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Applying an extended protection motivation theory to predict Covid-19 vaccination intentions and uptake in 50-64 year olds in the UK

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Abstract

Objectives. To examine the correlates of Covid-19 vaccination intentions and subsequent uptake as outlined in an extended version of protection motivation theory (PMT). *Design.* A two-wave online survey conducted at the start of the vaccination rollout to 50-64 year olds in the UK and three months later. *Measures.* Unvaccinated UK adults (*N* = 438) aged 50-64 completed baseline measures from PMT (perceived vulnerability, perceived severity, maladaptive response rewards, response efficacy, self-efficacy, response costs, intention) as well as measures of injunctive and descriptive norms, demographics, Covid-19 experiences, and past influenza vaccine uptake. Self-reported uptake of a Covid-19 vaccination was assessed three months later (*n* = 420). *Results.* The extended PMT explained 59% of the variance in Covid-19 vaccination intentions, after controlling for demographics, Covid-19 experiences, and past influenza vaccine uptake. All extended PMT variables, with the exception of perceived severity and descriptive norms, were significant independent predictors of intentions. In line with national figures, 94% of the sample reported having received a Covid-19 vaccination at follow-up with intention found to be the key predictor of uptake. *Conclusions.* Interventions to increase Covid-19 vaccination uptake need to increase intentions to be vaccinated by emphasizing the benefits of vaccination (e.g., in terms of reducing risk) and likely approval from others while also addressing the concerns (e.g., safety issues) and common misperceptions (e.g., natural immunity versus vaccines) that people might have about Covid-19 vaccines. Future research is needed in countries, and on groups, with lower uptake rates.

Keywords. COVID-19; Coronavirus; Vaccine; Vaccination; Intention; Hesitancy; Protection Motivation Theory; Norms

Introduction

In March 2020 the World Health Organization (WHO, 2020) declared the coronavirus outbreak to be a global pandemic. To date (17 December 2021), over 270 million confirmed cases of Covid-19, including over 5.3 million deaths, have been reported worldwide (WHO, 2021). To prevent the spread of the SARS-CoV-2 virus that causes Covid-19, governments across the world introduced various restrictions to movement and social interactions (e.g., local and national lockdowns, self-quarantining after exposure to Covid-19) and recommended or mandated a range of preventive measures (e.g., frequent hand washing, mask wearing on public transport and in shops). These measures have been shown to reduce transmission rates (Haug et al., 2020); however, only the widespread uptake of Covid-19 vaccines offers the possibility of a return to normality and an end to the pandemic (Agarwal & Gopinath, 2021).

Towards the end of 2020, phase III vaccine trial results were released indicating that Covid-19 vaccines are safe and produce a strong immune response (Shrotri et al., 2021). The first Covid-19 vaccine was subsequently given regulatory approval in the UK on 2 December 2020 (Shrotri et al., 2021) and, to date (17 December 2021), three Covid-19 vaccines have been approved for use in the UK (i.e., the Moderna, Oxford-AstraZeneca and Pfizer-BioNTech Covid-19 vaccines) (NHS, 2021a). Evidence indicates that Covid-19 vaccines reduce the risk of symptomatic disease, admission to hospital, and death from Covid-19 (Hungerford & Cunliffe, 2021; Public Health England, 2021). However, to achieve herd immunity and thereby bring an end to the pandemic, it has been estimated that 70% of the population needs to be vaccinated against Covid-19 (Irwin, 2021).

In addition to issues of supply and cost, weak intentions to be vaccinated and vaccine hesitancy (i.e., “delay in acceptance or refusal of vaccination despite availability of vaccination services”, WHO, 2014) represent key barriers to the successful rollout of vaccination programmes. For example, vaccine hesitancy has been noted in relation to a range of vaccines including those for Human Papillomavirus (HPV; Karafillakis et al., 2019), H1N1 influenza (Bish et al., 2011) and Covid-19 (Lin at al., 2021). In a review of surveys conducted in 2020 before the first Covid-19 vaccine was approved for use, Lin et al. (2021) reported that intended uptake ranged from 48% to 91%. A range of demographic and individual factors were reported to be associated with intended uptake of a Covid-19 vaccine, including (higher) education, (higher) income and (White) ethnicity as well as a range of beliefs about Covid-19 (e.g., perceived risk and severity) and Covid-19 vaccines (e.g., perceived effectiveness and safety), and the views of others (e.g., family and friends). In addition, those who had participated in other vaccination programmes (e.g., had received an influenza vaccination) were also reported to be more likely to intend to have a Covid-19 vaccine (Lin et al., 2021).

The research reviewed by Lin et al. (2021) suffered from two limitations. First, all of the surveys focused on intended, rather than actual, uptake of a Covid-19 vaccine as they were conducted before Covid-19 vaccines were approved for use. Second, the surveys failed to draw on social cognitive models of health behaviour that outline the proximal determinants of health behaviour (Conner & Norman, 2015). It is striking that many of the beliefs identified in the Lin et al. (2021) review map onto constructs contained in these models. Since the Lin et al. (2021) review, a few studies have reported applications of the health belief model and the theory of planned behaviour/reasoned action approach to explain intentions to receive a Covid-19 vaccine (e.g., Chu & Liu, 2021; Guidry et al., 2021; Lin et al., 2020; Lueck & Spiers, 2020; Salmon et al., 2021; Wong et al., 2021). For example, Guidry et al. (2021) reported that a model based on the health belief model and the theory of planned behaviour explained 67% of the variance in intended uptake of a Covid-19 vaccine. Perceived susceptibility, perceived benefits, perceived barriers, self-efficacy, attitude and subjective norms were significant predictors of intention along with education level, ethnicity (White > Black) and insurance status.

The present study draws on protection motivation theory (PMT; Rogers, 1983) to examine the determinants of Covid-19 vaccination intentions and subsequent uptake. According to PMT, when faced with a health threat, such as Covid-19, individuals engage in two appraisal processes: threat appraisal and coping appraisal. Threat appraisal focuses on the source of the health threat. Thus, perceived vulnerability to, and the perceived severity of, the health threat are seen to increase the likelihood of a protective behaviour, whereas rewards associated with a maladaptive response may decrease the likelihood of a protective behaviour. Coping appraisal focuses on evaluations of the recommended protective behaviour. Thus, response efficacy and self-efficacy are seen to increase the likelihood of a protective behaviour, whereas various response costs may decrease the likelihood of a protective behaviour. Protection motivation (i.e., intention) results from these two appraisal processes and is seen to be the sole proximal determinant of protective behaviour, mediating the effects of other PMT variables and more distal influences (e.g., demographics).

