborated T&T	3.25	1.64, 6.42	11.50	**.001**
Elaborated T&T + infographic	5.16	2.47, 10.82	18.94	**<.001**
Post test result behaviours				
Without (reference)				
With	0.81	0.48, 1.36	0.65	.421
Residual Risk Post-test result behaviours*				
NHS T&T * With (reference)				
Control * With	0.65	0.32, 1.33	1.38	.240
Elaborated T&T * With	0.95	0.38, 2.37	0.01	.907
Elaborated T&T + infographic * With	0.77	0.29, 2.04	0.27	.605

Gender[2]				
Male (reference)				
Female	1.06	0.78, 1.43	0.13	.716
Age				
18-24	1.76	0.93, 3.33	3.07	.080
25-34	1.45	0.85, 2.46	1.87	.172
35-44	1.56	0.91, 2.65	2.66	.103
45-54	1.74	1.03, 2.91	4.35	**.037**
55-64	1.68	1.04, 2.73	4.41	**.036**
65+ (reference)				
Education				
GCSE or equivalent (reference)				
A-level or equivalent	1.82	1.18, 2.80	7.27	**.007**
Undergraduate	2.73	1.82, 4.11	23.29	**<.001**
Postgraduate	4.95	2.85, 8.61	32.12	**<.001**
Ethnicity				
White British (reference)				
White Other	0.81	0.47, 1.41	0.53	.465
Asian	0.61	0.34, 1.09	2.83	.093
Black	0.33	0.15, 0.71	7.94	**.005**
Mixed	0.36	0.15, 0.91	4.70	**.030**
Other	0.64	0.12, 3.54	0.26	.613
Location				
London (reference)				
Northern Ireland	1.12	0.27, 4.57	0.02	.876
Scotland	0.82	0.41, 1.63	0.33	.567
Wales	0.62	0.28, 1.40	1.31	.252
South England	1.08	0.63, 1.83	0.08	.784
Midlands	1.46	0.84, 2.54	1.76	.185
North England	0.86	0.51, 1.46	0.32	.574
Numeracy				
Incorrect (reference)				
Correct	1.69	1.17, 2.45	7.85	**.005**

Notes: * Significant p-values are shown in bold.

Post-test result behaviours.

The variable measuring expectations to engage in protective behaviours remained negatively skewed after logarithmic transformations making the pre-planned ANOVA unsuitable. An ordinal

[2] To ensure meaningful comparisons between genders, participants who reported their gender as 'non-binary' (n=1) or 'prefer not to say' (n=2) were excluded from the logistic regression analysis given low numbers in each group. When included in the analysis, their understanding of residual risk was not significantly different from the reference category (male) nor did this alter the significance or direction of the other effects or analyses.

regression was conducted to explore the influence of information about residual risk, post test result behaviours and their interaction on expected engagement in protective behaviours, which was rounded to the nearest whole value and reverse scored to allow easier interpretation of the model. Communicating the need to maintain protective behaviours following a negative test result did not significantly increase expected engagement in protective behaviours (AOR=1.11 95%CI [0.69,1.80] $\chi^2(1)=0.18$, $p=.669$), which does not support Hypothesis 2. Neither the level of residual risk information nor the interaction between residual risk information and post-test result behaviours had a significant effect on expected engagement in protective behaviours (See Supplementary file, table 3 for full output). The model was a poor fit to the data (McFadden's pseudo $R^2=.002$).

An ordinal regression was also conducted to explore the influence of the predictors on expectations to follow guidelines compared to before receiving a negative result. This variable was clustered around the centre of the scale; 82% of participants selected option 4 – the same as before. Communicating the need to maintain protective behaviours following a negative test result did not significantly increase expectations to follow guidelines (AOR=1.24 95%CI [0.66, 2.29] $\chi^2(1)=0.45$, $p=.502$). Neither the level of residual risk information nor the interaction between residual risk and post-test result behaviours had a significant effect on expected engagement in protective behaviours (See Supplementary file, Table 3 for full output). This model was also a poor fit to the data (McFadden's pseudo $R^2=.009$).

Perceived accuracy. Perceived accuracy of lateral flow tests (see Table 2) was influenced by residual risk condition ($F(3,1192)=5.38$, $p=.001$, $\eta 2=.01$). Those who saw the infographic perceived lateral flow tests as more accurate ($M=5.95$, $SD=1.00$) than those who saw no residual risk information ($M=5.71$, $SD=1.10$; $p=.034$), existing NHS T&T messaging ($M=5.71$, $SD=1.10$; $p=.029$) and elaborated NHS T&T messaging ($M=5.61$, $SD=1.17$; $p=.001$) according to post-hoc tests (Tukey). There were no significant differences between other groups. Neither post-test result behaviours ($F(1,1192)=0.06$, $p=.809$, $\eta 2<.01$) nor their interaction with residual risk ($F(3,1192)=0.45$, $p=.714$, $\eta 2<.01$) affected perceived accuracy.

Uptake expectations. Expectations to engage in asymptomatic lateral flow testing in the future (see Table 2) were not affected by residual risk information ($F(3,1192)=0.27$, $p=.849$, $\eta 2<.01$), post-test result behaviours ($F(1,1192)=0.37$, $p=.545$, $\eta 2<.01$) or their interaction ($F(3,1192)=1.30$, $p=.272$, $\eta 2<.01$).

Association between understanding and behavioural expectations. We explored whether those who had a correct understanding (n=915) were more likely to engage in protective behaviours compared to those who reported that there was no residual risk (n=272), bearing in mind participants were not randomised to each group. Those with a correct understanding did not have higher expected

engagement in protective behaviours (*M*=6.40, *SD*=0.95) than those who believed there was no residual risk (*M*=6.38, *SD*=0.87) (*t*=0.47, df=1185, *p*=.641). Expectations to follow guidelines after receiving a negative test result as strictly as before were lower among those with a correct understanding of residual risk (*M*=4.19, *SD*=0.73) than those who believed there was no residual risk (*M*=4.35, *SD*=1.07) (*t*=2.24, df=349.37, *p*=.026).

