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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) × 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 (T&T); (3) message 2 plus 'But there is still a chance you may be infectious' (elaborated NHS T&T); and (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 (1) Proportion understanding residual risk of infectiousness and (2) likelihood of engaging in protective behaviours (scales 1–7).

Results The control message decreased understanding relative to the current NHS T&T message: 54% versus 71% (Adjusted Odds Ratio (AOR)=0.56 95% CI 0.34 to 0.95, p=0.030). Understanding increased with the elaborated NHS T&T (89%; AOR=3.25 95% CI 1.64 to 6.42, p=0.001) and elaborated NHS T&T+infographic (91%; AOR=5.16 95% CI 2.47 to 10.82, p<0.001) compared with current NHS T&T message. Likelihood of engaging in protective behaviours was unaffected by information (AOR=1.11 95% CI 0.69 to 1.80, $\chi^2(1)=0.18$, p=0.669), 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 T&T wording increased understanding of residual risk.

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

Strengths and limitations of this study

- 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 with 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 (ie, 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 with 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 with 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 with positive framing alone.[17–19] The addition of a negatively framed sentence to the existing NHS T&T messaging could therefore improve understanding.

Box 1 Intervention messages (A) residual risk and (B) post-test result behaviours

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 online supplemental 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 m apart from people you do not live with where possible, or 1 m with extra precautions in place (such as wearing face coverings).

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 (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 with 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) × 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 and 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 (V.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 χ^2 test instead. A sample of 547 can detect a difference between two groups with a small effect size (w=0.12), using a χ^2 test with α=0.05 and power >0.80. For four groups, it was estimated that double the sample size was needed, that is, 1094 participants. For hypothesis 2, 1095 participants can detect a small effect size (f=0.10) using a between-subjects analysis of variance (ANOVA) with α=0.05 and power >0.80. We planned to exclude participants who failed an attention check (see online supplemental 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 eight messages in a 4 (residual risk) × 2 (post-test result behaviour) factorial design (see box 1 and online supplemental 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 (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) 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 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 and space).

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 online supplemental 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' and '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 seven-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=0.86), 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 online supplemental 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 online supplemental 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 and 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 online supplemental material). Participants were unaware of the condition they were allocated to and paid at a rate of £25 per hour (ie, £2.10 for a 5 min experiment) (see online supplemental 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

Preregistered analyses were conducted using Stata (V.15) with a significance level of $p<0.05$. 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 preplanned 4 (residual risk) × 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]

Table 1 Participant demographic characteristics

Demographic characteristic	n	%
Gender		
Male	582	48.50
Female	615	51.20
Non-binary	1	0.10
Prefer not to say	2	0.20
Age (years)		
18–24	127	10.60
25–34	205	17.10
35–44	206	17.20
45–54	217	18.10
55–64	274	22.80
65+	171	14.30
Education		
GCSE or equivalent	221	18.40
A level or equivalent	298	24.80
Undergraduate degree	482	40.20
Postgraduate degree	199	16.60
Ethnicity		
White – British	906	75.50
White – other	113	9.40
Asian	98	8.20
Black	41	3.40
Mixed	32	2.70
Other	10	0.90
UK region		
Northern Ireland/Scotland/Wales	162	13.40
England – South	316	26.30
England – London	155	12.90
England – Midlands	268	22.30
England – North	299	24.90
Testing experience		
Yes – PCR	235	19.60
Yes – Lateral flow test	281	23.40
Yes – other (eg, antibody)	33	2.80
Yes – don't know	44	3.70
None	607	50.60

GCSE, General Certificate of Secondary Education.

RESULTS

Of the 1207 participants who completed the study, seven (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 online supplemental table 1).

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)

*Correct understanding of residual risk. Confidence is on a five-point scale and other continuous variables on a seven-point scale.
NHS, National Health Service; T&T, Test and Trace.

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=0.030) (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 to 6.42, $\chi^2(1)=11.50$, p=0.001). This was also the case for the elaborated NHS T&T message with the infographic (90.7%) (AOR=5.16 95% CI 2.47 to 10.82, $\chi^2(1)=18.94$, p<0.001). However, understanding in this condition was not significantly higher than the elaborated NHS T&T message alone ($\chi^2(1)=1.14$, p=0.286). Understanding was lower among those with lower education, those aged 65+ years compared with those aged 45–64 years, those with lower numeracy and those from black and mixed ethnicity compared with 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=0.910). In a separate exploratory analysis, previous testing experience (coded as yes: PCR, LFT, other and don't know, coded as no: none (ref category)), was added to the preplanned logistic regression model as a covariate. This did not significantly predict understanding of residual risk, nor did it alter any other effects (see online supplemental 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<0.001, $\eta 2=0.04$), 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<0.001), elaborated NHS T&T ($M=4.24$, $SD=0.81$, p<0.001) and elaborated NHS T&T with the infographic ($M=4.32$, $SD=0.80$, p<0.001) 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=0.304, $\eta 2<0.01$) nor the interaction