PMT has been applied to explain a wide range of health behaviours (for reviews, see Floyd et al., 2000; Milne et al., 2000; Norman et al., 2015) including intentions to receive a seasonal influenza vaccine (Ling et al., 2019) and adherence to Covid-19 protection behaviours (Scholz & Freund, 2021). PMT encompasses many of the beliefs associated with intended uptake of a Covid-19 vaccine identified in the Lin et al. (2021) review and, since this review, a number of cross-sectional studies have used PMT to explain Covid-19 vaccination intentions (Ansari-Moghaddam et al., 2021; Eberhardt & Ling, 2021; Huang et al., 2021; Tong et al., 2021) although, to date, no PMT studies have predicted subsequent uptake. For example, Eberhardt and Ling (2021) reported that PMT explained 68% of the variance in Covid-19 vaccination intentions. Perceived vulnerability, perceived severity, maladaptive response rewards and self-efficacy were found to be significant predictors. One limitation of PMT is that it doesn't directly consider the impact of normative influences on behaviour, as outlined in the reasoned action approach (Fishbein & Ajzen, 2010). For example, Lueck and Spiers (2020) found that measures of injunctive norms (i.e., approval from others) and descriptive norms (i.e., what others are doing) were predictive of Covid-19 vaccination intentions, and Scholz and Freund (2021) found that a measure of perceived social disapproval explained additional variance, over and above that explained by PMT variables, in intentions to engage in Covid-19 protection behaviours.

The Present Study

The present study reports an application of an extended version of PMT to explain Covid-19 vaccination intentions and subsequent uptake in 50-64 year olds in the UK. In addition to the core PMT variables (i.e., perceived vulnerability, perceived severity, maladaptive response rewards, response efficacy, self-efficacy, response costs), measures of both injunctive and description norms were also included. Lin et al. (2021) identified a number of demographic variables that have been associated with Covid-19 vaccination intentions that were also assessed in the study (i.e., age, sex, ethnicity, deprivation) along with measures of Covid-19 experiences (i.e., diagnosis, self-isolation) and previous influenza vaccination uptake. On the basis of previous research (e.g., Lin et al., 2021) and in line with the theoretical structure of PMT, it was hypothesised that the extended PMT variables would explain significant portions of variance in Covid-19 vaccination intentions and subsequent uptake over and above the influence of demographic variables, Covid-19 experiences, and past influenza vaccination behaviour. It was also predicted that intention would be the key proximal predictor of uptake, accounting for the effects of the extended PMT variables and other distal factors on uptake.

The UK vaccination programme began on 8 December 2020 with adults being invited to receive a Covid-19 vaccination in order of nine priority (i.e., vulnerable) groups based on age, occupation (frontline health and social care workers) and underlying health conditions (JCVI, 2021). The baseline survey was conducted on 1 March 2021, the point at which 50-64 year olds in the UK – the last of the priority groups – started to be invited to receive a Covid-19 vaccine. The uptake of Covid-19 vaccines in the previous priority group (65-69 year olds) in England was 85.4% at this time (NHS, 2021b). By 13 April 2021, all UK adults in priority groups 1-9 had been invited to receive a Covid-19 vaccination (BBC News, 2021). The follow-up survey was conducted on 25 May 2021, at which point 94.9% of 50-64 year olds in England had received a Covid-19 vaccine (NHS, 2021b).

Methods

Participants and Procedure

A sample of UK adults aged 60-64 years old was recruited via Prolific, a participant recruitment company, to complete an online survey hosted on Qualtrics. Only UK nationals who had not already received a Covid-19 vaccine (e.g., due to being aged 65 years or older, a health or social care worker, or a member of a clinically vulnerable patient group) were eligible to participate. The baseline survey was posted Prolific on 1 March 2021, the point at 50-64 year-olds started to be invited to receive a Covid-19 vaccine. Potential participants who clicked on the link to the survey were first presented with an online information sheet and consent form. Participants were required to indicate that they consented to take part in the study before being able to access the baseline survey. The baseline survey included measures of demographics, Covid-19 experiences, previous influenza vaccination behaviour, and the extended PMT variables. The follow-up survey was sent to participants who had completed the baseline survey by Prolific approximately three months later and was open from 25 May 2021 until 30 June 2021. The follow-up survey asked whether participants had received a Covid-19 vaccination or not. Details of the study items included in the baseline and follow-up surveys are provided in Supplementary File 1. Ethical approval for the study was obtained from the University of Sheffield Research Ethics Committee (ref. 038158).

Measures

Demographic data on age, sex and ethnicity were provided by Prolific. Participants were also asked to provide their postcodes which were linked to Index of Multiple Deprivation (IMD) deciles using databases and lookup tables for England (http://imd-by-postcode.opendatacommunities.org/imd/2019), Scotland (https://www.gov.scot/publications/scottish-index-of-multiple-deprivation-2020v2-postcode-look-up/), Wales (https://statswales.gov.wales/Catalogue/Community-Safety-and-Social-Inclusion/Welsh-Index-of-Multiple-Deprivation) and Northern Ireland (https://deprivation.nisra.gov.uk/). IMD represents an area-level measure of relative deprivation. IMD decile scores range from 1 (indicating the most deprived 10% of areas nationally) to 10 (indicating the least deprived 10% of areas nationally). In addition, participants were asked whether they had been diagnosed with Covid-19, had to self-isolate due to being in contact with someone who had Covid-19, and whether they had received an influenza vaccination earlier in the winter.

The baseline survey also contained measures of variables from PMT that were constructed in line with recommendations (Norman et al., 2015) and previous studies on vaccination behaviour (e.g., Ling et al., 2019; Martin & Petrie, 2017; Sherman et al., 2021). Measures of injunctive and descriptive norms were also included that were worded in line with recommendations (Conner & Sparks, 2015) and similar to those used in previous research on Covid-19 protection behaviours (Schüz et al., 2021). All items were rated on 7-point response scales (e.g., “Strong Disagree”–“Strongly Agree”), coded such that high scores indicated high levels of the variable of interest (e.g., high perceived severity, high response costs). Measures of each variable were constructed by taking the mean of relevant items.

Three items assessed perceived vulnerability (α = .84; e.g., "Without a Covid-19 vaccine, I am vulnerable to contracting Covid-19") and three items assessed perceived severity (α = .63; e.g., "Covid-19 can be a life-threatening disease"). Six items assessed maladaptive response rewards (α = .77) that focused on the advantages of not receiving a vaccine (e.g., "If I do not get a Covid-19 vaccination, then I won't have to spend time and effort getting vaccinated") as well as the benefits of natural exposure/immunity ("Natural immunity lasts longer than a Covid-19 vaccination"). Response efficacy (α = .70; e.g., "Having a Covid-19 vaccination would stop me from getting Covid-19") and self-efficacy (α = .86; e.g., "It would be very easy for me to have a Covid-19 vaccination") were each assessed with three items, and responses costs were assessed with five items (α = .79; e.g., "I would be worried about experiencing side effects from a Covid-19 vaccine"). Protection motivation (i.e., intention) was assessed with three items (α = .98; e.g., "I intend to have a Covid-19 vaccination"). In addition to the PMT measures, three items assessed injunctive norms (α = .95; e.g., "People who are important to me would approve of me having a Covid-19 vaccine") and two items assessed descriptive norms (α = .68; e.g., "Most people I know will have a Covid-19 vaccine").