Discussion

Enhanced communication of residual risk information in negative asymptomatic coronavirus test results improved understanding of residual risk, without evidence that it decreased the perceived accuracy of LFDs or testing uptake expectations. The elaborated NHS T&T message was better understood than the current NHS T&T message (89% vs 71% correct), which itself was more effective than giving no residual risk information (54% correct), in support of Hypothesis 1. The elaborated NHS T&T message added residual risk information which was negatively framed ('But there is still a chance you may be infectious') to the current NHS T&T message, which was positively framed ('It's likely you were not infectious when the test was done'). This study therefore echoes previous findings on negatively framed communications of residual risk,[5] which it furthers by evidencing the effectiveness of adding a negatively framed sentence to a positive frame. This somewhat resonates with other research showing that this framing order (positive followed by negative) results in lower perceived efficacy of the HPV vaccination than an exclusively positive frame.[19]

Adding an infographic with an icon array of residual risk did not significantly improve understanding relative to the elaborated NHS T&T message. This may be due to a ceiling effect given that the elaborated NHS T&T message increased understanding to nearly 90%. Although it contrasts with previous findings on the effectiveness of infographics,[12,13] there is a precedent for them not increasing understanding of residual risk relative to verbal communications.[4] The infographic increased perceptions of testing accuracy, which could be because it includes numerical information which participants associated with accuracy. Indeed, this seems akin to the 'seductive allure effect' whereby people find psychological explanations more convincing when presented alongside irrelevant neuroscience information.[27] Furthermore, this did not result in differences on other measures, suggesting it is not a meaningful effect in terms of understanding, behavioural expectations or uptake expectations.

Importantly, a substantial proportion of participants had an incorrect understanding of the residual risk inherent in a test-negative result after reading the negative result message without any residual risk information (46%) or the current message used by NHS Test and Trace (29%). This emphasises the importance of revising existing messaging and wider communications to better address misconceptions among the general public. Lower levels of understanding were also evidenced among certain demographic groups. Understanding was lower as education level and numeracy decreased, in those aged 65+ compared to those aged 45-64 and in groups self-classifying as Black and Mixed ethnicity compared to White British. This mirrors findings in other risk communication trials, where higher understanding is associated with higher education,[4,28,29] higher numeracy and White British ethnicity.[28] Communicating the need to maintain adherence to protective behaviours

following a negative test result did not increase expectations of engaging in protective behaviours (which does not support Hypothesis 2), although these may have been subject to ceiling effects given the high reported likelihood of engaging in protective behaviours across the sample (*M*=6.4, *SD*=0.9). This finding is akin to other similar Covid-19 vaccine communications tested during lockdown.[22] Information about post-test result behaviours did not increase expectations to follow coronavirus guidelines, with the majority of participants (82%) reporting that they would follow guidelines as strictly as before receiving a negative result. Participants who believe there to be no residual risk of infectiousness following a negative test result were more likely to report they expect to follow guidelines than those who correctly understood residual risk, although both groups reported that, on average, they would follow guidelines as strictly as before (and so there is no evidence of any backfiring effect). A speculative interpretation of this unexpected finding is that those who believe there to be no residual risk of infection are less familiar with Covid-19 guidance and thus engaging with it during this study prompted some individuals to reconsider their behaviour. Replication of this result as a pre-planned hypothesis is warranted before discussing further.

Strengths and weaknesses of the study

This study provides the first experimental evidence that some misunderstand there to be no residual risk of infectiousness following a negative asymptomatic Covid-19 test result, while demonstrating the effectiveness of simple, low-cost interventions to increase understanding. Implementing these interventions would be a valuable step in ensuring that the implications of asymptomatic LFD testing are more often understood by the public.

The study has several limitations. First, participants were responding to a hypothetical test result. The interventions would benefit from being tested in a real world setting to check that the increase in understanding is maintained. Second, expectations of engaging in protective behaviours were high. This could have been due to national lockdown restrictions being in place at the time, as in previous studies.[22,30] As restrictions ease, there might be more variability in the propensity to follow guidelines and more pronounced effects of messaging on behaviour. Third, a quota sample was used. Although it was broadly demographically representative of the UK population, it was limited to internet users and could have been subject to bias.[31] A quota sample was favoured as it enables rapid data collection and can therefore meet the demands of a crisis.[32] Participants were randomly allocated to each message, meaning their effects can be experimentally compared and any issues about representativeness are unlikely to affect the interpretation of the findings.

It is possible that the correct response to the measure of residual risk understanding was made salient to participants by the linguistic similarity between the information presented in three of the

residual risk conditions ("It's likely you were not infectious") and the wording of the correct item ("I am most likely not infectious"). However, significant differences in understanding were observed between conditions where this wording was used (NHS T&T, Elaborated condition, Infographic condition). This suggests that participant responses were not exclusively driven by recognition of wording similarity and that the addition of a single sentence ('But there is still a chance you may be infectious') was sufficient in improving relative understanding of residual risk. Future studies could investigate the influence of wording similarity by exploring alternative measures of residual risk understanding.

Implications for policymakers

The results of this study suggest that adding one sentence to a pre-existing single sentence can increase understanding of the meaning of a negative test result. These findings merit implementation with an evaluation to confirm whether understanding influences behaviour in a real-world setting. However, stronger messages may be needed in contexts where residual risk of infectiousness is higher than in asymptomatic community testing programmes. Messages which include only negatively framed residual risk information could be more effective than the combined positive and negative framing used in this study.

The study also suggests that there was a considerable level of misunderstanding (46%) among participants who received no residual risk information, with the majority believing that a negative LFT result means they are not infectious. It is likely that these misconceptions also exist in situations where residual risk information is absent, such as when individuals conduct an LFT at home and read their result directly from the test device. Residual risk information should be clearly communicated in information booklets that accompany home test kits and policymakers should consider how this can be disseminated beyond the testing environment to improve understanding among those less likely to read or receive test result messages.

Unanswered questions and future research

The effects of education, numeracy and ethnicity on understanding of residual risk were consistent with prior studies on risk communication,[4,28,29] and understanding was also lower among those in the most vulnerable age category (aged 65+). This suggests there are additional barriers to understanding in those who are older, have lower education, lower numeracy and of Black and Mixed ethnicity. Future research should seek to identify and tackle these barriers, to which end co-producing messages with these populations could be a useful approach.[33,34] Finally, future research should evaluate the effectiveness of the messages that people receive after a positive LFD

test result, in terms of encouraging self-isolation or following up with a PCR test. Ensuring people do self-isolate after a test-positive result is important given recent findings that fewer than 50% of symptomatic individuals fully self-isolate.[35]

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Contributors

EB contributed to conceptualising and designing the study, completed data collection and analysis and drafted the manuscript. SB contributed to conceptualising and designing the study, assisted with data collection and analysis, contributed to and approved the final manuscript. LFJ contributed to conceptualising and designing the study, contributed to and approved the final manuscript. HC contributed to conceptualising and designing the study, contributed to and approved the final manuscript. NG contributed to conceptualising and designing the study, contributed to and approved the final manuscript. RA contributed to conceptualising and designing the study, contributed to and approved the final manuscript. TMM framed the broad research question, contributed to conceptualising and designing the study, contributed to and approved the final manuscript. DW contributed to conceptualising and designing the study, contributed to and approved the final manuscript.