Table 3 Logistic regression predicting correct understanding of residual risk

	AOR	95% CI	Wald	P value*
Intercept	0.61	0.29 to 1.31	1.58	0.209
Residual risk				
Control	0.56	0.34 to 0.95	4.70	0.030
NHS T&T (reference)				
Elaborated T&T	3.25	1.64 to 6.42	11.50	0.001
Elaborated T&T+infographic	5.16	2.47 to 10.82	18.94	<0.001
Post-test result behaviours				
Without (reference)				
With	0.81	0.48 to 1.36	0.65	0.421
Residual risk* post-test result behaviours				
NHS T&T * with (reference)				
Control * with	0.65	0.32 to 1.33	1.38	0.240
Elaborated T&T * with	0.95	0.38 to 2.37	0.01	0.907
Elaborated T&T+infographic * with	0.77	0.29 to 2.04	0.27	0.605
Gender†				
Male (reference)				
Female	1.06	0.78 to 1.43	0.13	0.716
Age (years)				
18–24	1.76	0.93 to 3.33	3.07	0.080
25–34	1.45	0.85 to 2.46	1.87	0.172
35–44	1.56	0.91 to 2.65	2.66	0.103
45–54	1.74	1.03 to 2.91	4.35	0.037
55–64	1.68	1.04 to 2.73	4.41	0.036
65+ (reference)				
Education				
GCSE or equivalent (reference)				
A-level or equivalent	1.82	1.18 to 2.80	7.27	0.007
Undergraduate	2.73	1.82 to 4.11	23.29	<0.001
Postgraduate	4.95	2.85 to 8.61	32.12	<0.001
Ethnicity				
White British (reference)				
White other	0.81	0.47 to 1.41	0.53	0.465
Asian	0.61	0.34 to 1.09	2.83	0.093
Black	0.33	0.15 to 0.71	7.94	0.005
Mixed	0.36	0.15 to 0.91	4.70	0.030
Other	0.64	0.12 to 3.54	0.26	0.613
Location				
London (reference)				
Northern Ireland	1.12	0.27 to 4.57	0.02	0.876
Scotland	0.82	0.41 to 1.63	0.33	0.567
Wales	0.62	0.28 to 1.40	1.31	0.252
South England	1.08	0.63 to 1.83	0.08	0.784
Midlands	1.46	0.84 to 2.54	1.76	0.185
North England	0.86	0.51 to 1.46	0.32	0.574
Numeracy				

Continued

Table 3 Continued

	AOR	95% CI	Wald	P value*
Incorrect (reference)				
Correct	1.69	1.17 to 2.45	7.85	0.005

*Significant p values are shown in bold.
†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.

between residual risk and post-test result behaviours (F(3,907)=0.53, p=0.664, η2<0.01) had a significant effect on confidence.

Post-test result behaviours

The variable measuring expectations to engage in protective behaviours remained negatively skewed after logarithmic transformations making the preplanned ANOVA unsuitable. An ordinal 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 to 1.80, χ^2(1)=0.18, p=0.669), 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 online supplemental table 3 for full output). The model was a poor fit to the data (McFadden's pseudo R^2=0.002).

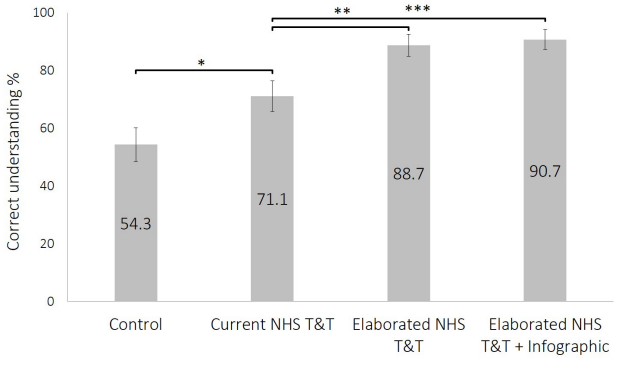

Figure 1 Percentage of participants with a correct understanding of residual risk by residual risk experimental group. Error bars represent 95% CIs. Significance levels are based on the logistic regression in table 3). *P<0.05, **p<0.01, ***p<0.001.

An ordinal regression was also conducted to explore the influence of the predictors on expectations to follow guidelines compared with 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 to 2.29, χ^2(1)=0.45, p=0.502). 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 online supplemental table 3 for full output). This model was also a poor fit to the data (McFadden's pseudo R^2=0.009).

Perceived accuracy

Perceived accuracy of lateral flow tests (see table 2) was influenced by residual risk condition (F(3,1192)=5.38, p=0.001, η2=0.01). 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=0.034), existing NHS T&T messaging (M=5.71, SD=1.10; p=0.029) and elaborated NHS T&T messaging (M=5.61, SD=1.17; p=0.001) 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=0.809, η2<0.01) nor their interaction with residual risk (F(3,1192)=0.45, p=0.714, η2<0.01) 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=0.849, η2<0.01), post-test result behaviours (F(1,1192)=0.37, p=0.545, η2<0.01) or their interaction (F(3,1192)=1.30, p=0.272, η2<0.01).

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 with 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=0.641). 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=0.026).

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 that 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 that 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 T&T (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+ years compared with those aged 45–64 years and in groups self-classifying as black and mixed ethnicity compared with 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 preplanned 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 that 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+ years). 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 coproducing 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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