Approximately three months later, participants were asked to report whether or not they had received a Covid-19 vaccination (i.e., "Have you received a Covid-19 vaccination?"). Participants were instructed to answer yes if they had just the first dose or two doses since the first survey and no if they had not received a Covid-19 vaccination.

Data analysis

Copies of data files and coding (syntax) for the analyses are openly available at https://osf.io/a84sk/. Data were analysed using SPSS (version 26) using complete cases for each analysis (i.e., pairwise deletion for bivariate analyses and listwise deletion for multivariate analyses). The analyses were conducted in three phases. First, descriptive statistics were conducted for measures of the study variables (i.e., demographics, Covid-19 experiences, the extended PMT variables, and vaccination uptake) (see Tables 1 and 2) and correlations were computed between the study variables and Covid-19 vaccination intentions at baseline and Covid-19 vaccine uptake at follow-up (see Table 2 and Supplementary File 2). The strength of the correlations were interpreted according to Cohen's (1992) criteria, where rs $\geq$ .10, .30 and .50, are considered to be small, medium and large-sized effects, respectively. Second, a hierarchical linear regression analysis was conducted in which the independent variables were entered in two blocks to explain Covid-19 vaccination intentions (see Table 3). Age, sex, ethnicity, IMD decile, Covid-19 diagnosis, self-isolation, and previous influenza vaccination were entered in block 1, and the extended PMT variables were added in block 2. Third, given the dichotomous nature of the measure of vaccination uptake, a hierarchical logistic regression analysis was conducted to examine the predictors of Covid-19 vaccination uptake (see Table 4). Categorical predictors that had cells with very small numbers ($n < 5$) when cross-tabulated with Covid-19 vaccine uptake, were not included in the logistic regression analysis (i.e., ethnicity, Covid-19 diagnosis, self-isolation, and previous influenza vaccination). The independent variables were entered in three blocks. Age, sex and IMD decile were entered in block 1, followed by the extended PMT variables in block 2, and intention in block 3.

Missing data

The amount of missing data was calculated and Little's MCAR test used to test whether the data were missing completely at random. Multiple imputation techniques were then used to produce five imputed datasets using Missing Values Analysis within SPSS. The correlation and regression analyses were rerun in SPSS using these imputed datasets. The results for these analyses with pooled data are reported in Supplementary File 3 (Tables 1-3). As recommended by Altman (2009), these analyses were conducted as sensitivity analyses to assess the robustness of the main findings. In addition, attrition analyses were conducted to compare those lost to follow-up with those who completed both surveys on the baseline measures.

Results

Sample characteristics

Initially, 536 potential participants accessed the link to the study. Of these, 28 did not provide consent, seven were excluded as they had > 90% missing data, and 63 were excluded due to having had already received a Covid-19 vaccine at baseline. The baseline sample therefore comprised 438 participants. The characteristics of the baseline sample are reported in Table 1. The follow-up survey was completed by 420 participants (95.9%), of whom 395 (94.0%) reported that they had been vaccinated. A retrospective power analysis indicated that with a baseline sample of 438 and a follow-up sample of 420, the study had 80% power to detect a small-sized correlation of $r = .13$ with intention and $r = .14$ with Covid-19 vaccine uptake, with alpha = .05.

Missing data analyses indicated that there was only one (0.2%) missing data point for IMD decile at baseline and 18 (4.1%) missing data points for the measure of uptake of a Covid-19 vaccination at follow-up. Overall, only 0.2% of data points were missing from the dataset. Little's MCAR test indicated that the data were missing completely at random, $\chi^2(10) = 5.88$, $p = .83$.

Attrition analyses revealed no significant differences between those who did and did not complete the follow-up survey in terms of baseline demographics (*p*s ≥ .12), Covid-19 experiences (*p*s ≥ .43), previous influenza vaccination behaviour ($p = .66$) or the extended PMT variables (*p*s ≥ .48, with the exception of self-efficacy, $p = .07$).

Associations with Covid-19 vaccination intentions

Considering the demographic variables, only ethnicity and relative deprivation had significant associations with Covid-19 vaccination intentions (see Supplementary File 2), although both correlations were small-sized. The direction of the correlations indicated that White (versus non-White) participants and those living in less deprived areas had stronger Covid-19 vaccination intentions. Age and sex, as well as whether or not participants had been diagnosed with Covid-19 or had self-isolated, were not significantly associated with Covid-19 vaccination intentions. Those who had received an influenza vaccination had significantly stronger Covid-19 vaccination intentions, although the size of the correlation was small. All of the extended PMT variables had significant correlations with Covid-19 vaccination intentions (see Table 2). Higher levels of perceived vulnerability, perceived severity, response efficacy and self-efficacy as well as more positive injunctive and descriptive norms were associated with stronger Covid-19 vaccination intentions. In contrast, higher maladaptive response rewards and response costs were associated with weaker Covid-19 vaccination intentions. All of the correlations were large-sized, apart from the correlations for perceived severity and response efficacy which were medium-sized. The size and significance of the correlations with intention using the imputed datasets were virtually identical (see Supplementary File 3, Table 1).

Hierarchical linear regression analysis predicting Covid-19 vaccination intentions

As shown in Table 3, the independent variables entered in block 1 (i.e., age, sex, ethnicity, IMD decile, Covid-19 diagnosis, self-isolation, and previous influenza vaccination) explained 11% of the variance in Covid-19 vaccination intentions, $R^2 = .11$, $F(7,429) = 7.31$, $p < .001$. Ethnicity, IMD decile and previous influenza vaccination were the only independent variables that significantly contributed to the regression model, such that White (versus non-White) participants, those living in less deprived areas and those who had received an influenza vaccination had stronger Covid-19 vaccination intentions. Adding the extended PMT variables in block 2 explained an additional 59% of the variance in Covid-19 vaccination intentions, $\Delta R^2 = .59$, $\Delta F(8,421) = 104.45$, $p < .001$. All of the extended PMT variables, with the exception of perceived severity and descriptive norms, were significant predictors. Ethnicity, IMD decile and previous influenza vaccination were no longer significant predictors when the extended PMT variables were added in block 2. The final regression model explained 70% of the variance in intention, $R^2 = .70$, $F(15, 421) = 65.71$, $p < .001$. The results of the regression analysis indicated that greater perceived vulnerability, response efficacy and self-efficacy as well as more positive injunctive norms were associated with stronger Covid-19 vaccination intentions, whereas greater perceived maladaptive response rewards (of not being vaccinated) and responses costs (of being vaccinated) were associated with weaker Covid-19 vaccination intentions. Of the extended PMT variables, injunction norms had the strongest effect on Covid-19 vaccination intentions, followed by maladaptive response rewards and self-efficacy. Rerunning the regression analysis with the imputed datasets produced virtually identical results (see Supplementary File 3, Table 2).