Ethics approval

The study was reviewed and approved by Public Health England's Research and Ethics Governance Group (RD432).

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Competing interests

The authors have no competing interests to declare.

Transparency statement

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as originally planned have been explained.

Dissemination to participants and related patient and public communities

Participants took part in the study anonymously, meaning the authors do not have the necessary details to send participants the results of the study. These findings have been disseminated to relevant stakeholders across government.

Data sharing

The dataset is publicly available from Open Science Framework: https://osf.io/byfz3/.

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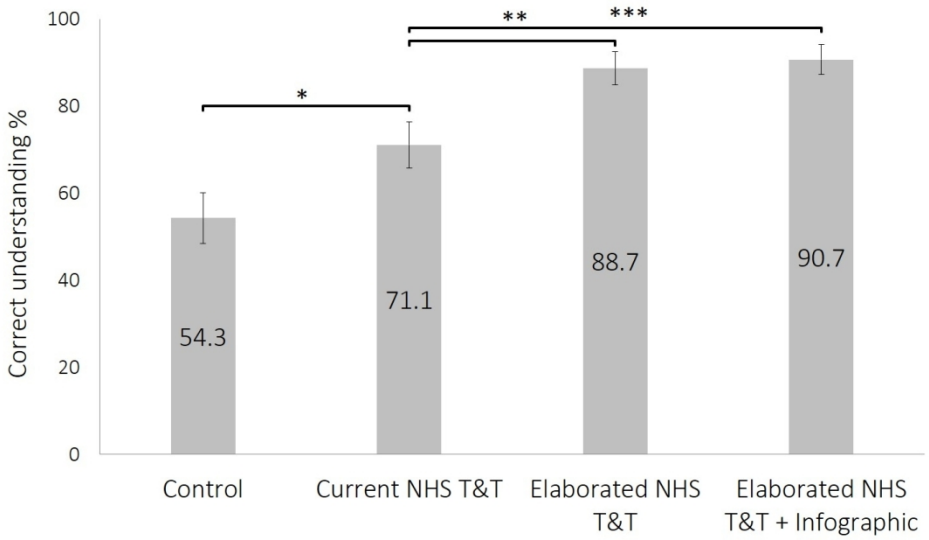
Figure legends

Figure 1: Percentage of participants with a correct understanding of residual risk by residual risk experimental group. Error bars represent 95% confidence intervals. Significance levels are based on the logistic regression in Table 3). * refers to p<.05, ** refers to p<.01, *** refers to p<.001.



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260x176mm (150 x 150 DPI)

Supplementary material

Survey instructions

General Instructions

You will be asked to imagine that you have participated in a mass testing programme for coronavirus. You will be presented with test results and answer a series of questions about this.

Please read the information carefully as afterwards we will ask you some questions about it, including testing if you remember what the information was.

Scenario

Imagine that you have agreed to take part in a mass testing programme for coronavirus in your local area. The programme intends to test as many people as possible who are not currently experiencing symptoms using rapid lateral flow tests.

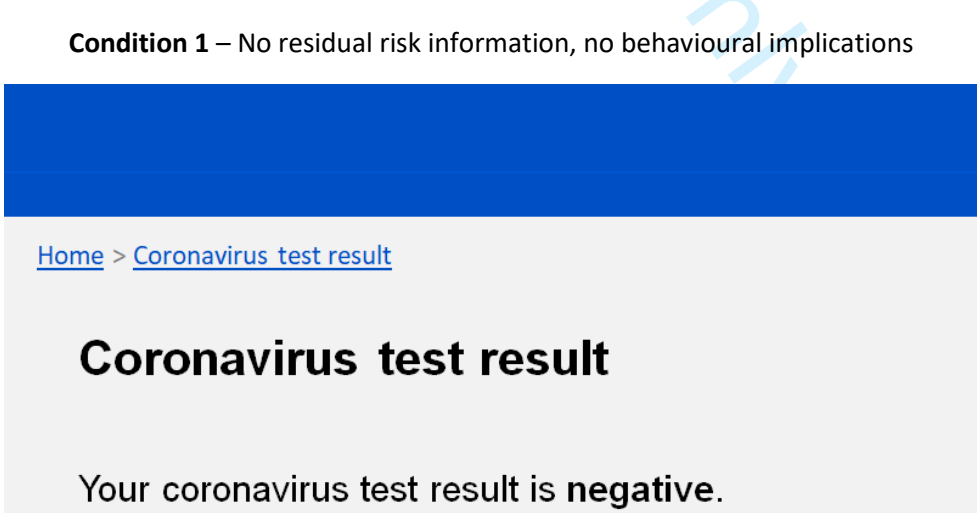
You arrive at the test site and are tested using a lateral flow test which involves taking a swab from the back of the throat or the nose. You then leave the test site and are told you will be sent results in approximately 30 minutes.

Half an hour later, you receive your test results.

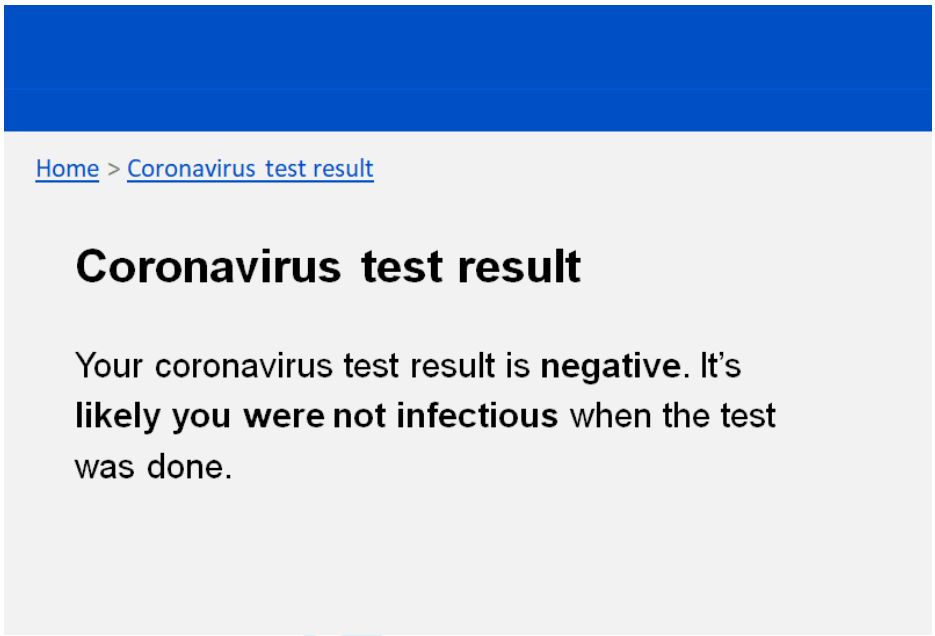
Messages

(Note all messages were displayed with the same font size)