Associations with Covid-19 vaccination uptake

Considering the demographic variables, only ethnicity and relative deprivation had significant, but small-sized, correlations with self-reported receipt of a Covid-19 vaccination at follow-up (see Supplementary File 2), such that White (versus non-White) participants and those living in less deprived areas were more likely to have had a Covid-19 vaccination. Age and sex had non-significant associations with receipt of a Covid-19 vaccination as did whether participants had been diagnosed with Covid-19 or had self-isolated. Those who had received an influenza vaccination were significantly more likely to also have a Covid-19 vaccination, although the size of the effect was small. All of the extended PMT variables had significant correlations with self-reported receipt of a Covid-19 vaccination at follow-up (see

Table 2). The correlations for intention and injunction norms were large-sized, and the correlations for perceived vulnerability, maladaptive response rewards, response costs and descriptive norms were medium-sized, whereas the correlations for perceived severity, response efficacy and self-efficacy were small-sized. The direction of the correlations indicated that higher levels of perceived vulnerability, perceived severity, response efficacy and self-efficacy as well as more positive injunctive and descriptive norms were associated with a greater uptake of a Covid-19 vaccination, whereas higher maladaptive response rewards and response costs were associated lower uptake of a Covid-19 vaccination. Intention was the strongest correlate of Covid-19 vaccination uptake at follow-up. The size and significance of the correlations with Covid-19 vaccination uptake using the imputed datasets were virtually identical (see Supplementary File 3, Table 1).

Hierarchical logistic regression analysis predicting Covid-19 vaccination uptake

As shown in Table 4, the demographic variables entered in block 1 (i.e., age, sex, IMD decile) provided a non-significant prediction of Covid-19 vaccination uptake, $\chi^2(3) = 5.49$, $p = .14$, Naglekerke $R^2 = .04$, although IMD decile was a significant independent predictor of uptake, such that participants living in less deprived areas were more likely to report being vaccinated. Adding the extended PMT variables in block 2 produced a significant improvement in the prediction of Covid-19 vaccination uptake, $\Delta\chi^2(8) = 94.75$, $p < .001$, ΔNaglekerke $R^2 = .55$. The previously significant effect for IMD decile became non-significant and maladaptive response rewards and response costs emerged as significant independent predictors of Covid-19 vaccination uptake, such that perceptions of greater maladaptive response rewards and greater response costs were associated with lower uptake. Adding intention in block 3 led to a further significant improvement in the prediction of Covid-19 vaccination uptake, $\Delta\chi^2(1) = 11.66$, $p < .001$, ΔNaglekerke $R^2 = .06$. The previously significant effects for maladaptive response rewards and response costs became non-significant and intention was a significant independent predictor of uptake. In addition, self-efficacy was found to have a significant negative effect on uptake in model 3. However, given that self-efficacy had significant positive bivariate association with uptake, the negative effect in the regression analysis is likely to be due to a suppressor effect and is therefore not interpreted further. Rerunning the regression analysis with the imputed datasets produced almost identical results (see Supplementary File 3, Table 3), except that the previously significant effect of response costs in model 2 was non-significant in the imputed datasets.

Discussion

The present study applied an extended version of PMT to explain Covid-19 vaccination intentions and uptake in a sample of UK adults aged 50-64 years old. The study also considered the influence of demographics, experiences with Covid-19, and past influenza vaccination behaviour. Considering the demographic variables, ethnicity and relative deprivation, but not age and sex, had significant but small-sized correlations with both Covid-19 vaccination intentions and subsequent uptake. The current findings are in line with previous research that has indicated that people from non-White ethnicities are more hesitant towards receiving a Covid-19 vaccine in the UK (Kamal et al., 2021) and USA (e.g., Latkin et al., 2021; Salmon et al. 2021). Coupled with the higher Covid-19 mortality rates risk experienced by people from non-White, versus White, ethnicities (ONS, 2020) and a greater mistrust in healthcare providers (Acharya et al., 2021; Sze et al., 2020), the current findings indicate that targeted interventions for people from non-White ethnicities are a public health priority. In addition, people from more deprived areas of the UK also had weaker Covid-19 vaccination intentions and were less likely to have been vaccinated at follow-up. While relative deprivation has not been examined previously in relation to Covid-19 vaccination intentions and uptake, numerous studies have indicated that lower income and education are associated with increased hesitancy towards Covid-19 vaccines (e.g., Alfageeh et al., 2021; Alley et al., 2021; Freeman et al., 2020; Gan et al., 2021; Latkin et al., 2021; Robertson et al., 2021; Ruiz & Bell, 2021; Salmon et al., 2021). Again, these findings indicate that there may be social and economic inequalities in relation to the uptake of Covid-19 vaccines that vaccination programmes need to address. In contrast, age and sex were found to have non-significant correlations with Covid-19 vaccination intentions and uptake, in line with the inconclusive findings reported by the Lin at al. (2021) review.

Having been diagnosed with Covid-19 or having had to self-isolate as a result of a close contact with someone with Covid-19 were not significantly correlated with Covid-19 vaccination intentions and uptake, as also reported by Lin at al. (2021). In contrast, those who had received an influenza vaccination had stronger Covid-19 vaccination intentions and were more likely to be vaccinated at follow-up. The significant effect of previous engagement with vaccination programmes was also highlighted by Lin at al. (2021), and suggests that the concerns or barriers of those who have previously declined vaccinations need to be addressed to maximise the uptake of Covid-19 vaccinations. Such a finding is also consistent with research on health behaviour that indicates that past behaviour is a strong predictor of future behaviour (McEachan et al., 2011), although it should be noted that the size of the correlations between uptake of an influenza vaccination and Covid-19 vaccination intentions and subsequent uptake were small in the present study.

All of the extended PMT variables had significant correlations with both Covid-19 vaccination intentions and subsequent uptake. The correlations with Covid-19 vaccination intentions were medium- or large-sized. Weaker correlations were found with subsequent uptake, although the correlations for intention and injunctive norms were large-sized and those for perceived vulnerability, maladaptive response rewards, response costs and descriptive norms were medium-sized. Thus, stronger Covid-19 vaccination intentions and greater uptake were associated with higher perceived vulnerability, perceived severity, response efficacy and self-efficacy, lower maladaptive response rewards and response costs, and more supportive injunctive and descriptive norms.

Together, the extended PMT variables explained 59% of the variance in intention after controlling for the effects of demographics, previous Covid-19 experiences and past influenza vaccination behaviour. All of the extended PMT variables, with the exception of perceived severity and descriptive norms, were significant predictors. Moreover, the previously significant effects for ethnicity, relative deprivation and past influenza vaccination behaviour became non-significant when the extended PMT variables were entered into the regression analysis, consistent with the idea that the beliefs outlined in PMT should mediate the effect of more distal predictors (Orbell et al., 2017). Similarly, the significant effect of relative deprivation on lower uptake of a Covid-19 vaccine, became non-significant when the extended PMT variables were entered into the logistic regression analysis. In turn, the significant effects of maladaptive response rewards and responses costs on lower uptake also became non-significant after controlling for intention, which was found to be the key predictor of subsequent uptake of a Covid-19 vaccine.

The present findings are in line with the Lin et al. (2021) review which reported a range of beliefs about Covid-19 and Covid-19 vaccines to have significant correlations with Covid-19 vaccination intentions. The current study extends this work by finding that strong Covid-19 vaccination intentions are associated with greater subsequent uptake and account for the effects of other beliefs about Covid-19 and Covid-19 vaccines as well as the effects of more distal variables such as demographics. Similar findings have recently been reported by Shiloh et al. (2021) who found that intention mediated the effects of other beliefs (e.g., attitude, anticipated regret, perceived barriers, trust in Covid-19 vaccines, and social norms) on the uptake of a Covid-19 vaccine in Israel. The current findings are also in line with meta-analyses (Floyd et al., 2000; Milne et al., 2000) and reviews (Norman et al., 2015) of PMT which have noted that coping appraisals are stronger correlates of protective intentions than threat appraisals, and that intention is the strongest correlate of future behaviour.

It is possible that some of the impact of response costs (e.g., concerns about the safety of Covid-19 vaccines) on intentions to be vaccinated may be linked to issues of trust. Lin et al. (2021) highlighted trust as an important factor in relation to people's decisions whether or not to be vaccinated, although measures of trust in the state, health care organisations, health care professionals, scientists and manufacturers, typically have small sized correlations with Covid-19 vaccination intentions (Murphy et al., 2021; Salmon et al., 2021; Wong et al., 2021). In contrast, Shiloh et al. (2021) found that a more specific measure of trust in Covid-19 vaccines had a large sized correlation with Covid-19 vaccination intentions and was a significant predictor in a regression analysis controlling for a range of other variables.

The current study has a number of strengths. First, the study focused on the uptake of Covid-19 vaccines rather solely considering intended uptake, which has been the focus of almost all research to date. Second, the study also employed a prospective rather than a cross-sectional design, thereby providing greater confidence regarding the direction of effects. Third, the study considered many of the demographic variables and beliefs that were highlighted in Lin et al. (2021) review. Fourth, the study used an extended version of PMT as a theoretical framework to consider the correlates of Covid-19 vaccination intentions and behaviour. The study is one of the few to test all six components of PMT, as most applications of PMT fail to assess maladaptive response rewards and response costs (see Ling et al., 2019, for a recent exception). In addition, the study also considered the impact of normative influences which are not part of PMT. Interestingly, injunctive norms, rather than descriptive norms, were found to be predictive of intentions to receive a Covid-19 vaccine. This suggests that perceptions of others' approval, rather than others' behaviour, have a greater influence on people's decisions whether or not to be vaccinated.

The current study has a number of weaknesses that may temper conclusions drawn from the findings. First, the study included a self-report measure of receipt of a Covid-19 vaccine at follow-up which may be open to social desirability effects. Nonetheless, the reported uptake rate in the current study (94.0%) was very similar to officially recorded vaccination rates (of at least one dose) at the time of the follow-up which, for example, was 94.9% for 50-64 year olds in England (NHS, 2021b). Second, the sample was not representative of the UK population of 50-64 year olds which therefore limits the generalizability of the findings, although the findings are consistent with previous research on the correlates of intend uptake of Covid-19 vaccines (Lin et al., 2021). Relatedly, there are likely to be some self-selection biases in the sample given the method of recruitment, although it is possible that those with very positive or, equally, negative attitudes towards Covid-19 vaccines may have been more inclined to participate in the study. Third, there was some loss to follow-up which may have further biased the findings, although attrition analyses revealed no significant baseline differences between those lost to follow-up and those who completed both surveys. In addition, missing data analyses indicated that data were missing at completely at random and that re-running the main analyses with imputed datasets produced almost identical results, therefore pointing to the robustness of the findings. Fourth, the study was conducted in a country and in an age group with high uptake rates. Future research is therefore needed in countries, and on groups, with lower vaccination rates. For example, evidence from the UK vaccination programme indicates that younger age groups are less likely to be vaccinated (NHS, 2021b). Nonetheless, health cognitions outlined in PMT would still be expected to be predictive of Covid-19 intentions and uptake, although the specific predictors are likely to vary as a function of the population examined (Ajzen, 1988). Future research should also focus on the uptake of second doses and booster doses over the course of the pandemic.

Notwithstanding the above limitations, the current findings have both theoretical and applied implications. From a theoretical perspective, the current findings indicate that PMT provides an appropriate theoretical framework for considering the determinants of Covid-19 vaccination intentions and uptake. However, as indicated by the current findings, the model could be usefully expanded to consider the role of normative influences on behaviour, as also noted by Scholz and Freund (2021). One of the strengths of PMT is that it has been subjected to many experimental tests which have shown that it is possible to manipulate PMT constructs with consequent effects on cognitions, intentions and behaviour (see Norman et al., 2015, for a review). As a result, PMT may also provide an appropriate framework for developing interventions to increase the uptake of Covid-19 vaccines. Moreover, the medium and large sized associations found between the extended PMT variables and Covid-19 vaccination intentions and behaviour indicate that they are likely to be key variables to target in interventions. The current findings suggest that interventions to increase the Covid-19 vaccination uptake need to first increase intentions to be vaccinated. To achieve this, interventions should focus more on beliefs (i.e., benefits and costs) about being vaccinated (or unvaccinated) rather than the severity of Covid-19 per se. In particular, interventions need to emphasize the benefits of vaccination (e.g., in terms of protecting oneself) and likely approval from others while also addressing the concerns (e.g., safety issues) and common misperceptions (e.g., natural immunity versus vaccines) that people might have about Covid-19 vaccines. Encouragingly, emerging evidence indicates that providing simple written information on the efficacy, benefits and safety of Covid-19 vaccines can increase intentions to be vaccinated (Davis et al., 2021; Freeman et al., 2021).