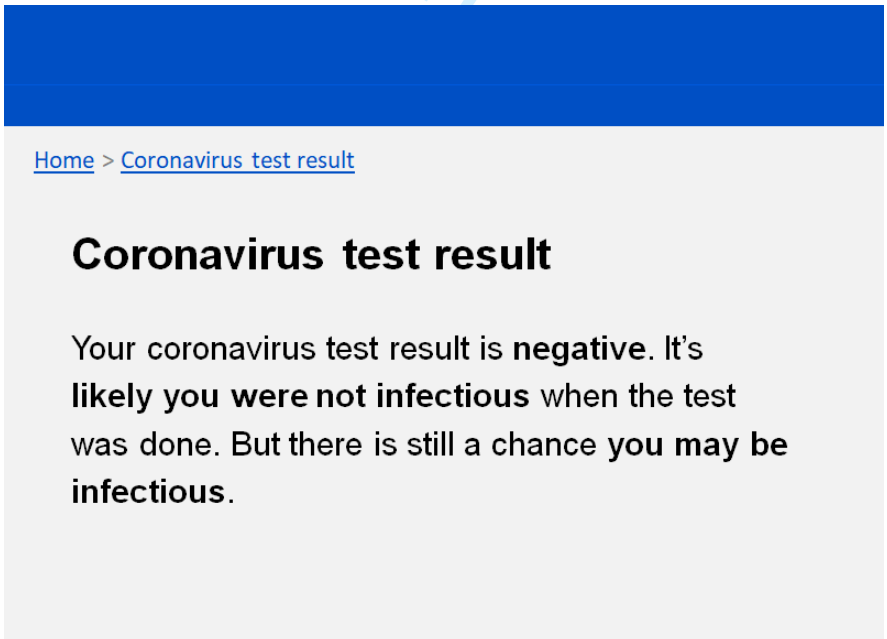
Condition 1 – No residual risk information, no behavioural implications



Condition 2 – Current NHS Test & Trace message, no behavioural implications



Condition 3 – Elaborated NHS Test & Trace message, no behavioural implications



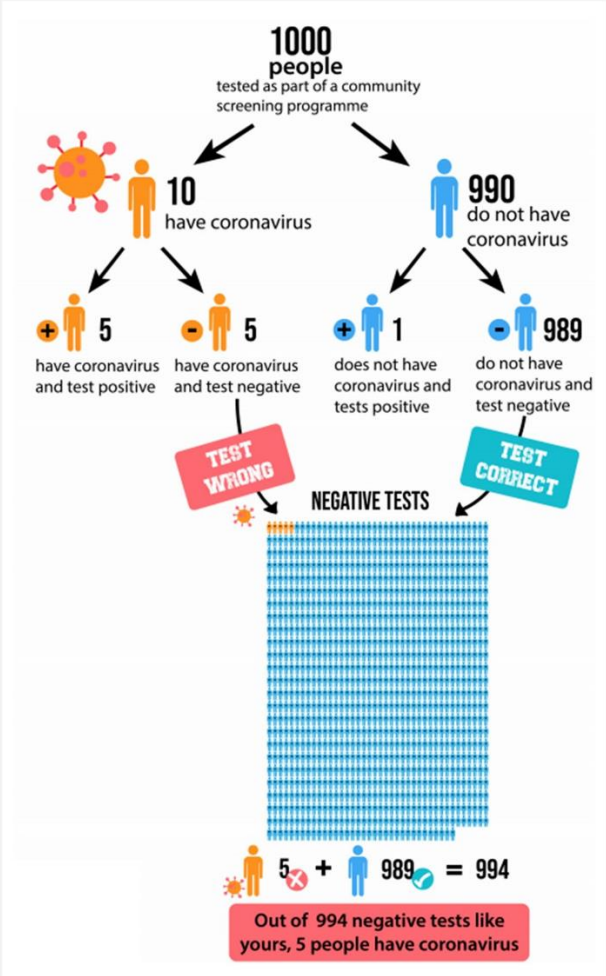
Condition 4 – Elaborated NHS Test & Trace message with infographic, no behavioural implications

Home > Coronavirus test result

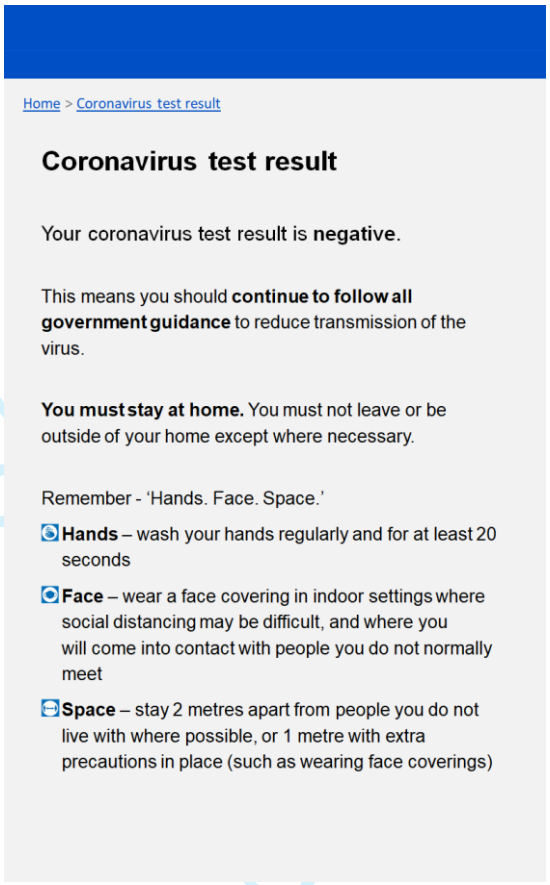
Coronavirus test result

Your coronavirus test result is **negative**. It's **likely you were not infectious** when the test was done. But there is still a chance **you may be infectious**.