References

Acharya, A., Lam, K., Danielli, S., Ashrafian, H., & Darzi, A. (2021). Covid-19 vaccinations among Black Asian and Minority Ethnic (BAME) groups: Learning the lessons from influenza. *International Journal of Clinical Practice*, e14641. doi: 10.1111/IJCP.14641

Agarwal, R., & Gopinath, G. (2021, May 19). *A proposal to end the Covid-19 pandemic*. International Monetary Fund. https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2021/05/19/A-Proposal-to-End-the-COVID-19-Pandemic-460263

Ajzen, I. (1988). *Attitudes, personality and behavior*. Buckingham: Open University Press.

Alfageeh, E.I., Alshareef, N., Angawi, K., Alhazmi, F., & Chirwa, G.C. (2021). Acceptability of a Covid-19 vaccine among the Saudi population. *Vaccines*, *9*, 1-13. doi: 10.3390/vaccines9030226

Alley, S.J., Stanton, R., Browne, M., To, Q.G., Khalesi, S., Williams, S.L., Thwaite, T.L., Fenning, A.S., & Vandelanotte, C. (2021). As the pandemic progresses, how does willingness to vaccinate against covid-19 evolve? *International Journal of Environmental Research and Public Health*, *18*, 1-14. doi:10.3390/ijerph18020797

Altman, D.G. (2009). Missing outcomes in randomized trials: Addressing the dilemma. *Open Medicine*, *3*, 51-3.

Ansari-Moghaddam, A., Seraji, M., Sharafi, Z., Mohammadi, M., & Okati-Aliabad H. (2021). The protection motivation theory for predict intention of COVID-19 vaccination in Iran: A structural equation modeling approach. *BMC Public Health, 21*, 1165. doi: 10.1186/s12889-021-11134-8

BBC News. (2021, April 13). *Covid vaccine: All over-50s and high risk groups offered first dose*. https://www.bbc.co.uk/news/uk-56725940

Bish, A., Yardley, L., Nicoll, A., & Michie, S. (2011). Factors associated with uptake of vaccination against pandemic influenza: A systematic review. *Vaccine*, *29*, 6472-6484. doi: 10.1016/j.vaccine.2011.06.107

Chu, H., & Liu, S. (2021). Integrating health behavior theories to predict American's intention to receive a COVID-19 vaccine. *Patient Education and Counseling*, *104*, 1878-1886. doi: 10.1016/j.pec.2021.02.031

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159. doi: 10.1037//0033-2909.112.1.155.

Conner, M., & Norman, P. (Eds.). (2015). *Predicting and changing health behaviour: Research and practice with social cognition models* (3rd ed.). Buckingham: Open University Press.

Conner, M., & Sparks, P. (2015). The theory of planned behaviour and the reasoned action approach. In M. Conner & P. Norman (Eds.), *Predicting and changing health behaviour: Research and practice with social cognition models* (3rd ed., pp. 142-188). Buckingham: Open University Press.

Davis, C.J., Golding, M., & McKay, R. (2021). Efficacy information influences intention to take COVID-19 vaccine. *British Journal of Health Psychology*. doi: 10.1111/bjhp.12546

Eberhardt, J., & Ling, J. (2021). Predicting COVID-19 vaccination intention using protection motivation theory and conspiracy beliefs. *Vaccine*, *39*, 6269–6275. doi: 10.1016/j.vaccine.2021.09.010

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach.* New York, NY: Psychology Press.

Floyd, D.L., Prentice-Dunn, S., & Rogers, R.W. (2000). A meta-analysis of research on protection motivation theory, *Journal of Applied Social Psychology, 30*, 407-429. doi: 10.1111/j.1559-1816.2000.tb02323.x

Freeman, D., Loe, B.S., Chadwick, A., Vaccari, C., Waite, F., Rosebrock, L., Jenner, L., Petit, A., Lewandowsky, S., Vanderslott, S., et al. (2020). Covid-19 vaccine hesitancy in the UK: The Oxford coronavirus explanations, attitudes, and narratives survey (Oceans) II. *Psychological Medicine*. doi: 10.1017/S0033291720005188

Freeman, D., Loe, B.S., Yu, L.M., Freeman, J., Chadwick, A., Vaccari, C., Shanyinde, M., Harris, V., Waite, F., Rosebrock, L., et al. (2021). Effects of different types of written vaccination information on COVID-19 vaccine hesitancy in the UK (OCEANS-III): A single-blind, parallel-group, randomised controlled trial. *Lancet Public Health, 6*, e416-e427. doi: 10.1016/S2468-2667(21)00096-7

Gan, L., Chen, Y., Hu, P., Wu, D., Zhu, Y., Tan, J., Li, Y., & Zhang, D. (2021). Willingness to receive SARS-CoV-2 vaccination and associated factors among Chinese adults: A cross sectional survey. *International Journal of Environmental Research and Public Health*, *18*, 1-11. doi: 10.3390/ijerph18041993

Guidry, J.P.D., Laestadius, L.I., Vraga, E.K., Miller, C.A., Perrin, P.B., Burton, C.W., Ryan, M., Fuemmeler, B.F., & Carlyle, K.E. (2021). Willingness to get the COVID-19 vaccine with and without emergency use authorization. *American Journal* of *Infection Control*, *49*, 137-142. doi: 10.1016/j.ajic.2020.11.018

Haug, N., Geyrhofer, L., Londei, A., Dervic, E., Desvars-Larrive, A., Loreto, V., Pinior, B., Thurner, S., & Klimek, P. (2020). Ranking the effectiveness of worldwide Covid-19 government interventions. *Nature Human Behaviour, 4*, 1303–1312. doi: 10.1038/s41562-020-01009-0

Huang, P. C., Hung, C. H., Kuo, Y. J., Chen, Y. P., Ahorsu, D. K., Yen, C. F., Lin, C. Y., Griffiths, M. D., & Pakpour, A. H. (2021). Expanding protection motivation theory to explain willingness of COVID-19 vaccination uptake among Taiwanese university students. *Vaccines*, *9*, 1046. doi: 10.3390/vaccines9091046

Hungerford, D., & Cunliffe, N.A. (2021). Real world effectiveness of Covid-19 vaccines. *BMJ, 374*, n2034. doi: 10.1136/bmj.n2034

Irwin, A. (2021, March 25). *What it will take to vaccinate the world against COVID-19*. Nature. https://www.nature.com/articles/d41586-021-00727-3

Joint Committee on Vaccination and Immunisation (2021, January 6). *Advice on priority groups for Covid-19 vaccination, 30 December 2020.* https://www.gov.uk/government/publications/priority-groups-for-coronavirus-covid-19-vaccination-advice-from-the-jcvi-30-december-2020/joint-committee-on-vaccination-and-immunisation-advice-on-priority-groups-for-covid-19-vaccination-30-december-2020

Kamal, A., Hodson, A., & Pearce, J.M. (2021). A rapid systematic review of factors influencing COVID-19 vaccination uptake in minority ethnic groups in the UK. *Vaccines*, *9*, 1121. doi: 10.3390/vaccines9101121

Karafillakis, E., Simas, C., Jarrett, C., Verger, P., Peretti-Watel, P., Dib, F., De Angelis, S., Takacs, J., Ali, K.A., Pastore, L., & Larson, H. (2019). HPV vaccination in a context of public mistrust and uncertainty: A systematic literature review of determinants of HPV vaccine hesitancy in Europe. *Human Vaccines and Immunotherapeutics*, *15*, 1615-1627. doi: 10.1080/21645515.2018.1564436

Latkin, C.A., Dayton, L., Yi, G., Colon, B., & Kong, X. (2021). Mask usage, social distancing, racial, and gender correlates of COVID-19 vaccine intentions among adults in the US. *PLoS One*, *16*, e0246970. doi: 10.1371/journal.pone.0246970

Lin, C., Tu, P., & Beitsch, L.M. (2021). Confidence and receptivity for Covid-19 vaccines: A rapid systematic review. *Vaccines*, *9*, 1-32. doi: 10.3390/vaccines9010016

Lin, Y., Hu, Z., Zhao, Q., Alias, H., Danaee, M., & Wong, L.P. (2020). Understanding Covid-19 vaccine demand and hesitancy: A nationwide online survey in China. *PLoS*

Neglected Tropical Diseases, *14*, e0008961. doi: 10.1371/journal.pntd.0008961.

Ling, M., Kothe, E.J., & Mullan, B.A. (2019). Predicting intention to receive a seasonal influenza vaccination using protection motivation theory. *Social Science and Medicine*, 233, 87-92. doi: 10.1016/j.socscimed.2019.06.002

Lueck, J.A., & Spiers, A. (2020). Which beliefs predict intention to get vaccinated against COVID-19? A mixed-methods reasoned action approach applied to health communication. *Journal of Health Communication*, *25*, 790-798. doi: 10.1080/10810730.2020.1865488

Martin, L. R., & Petrie, K. J. (2017). Understanding the dimensions of anti-vaccination attitudes: The Vaccination Attitudes Examination (VAX) Scale. *Annals of Behavioral Medicine, 51*, 652–660. doi: 10.1007/s12160-017-9888-y

McEachan, R.R.C., Conner, M., Taylor, N.J., & Lawton, R.J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis, *Health Psychology Review*, *5*, 97-144, doi: 10.1080/17437199.2010.521684

Milne, S., Sheeran, P., & Orbell, S. (2000). Prediction and intervention in health-related behavior: A meta-analytic review of protection motivation theory, *Journal of Applied Social Psychology, 30*, 106-143. doi: 10.1111/j.1559-1816.2000.tb02308.x

Murphy, J., Vallières, F., Bentall, R.P., Shevlin, M., McBride, O., Hartman, T.K., McKay, R., Bennett, K., Mason, L., Gibson-Miller, J., et al. (2021). Psychological characteristics associated with Covid-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. *Nature Communications*, 12, 29. doi:10.1038/s41467-020-20226-9

NHS. (2021a, September 7). Coronavirus (COVID-19) vaccines. https://www.nhs.uk/conditions/coronavirus-covid-19/coronavirus-vaccination/coronavirus-vaccine/

NHS. (2021b). COVID -19 vaccinations. https://www.england.nhs.uk/statistics/statistical-work-areas/covid-19-vaccinations/

Norman, P., Boer, H., Seydel, E.R., & Mullan, B. (2015). Protection motivation theory. In M. Conner & P. Norman (Eds.), *Predicting and changing health behaviour: Research and practice with social cognition models* (3rd ed., pp. 70-106). Buckingham: Open University Press.

Office for National Statistics. (2020, October 16). *Updating ethnic contrasts in deaths involving the coronavirus (COVID-19), England and Wales: Deaths occurring 2 March to 28 July 2020.* https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/updatingethniccontrastsindeathsinvolvingthecoronaviruscovid19englandandwales/deathsoccurring2marchto28july2020

Orbell, S., Szczepura, A., Weller, D., Gumber, A., & Hagger, M.S. (2017). South Asian ethnicity, socioeconomic status, and psychological mediators of faecal occult blood colorectal screening participation: A prospective test of a process model. *Health Psychology*, *36,* 1161-1172. doi: 10.1037/hea0000525

Public Health England. (2021). Covid-19 vaccine surveillance report week 37. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1018416/Vaccine_surveillance_report_-_week_37_v2.pdf

Robertson, E., Reeve, K.S., Niedzwiedz, C.L., Moore, J., Blake, M., Green, M., Katikireddi, S.V., & Benzeval, M.J. (2021). Predictors of COVID-19 vaccine hesitancy in the UK household longitudinal study. *Brain*, *Behavior*, *and Immunity*, *94*, 41-50. doi: 10.1016/j.bbi.2021.03.008

Rogers, R.W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J.T. Cacioppo & R.E. Petty

(Eds.), *Social psychophysiology: A source book* (pp. 153-176). New York: Guilford Press.

Ruiz, J.B., & Bell, R.A. (2021). Predictors of intention to vaccinate against Covid-19: Results of a nationwide survey. *Vaccine*, *39*, 1080-1086. doi: 10.1016/j.vaccine.2021.01.010

Salmon, D.A., Dudley, M.Z., Brewer, J., Kan, L., Gerber, J.E., Budigan, H., Proveaux, T.M., Bernier, R., Rimal, R., & Schwartz, B. (2021). Covid-19 vaccination attitudes, values and intentions among United States adults prior to emergency use authorization. *Vaccine*, *39*, 2698-2711. doi: 10.1016/j.vaccine.2021.03.034

Scholz, U., & Freund, A.M. (2021), Determinants of protective behaviours during a nationwide lockdown in the wake of the COVID-19 pandemic. *British Journal of Health Psychology*, *26*, 935-957. doi: 10.1111/bjhp.12513

Schüz, B., Conner, M., Wilding, S., Alhwatan, R., Prestwich, A., & Norman, P. (2021). Do socio-structural factors moderate the effects of health cognitions on Covid-19 protection behaviours? *Social Science and Medicine*, 285, 114261. doi: 10.1016/j.socscimed.2021.114261