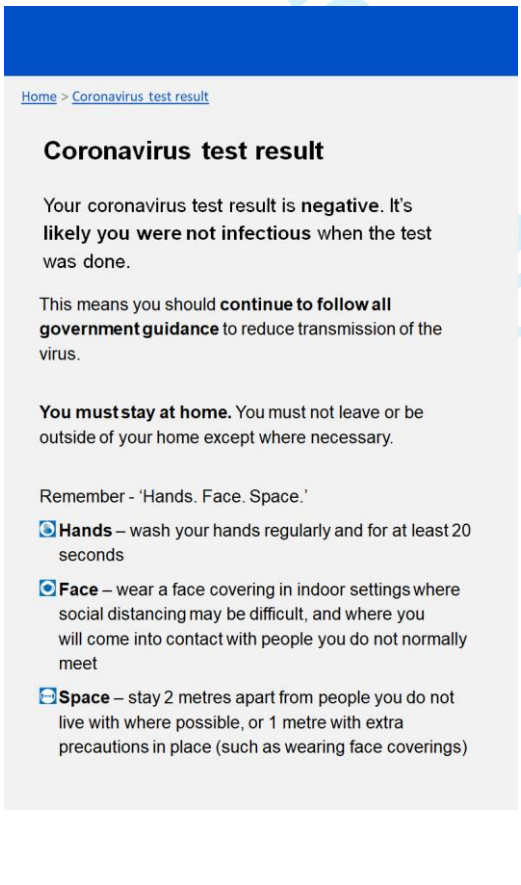
The infographic shows you how likely it is that you are infectious.



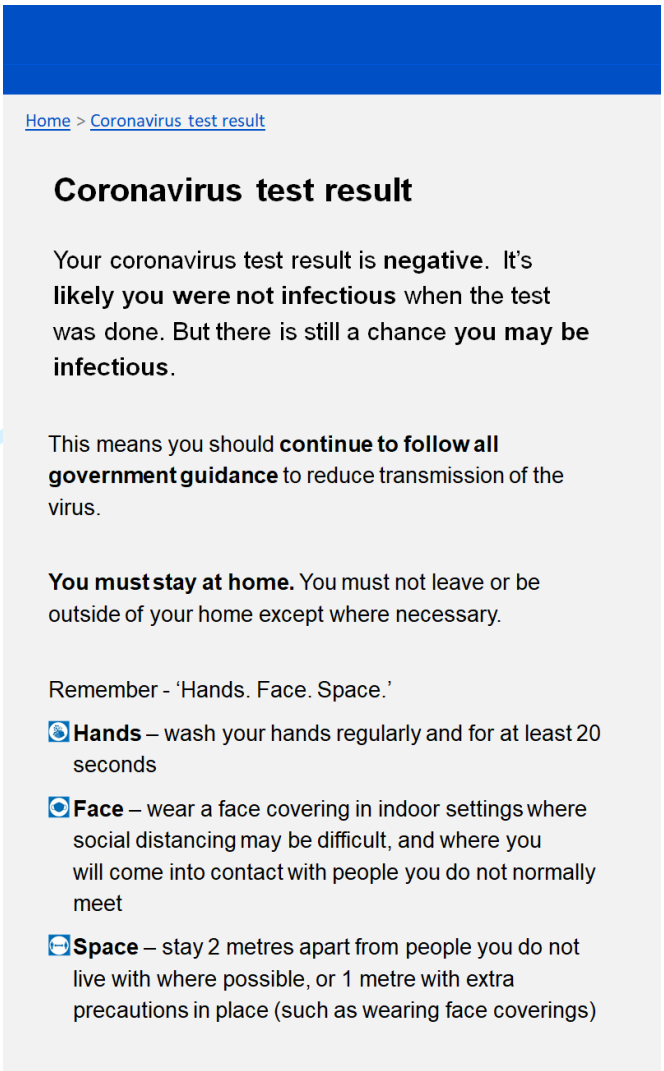
Condition 5 – No residual risk information, with behavioural implications



Condition 6 – Current NHS Test & Trace message, with behavioural implications



Condition 7 – Elaborated NHS Test & Trace message, with behavioural implications



Home > Coronavirus test result

Coronavirus test result

Your coronavirus test result is **negative**. It's **likely you were not infectious** when the test was done. But there is still a chance **you may be infectious**.

This means you should **continue to follow all government guidance** to reduce transmission of the virus.

You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- **Hands** – wash your hands regularly and for at least 20 seconds
- **Face** – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet
- **Space** – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)

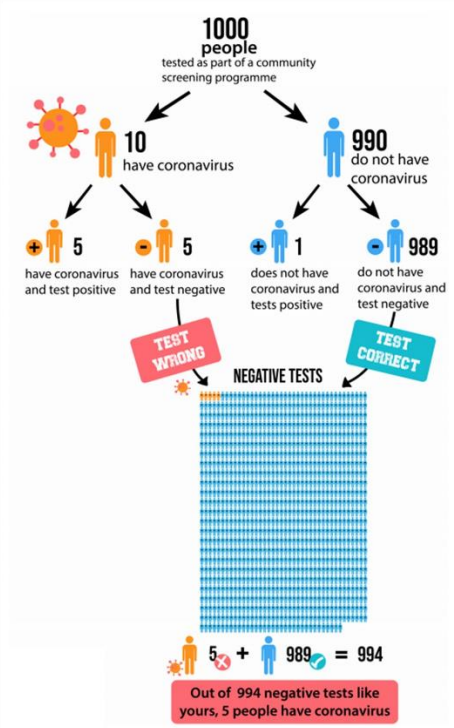
Condition 8 – Elaborated NHS Test & Trace message with infographic and behavioural implications

Home > Coronavirus test result

Coronavirus test result

Your coronavirus test result is **negative**. It's **likely you were not infectious** when the test was done. But there is still a chance **you may be infectious**.

The infographic shows you how likely it is that you are infectious.



This means you should **continue to follow all government guidance** to reduce transmission of the virus.

You must stay at home. You must not leave or be outside of your home except where necessary.

Remember - 'Hands. Face. Space.'

- **Hands** – wash your hands regularly and for at least 20 seconds
- **Face** – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet
- **Space** – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)

Question set

Primary and secondary outcome measures

Understanding of residual risk

Having received this test result, which one of the following statements is true?

1. I am not infectious with coronavirus
2. I am most likely not infectious with coronavirus
3. I am most likely infectious with coronavirus
4. I am infectious with coronavirus

Confidence in understanding

How confident are you that you have answered the previous question correctly?

5- Extremely confident
4- Very confident
3- Moderately confident
2- Slightly confident
1- Not at all confident

Attention check question

How worried would we be if you didn't pay attention? To check that you are paying attention, please do not select an answer below.

a. Strongly agree
b. Somewhat agree
c. Neither agree nor disagree
d. Somewhat disagree
e. Strongly disagree
f. Don't know

Behavioural intention - general behaviours

Having received this test result, how strictly would you follow coronavirus guidelines now compared to before taking the test?

7. A lot more strictly
6. More strictly
5. Slightly more strictly
4. The same as before
3. Slightly less strictly
2. Less strictly
1. A lot less strictly

Behavioural intention - Specific protective behaviours

After receiving this test result, how likely is it that you would engage in the following behaviours because of coronavirus?

> Social distancing - staying more than 1m from people not in your bubble
> Washing your hands carefully and frequently
> Wearing a face covering in indoor public spaces
> Avoiding meeting with others
> Working from home whenever possible
> Avoiding public transport whenever possible

7 - Very likely
6 - Moderately likely
5 - Slightly likely

4 - Neither likely nor unlikely
3 - Slightly unlikely
2 - Moderately unlikely
1 - Very unlikely

Perceived test accuracy
How accurate do you think rapid lateral flow tests for coronavirus are? (The test you imagined doing in this study was a rapid lateral flow test)
7 - Very accurate
6 - Moderately accurate
5 - Slightly accurate
4 - Neither accurate nor inaccurate
3 - Slightly inaccurate
2 - Moderately inaccurate
1 - Very inaccurate

Testing uptake intentions
If available to you, how likely are you to take a rapid lateral flow test in the future?
7. Very likely
6. Moderately likely
5. Slightly likely
4. Neither likely nor unlikely
3. Slightly unlikely
2. Moderately unlikely
1. Very unlikely

Previous testing behaviour
When was the last time you took any type of test for coronavirus?
a. In the last 2 weeks
b. In the last month
c. In the last 3 months
d. In the last year
e. Never

If answer is a/b/c/d:
What type of test was the one you took most recently?
a. Lateral Flow Test (LFT) - commonly used for individuals who are asymptomatic and provides results in approximately 30 minutes
b. Polymerase Chain Reaction (PCR) test – commonly booked through the NHS website and used to test individuals who are showing symptoms. Results take between 1-3 days.
c. Other
d. I don't know what type of test it was

Numeracy question
Which of the following numbers represents the biggest risk of getting a disease?
a. 1 in 100
b. 1 in 1000
c. 1 in 10

Recognition question

In this study, what were you told when you received your test result?

a. Your coronavirus test result is inconclusive
b. Your coronavirus test result is positive
c. Your coronavirus test result is negative

Infographic questions (for those in infographic conditions only)

To what extent did you find the infographic (the diagram of what a negative test result means) easy or difficult to understand?
5 - Very easy
4 - Somewhat easy
3 - Neither easy nor difficult
2 - Somewhat difficult
1 - Very difficult

Do you have any suggestions for how the infographic could be improved? Text box

Demographic questions

What is your gender? Male/Female/Non-binary/Prefer not to say/Other

How old are you? Text box (restricted to numbers between 18 and 100)

What is your ethnicity? White British/White other/Asian/Black/Arab/Mixed/Other

In which part of the UK are you currently based? Northern Ireland/Scotland/Wales/ England-South East/England-South West/ England – London/ England-East of England/ England – East Midlands/ England West Midlands/ England – North West/ England – North East/ England – Yorkshire and Humber

What is the highest level of education you have completed? GCSE or equivalent, A levels or equivalent, undergraduate degree, post graduate master's level, postgraduate PhD level

End of study questions

Do you have any comments or feedback about the study (e.g. your experience, how it could be improved)?

Supplementary findings

Table 1: Sociodemographic characteristics within each level of the independent variables

	Residual Risk					Post-test result behaviours		
	Control	NHS T&T	Elaborated	Infographic	p*	None	Included	p*
Gender					.717			.365
Male	143 (47.7%)	152 (51.0%)	141 (46.7%)	146 (48.7%)		288 (47.8%)	294 (49.2%)	
Female	157(52.3%)	145 (48.7%)	160 (53.0%)	153 (51.0%)		312 (51.8%)	303 (50.7%)	
Non-binary	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.3%)		0 (0.0%)	1 (0.2%)	
Prefer not to say	0 (0.0%)	1 (0.3%)	1 (0.3%)	0 (0.0%)		2 (0.3%)	0 (0.0%)	
Age					.283			.281
18-24	21 (7.0%)	30 (10.1%)	34 (11.3%)	42 (14.0%)		63 (10.5%)	64 (10.7%)	
25-34	61 (20.3%)	48 (16.1%)	51 (16.9%)	45 (15.0%)		108 (17.9%)	97 (16.2%)	
35-44	52 (17.3%)	48 (16.1%)	57 (18.9%)	49 (16.3%)		88 (14.6%)	118 (19.7%)	
45-54	58 (19.3%)	58 (19.5%)	49 (16.2%)	52 (17.3%)		113 (18.8%)	104 (17.4%)	
55-64	69 (23.0%)	60.0 (20.1%)	73.0 (24.2%)	72 (24.0%)		145 (24.1%)	129 (21.6%)	
65+	39 (13.0%)	54 (18.1%)	38 (12.6%)	40 (13.3%)		85 (14.1%)	86 (14.4%)	
Education					.072			.989
GCSE or equivalent	64 (21.3%)	51 (17.1%)	52 (17.2%)	54 (18.0%)		112 (18.6%)	109 (18.2%)	
A level or equivalent	67 (22.3%)	74 (24.8%)	66 (21.9%)	91 (30.3%)		150 (24.9%)	148 (24.8%)	
Undergraduate degree	111 (37.0%)	133 (44.6%)	126 (41.7%)	112 (37.3%)		239 (39.7%)	243 (40.6%)	
Postgraduate degree	58 (19.3%)	40 (13.4%)	58 (19.2%)	43 (14.3%)		101 (16.8%)	98 (16.4%)	

Ethnicity					.617		.690
White - British	230 (76.7%)	221 (74.2%)	232 (76.8%)	223 (74.3%)		466 (77.4%)	440 (73.6%)
White - Other	28 (9.3%)	34 (11.4%)	25 (8.3%)	26 (8.7%)		54 (9.0%)	59 (9.9%)
Asian	19 (6.3%)	26 (8.7%)	29 (9.6%)	24 (8.0%)		46 (7.6%)	52 (8.7%)
Black	13 (4.3%)	10 (3.4%)	7 (2.3%)	11 (3.7%)		19 (3.2%)	22 (3.7%)
Mixed	8 (2.7%)	6 (2.0%)	5 (1.7%)	13 (4.3%)		13 (2.2%)	19 (3.2%)
Other	2 (0.7%)	1 (0.3%)	4 (1.3%)	3 (1.0%)		4 (0.7%)	6 (1.0%)
UK region					.215		.203
NI/Scotland/Wales	37 (12.3%)	41 (13.8%)	45 (14.9%)	39 (13.0%)		85 (14.1%)	77 (12.9%)
England – South	81 (27.0%)	63 (21.1%)	82 (27.2%)	90 (30.0%)		160 (26.6%)	156 (26.1%)
England – London	35 (11.7%)	51 (17.1%)	37 (12.3%)	32 (10.7%)		75 (12.5%)	80 (13.4%)
England – Midlands	68 (22.7%)	56 (18.8%)	69 (22.9%)	75 (25.0%)		133 (22.1%)	135 (22.6%)
England – North	79 (26.3%)	87 (29.2%)	69 (22.9%)	64 (21.3%)		149 (24.8%)	150 (25.1%)
Testing experience					.751		.037
Yes - PCR	72 (24.0%)	56 (18.8%)	56 (18.5%)	51 (17.0%)		103 (17.1%)	132 (22.1%)
Yes - LFT	65 (21.7%)	67 (22.5%)	80 (26.5%)	69 (23.0%)		158 (26.3%)	123 (20.6%)
Yes - Other (e.g. antibody)	7 (2.3%)	11 (3.7%)	7 (2.3%)	8 (2.7%)		13 (2.2%)	20 (3.3%)
Yes – Don't know	11 (3.7%)	11 (3.7%)	11 (3.6%)	11 (3.7%)		25 (4.2%)	19 (3.2%)
None	145 (48.3%)	153 (51.3%)	148 (49.0%)	161 (53.7%)		303 (50.3%)	304 (50.8%)

* χ^2 p-value with Bonferroni correction applied, significant p-values (if any) are shown in bold.

Table 2: Pre-planned logistic regression with testing experience as an additional covariate

	AOR	95% CI	Wald	*p*
Intercept	0.56	0.26, 1.21	2.18	.140
Residual risk				
Control	0.56	0.33, 0.94	4.84	**.028**
NHS T&T (reference)				
Elaborated T&T	3.24	1.64, 6.41	11.42	**.001**
Elaborated T&T + infographic	5.22	2.49, 10.95	19.18	**<.001**
Post-test result behaviours				
Without (reference)				
With	0.81	0.48, 1.37	0.63	.426
*Residual risk * Post-test result behaviours*				
NHS T&T * With (reference)				
Control * With	0.66	0.32, 1.34	1.34	.248
Elaborated T&T * With	0.95	0.38, 2.38	0.01	.912
Elaborated T&T + infographic * With	0.77	0.29, 2.03	0.28	.594
Gender				
Male (reference)				
Female	1.05	0.78, 1.42	0.09	.761
Age				
18-24	1.65	0.87, 3.15	2.35	.126
25-34	1.36	0.79, 2.33	1.26	.262
35-44	1.50	0.88, 2.57	2.22	.136
45-54	1.69	1.00, 2.84	3.90	**.048**
55-64	1.68	1.04, 2.74	4.43	**.035**
65+ (reference)				
Education				
GCSE or equivalent (reference)				
A-level or equivalent	1.83	1.19, 2.83	7.48	**.006**
Undergraduate	2.77	1.84, 4.17	23.85	**<.001**
Postgraduate	5.04	2.89, 8.78	32.62	**<.001**
Ethnicity				
White British (reference)				
White Other	0.84	0.48, 1.45	0.40	.526
Asian	0.61	0.34, 1.09	2.75	.097
Black	0.34	0.16, 0.74	7.44	**.006**
Mixed	0.37	0.15, 0.92	4.58	**.032**
Other	0.64	0.12, 3.50	0.26	.611
Location				
London (reference)				
Northern Ireland	1.17	0.29, 4.84	0.05	.823
Scotland	0.85	0.43, 1.69	0.22	.641
Wales	0.66	0.29, 1.48	1.02	.312
South England	1.10	0.65, 1.88	0.13	.715
Midlands	1.47	0.85, 2.57	1.87	.172
North England	0.87	0.51, 1.47	0.28	.597
Numeracy				

Incorrect (reference)				
Correct	1.70	1.17, 2.46	7.93	**.005**
Testing experience				
No (reference)				
Yes	1.22	0.89, 1.66	1.57	.211

* Significant p-values are shown in bold.

Table 3: Ordinal regressions predicting expected engagement in protective behaviours and expectations to follow guidelines

	Expected engagement in protective behaviours				*Expectations to follow guidelines*			
	AOR	95% CI	Wald	*p*	AOR	95% CI	Wald	*p*
Residual risk								
Control	1.35	0.84, 2.18	1.52	.218	1.00	0.53, 1.87	<.01	.988
NHS T&T (reference)								
Elaborated T&T	0.98	0.60, 1.60	0.01	.939	1.33	0.72, 2.46	0.85	.357
Elaborated T&T + infographic	1.17	0.73, 1.88	0.42	.515	1.58	0.86, 2.89	2.21	.137
Post-test result behaviours								
Without (reference)								
With	1.11	0.69, 1.80	0.18	.669	1.24	0.66, 2.29	0.45	.502
*Residual Risk * Post test result behaviours*								
NHS T&T * With (reference)								
Control * With	0.64	0.32, 1.26	1.67	.197	1.38	0.58, 3.27	0.53	.465
Elaborated T&T * With	0.98	0.49, 1.93	0.00	.948	1.11	0.48, 2.58	0.06	.811
Elaborated T&T + infographic * With	0.95	0.49, 1.87	0.02	.888	1.27	0.55, 2.88	0.32	.574

Protocol: Reducing false reassurance following negative results from asymptomatic coronavirus (Covid-19) testing: an online experiment

Introduction

Mass Covid-19 testing programmes aim to test large numbers of asymptomatic individuals to reduce the transmission of the virus. Programmes typically utilise lateral flow tests (LFTs) which require a swab taken from the back of the nose or throat and produce results within 30 minutes. Recent data suggest that the sensitivity of LFTs is 50% and the specificity is 99.93%. This means that in a given population, only half of those who are infected with the virus will receive a positive test result. Consequently, among those who receive a negative test result, some individuals will in fact be infected with the COVID-19.

The effectiveness of asymptomatic testing in reducing rates of COVID-19 depends in part on the behavioural responses of those receiving a test-negative result, the great majority of those undergoing such tests. Of concern is that receiving such test results may decrease engagement with behaviours that reduce transmission, including social distancing, wearing face-coverings and hand-washing.

A recent survey by the Winton Centre investigated the impact of messages containing different levels of uncertainty on interpretations of a negative PCR test result. They found that that those who saw a New Zealand based message containing uncertainty were more likely to agree that a symptomatic individual should continue to self-isolate after receiving a negative test than individuals who saw a UK based message that mentioned no uncertainty. This suggests that the influence of test result messages needs to be further explored to understand how behavioural responses to a negative Covid-19 result can be improved in asymptomatic testing.

The current study aims to identify whether communicating residual risk of infection following a negative test can mitigate any unintended consequences on behaviour, i.e. being less likely to follow coronavirus guidelines following a negative test. We will test various methods of communicating uncertainty relating to residual risk to identify which are more effective. We will test messages that are currently communicated to people in the UK as well as more evidence-based messages which should increase understanding of residual risk. We will also examine the influence of messages that contain information about behavioural implications on behavioural intentions.

Aims

To investigate whether understanding and behavioural responses to receiving negative test results can be improved by (a) communicating the residual risk of COVID-19 inherent in a test-negative result using verbal and visual explanations and (b) information about the behavioural implications of a test-negative result.

Methods

Design

An online experiment with a between-subjects design. Participants will read one of several possible messages about receiving a negative Covid-19 test result. The message will contain a) some or no information about residual risk (4 levels) and b) some or no information about the behavioural implications of the test result (2 levels). See Appendix for details of the messages.

a. Residual risk information

1. None
   Your coronavirus test result is negative.

2. Uncertainty – positive framing
   Your coronavirus test result is negative. It's likely you were not infectious when the test was done. [Wording used by NHS T&T]

3. Uncertainty – positive framing + negative framing
   Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.

4. Uncertainty – positive framing + negative framing + infographic
   Your coronavirus test result is negative. It's likely you were not infectious when the test was done. But there is still a chance you may be infectious.

b. Behavioural implications

i. None

ii. Described
   This means you should continue to follow all government guidance to reduce transmission of the virus. You must stay at home. You must not leave or be outside of your home except where necessary.
   Remember - 'Hands. Face. Space.'
   - hands – wash your hands regularly and for at least 20 seconds
   - face – wear a face covering in indoor settings where social distancing may be difficult, and where you will come into contact with people you do not normally meet
   - space – stay 2 metres apart from people you do not live with where possible, or 1 metre with extra precautions in place (such as wearing face coverings)

[listed as current government guidance under national lockdown (excluding first sentence): [https://www.gov.uk/guidance/national-lockdown-stay-at-home]

The study is expected to last approximately 6 minutes and will be run on Qualtrics with participant recruitment done using Prolific.

Participants

We will recruit 1205 adults. Gender, age, ethnicity, level of education and UK region will be recorded. Participants who fail the attention check will be excluded and will not be compensated.

Sample size estimate

The two primary outcomes (dependent variables):

(a) understanding of residual risk.

(b) intentions to follow covid-19 rules and regulations.

We will recruit 1205 participants. Based on previous studies, we expect 10% of participants (N=110) to fail the attention check, which leaves 1095 participants in total. We used G*Power (version 3.1) to conduct our power analyses.
For Hypothesis 1, given the lack of prior data we are unable to conduct a power analysis for a logistic regression. We base our power calculation on a chi-square test instead. A sample of 547 allows us to detect a difference with a small effect size (w=0.12) between two groups, using a chi-square test with α=0.05 and power >.80. As we have 4 groups, we estimate that we need double the sample size, i.e. 1094 participants.
For Hypothesis 2, 1095 participants allows us to detect a small effect size (f=0.10) using a between-subjects ANOVA with α=0.05 and power >.80.

Recruitment

A representative sample of the UK adult population (based on age, gender and ethnicity) will be recruited via the online platform Prolific (https://www.prolific.co/).

Measures

Two primary endpoints:

- *Understanding of residual risk (understanding and confidence)*
- *Behavioural intention (general intention and specific behaviours)*

Other measures

- *Perceived test accuracy*
- *Testing uptake intentions*
- *Previous testing behaviour*

Hypotheses

Hypothesis 1: The positive framing message (NHS T&T; group 2) increases understanding of residual risk compared to no message about residual risk (group 1) but reduces understanding compared to adding a negative framing message (group 3) and an infographic (group 4).

Hypothesis 2: Intentions to follow Covid-19 guidelines are higher when the message contains information about continuing to follow Covid-19 rules and regulations after receiving a negative test result.

Analysis

Preregistered analyses (as per the OSF form)

To test Hypothesis 1, we will conduct a binomial logistic regression with residual risk communication, behavioural implications and an interaction term as predictors of understanding of residual risk (coded as correct: 'I am most likely not infectious with coronavirus', or incorrect: all other responses). Group 2 (positive framing) will be used as the reference category for the residual risk communication predictor. Age, gender, ethnicity, education, location and numeracy will be added to the model as covariates.

To test Hypothesis 2, we will conduct a 4 (residual risk communication) x 2 (behavioural implications) between-subjects ANOVA on specific protective behaviours (average score across the 6 questions). If the outcome variable is skewed, we will use transformations to ensure it is normally distributed.

Procedure

After consenting to take part in the study, participants will be asked to imagine that they have taken part in a mass testing programme and received a message about the outcome of the test. They will be randomly allocated to view one of eight possible messages containing a) some or no residual risk information (4 levels) b) some or no information about the behavioural implications of a negative test result (2 levels).

After reading the message, participants will be asked questions that measure their behavioural intentions and understanding of residual risk. These will be informed by the behaviour and intention literature and adapted from previous research by Waller et al. 2020 and the Winton Centre.

Participants will also be asked to answer demographic questions, a numeracy question to assess their understanding of proportions and attention checks to ensure they are paying attention.

Ethical considerations

The study will ask participants about their behaviours and intentions. Informed consent will be obtained from all participants before they participate in the study. The study will be submitted and reviewed by the PHE Research Ethics and Governance Group. Data will be stored in line with GDPR requirements, and no identifiable information will be recorded. The study will be preregistered on the Open Science Framework.

Data handling

Survey responses will remain anonymous, will be stored on secure PHE servers and will not be shared outside of the working group, in line with GDPR regulations.

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	3-4
	2b	Specific objectives or hypotheses	5
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	6
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	NA
Participants	4a	Eligibility criteria for participants	6
	4b	Settings and locations where the data were collected	8
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	6-7
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	7-8
	6b	Any changes to trial outcomes after the trial commenced, with reasons	NA
Sample size	7a	How sample size was determined	6
	7b	When applicable, explanation of any interim analyses and stopping guidelines	NA
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	8
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	8
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	8
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	8
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	8

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		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	7
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	9
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	9
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	9-10
	13b	For each group, losses and exclusions after randomisation, together with reasons	9
Recruitment	14a	Dates defining the periods of recruitment and follow-up	6
	14b	Why the trial ended or was stopped	6
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	9-10
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	9-14
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	10-14
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	11-13
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	13-15
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	13-15
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	17-18
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	17-18
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	16-18
Other information			
Registration	23	Registration number and name of trial registry	5
Protocol	24	Where the full trial protocol can be accessed, if available	5
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	19

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.