Shiloh, S., Peleg, S., Nudelman, G. (2021). Vaccination against COVID-19: A longitudinal trans-theoretical study to determine factors that predict intentions and behavior. *Annals of Behavioral Medicine*. doi:10.1093/abm/kaab101

Sherman, S.M., Smith, L.E., Sim, J., Amlôt, R., Cutts, M., Dasch, H., Rubin, G.J., & Sevdalis, N. (2021). Covid-19 vaccination intention in the UK: Results from the COVID-19 vaccination acceptability study (CoVAccS), a nationally representative cross-sectional survey. *Human Vaccines and Immunotherapeutics*, *17*, 1612-1621. doi: 10.1080/21645515.2020.1846397

Shrotri, M., Swinnen, T., Kampmann, B., & Parker, E.P.K. (2021). An interactive website tracking COVID-19 vaccine development. *Lancet Global Health*, *9*, e590-e592. doi:

10.1016/S2214-109X(21)00043-7

Sze, S., Pan, D., Nevill, C., Gray, L., Martin, C., Nazareth, J., Minhas, J., Divall, P., Khunti, K., Abrams, K., et al. (2020). Ethnicity and clinical outcomes in Covid-19: A systematic review and meta-analysis. *EClinicalMedicine, 29*. 100630. doi: 10.1016/J.ECLINM.2020.100630

Tong, K.K., He, M., Wu, A.M.S., Dang, L., & Chen, J.H. (2021). Cognitive factors influencing COVID-19 vaccination intentions: An application of the protection motivation theory using a probability community sample. *Vaccines*. 2021, 9, 1170. doi: 10.3390/vaccines9101170

Wong, M.C.S., Wong, E.L.Y., Huang, J., Cheung, A.W.L., Law, K., Chong, M.K.C., Ng, R.W.Y., Lai, C.K.C., Boon, S.S., Lau, J.T.F., et al. (2021). Acceptance of the Covid-19 vaccine based on the health belief model: A population-based survey in Hong Kong. *Vaccine*, *39*, 1148-1156. doi: 10.1016/j.vaccine.2020.12.083

World Health Organisation. (2014, October 1). *Report of the SAGE working group on vaccine hesitancy.* https://www.who.int/immunization/sage/meetings/2014/october/1_Report_WORKING_GROUP_vaccine_hesitancy_final.pdf

World Health Organisation. (2020, March 11). *Coronavirus disease 2019 (COVID-19): Situation report - 51.* https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10

World Health Organization. (2021, December 17). *WHO coronavirus (COVID-19) dashboard*. https://covid19.who.int/

Table 1. *Baseline Sample Characteristics (N = 438).*

		M	*SD*	*N*	%
Age		55.61	4.12		
Sex	Male			174	39.7
	Female			264	60.3
Ethnicity	White			420	95.9
	Non-white			18	4.1
IMD Decile [a]		6.09	2.66		
Covid-19 Diagnosis	Yes			14	3.2
	No			424	96.8
Self-isolated	Yes			48	11.0
	No			390	89.0
Influenza Vaccination	Yes			217	49.5
	No			221	50.5

Note. [a] $n = 437$.

Table 2. *Means, Standard Deviations and Correlations between the Extended Protection Motivation Theory Measures and Covid-19 Vaccination Intentions and Uptake (N = 438).*

	M (*SD*)	2.	3.	4.	5.	6.	7.	8.	9.	10.[bc]
1. Perceived Vulnerability	5.43 (1.28)	.56***	-.54***	.43***	.42***	-.37***	.57***	.42***	.59***	.40***
2. Perceived Severity	5.88 (0.94)		-.38***	.21***	.21***	-.16***	.38***	.29***	.37***	.29***
3. Maladaptive Response Rewards	2.67 (1.51)			-.32***	-.45***	.56***	-.54***	-.44***	-.64***	-.45***
4. Response Efficacy	4.40 (1.35)				.31***	-.34***	.35***	.30***	.43***	.28***
5. Self-Efficacy	6.32 (1.01)					-.54***	.55***	.47***	.62***	.27***
6. Response Costs	3.03 (1.75)						-.47***	-.38***	-.58***	-.37***
7. Injunctive Norms	6.50 (1.01)							.69***	.73***	.51***
8. Descriptive Norms	6.15 (0.98)								.55***	.37***
9. Intention	6.44 (1.32)									.68***
10. Covid-19 Vaccination Uptake [a]										

Note. [a] 0 = No, 1 = Yes. [b] $n = 420$. [c] Point-biserial correlations. *** $p < .001$.

Table 3. *Summary of Hierarchical Regression Analysis Predicting Covid-19 Vaccination Intentions (N = 437).*

Model	*B*	*SE*	*β*	*B*	*SE*	*β*
1. Age	-0.01	0.02	-.03	0.003	0.01	.01
Sex [a]	0.01	0.13	.002	0.13	0.08	.05
Ethnicity [b]	0.73	0.31	.11*	0.25	0.19	.04
IMD Decile	0.07	0.02	.13**	0.01	0.01	.02
Covid-19 Diagnosis [c]	-0.17	0.38	-.02	0.01	0.22	.001
Self-isolated [c]	-0.06	0.21	-.02	-0.12	0.12	-.03
Influenza Vaccination [c]	0.68	0.12	.26***	0.13	0.08	.05
2. Perceived Vulnerability				0.09	0.04	.08*
Perceived Severity				0.04	0.05	.03
Maladaptive Response Rewards				-0.22	0.04	-.19***
Response Efficacy				0.09	0.03	.09**
Self-Efficacy				0.24	0.05	.19***
Response Costs				-0.11	0.04	-.10**
Injunctive Norms				0.44	0.05	.34***
Descriptive Norms				0.08	0.05	.06

Note. [a] 0 = Female, 1 = Male. [b] 0 = Non-White, 1 = White. [c] 0 = No, 1 = Yes.
Model 1 R^2 = .11***. Model 2 R^2 = .70***. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4. *Summary of Hierarchical Logistic Regression Analysis Predicting Covid-19 Vaccination Uptake (N = 419).*

Model	*B*	*SE*	*OR*	(95% *CI*)	*B*	*SE*	*OR*	(95% *CI*)	*B*	*SE*	*OR*	(95% *CI*)
1. Age	0.003	0.05	1.00	(0.91-1.11)	0.03	0.07	1.04	(0.90-1.20)	0.02	0.08	1.02	(0.87-1.20)
Sex [a]	0.21	0.43	1.23	(0.53-2.87)	1.04	0.75	2.83	(0.65-12.33)	0.71	0.82	2.04	(0.41-10.24)
IMD Decile	0.18	0.08	1.19*	(1.02-1.39)	0.02	0.11	1.02	(0.82-1.27)	-0.05	0.13	0.96	(0.75-1.22)
2. Perceived Vulnerability					0.08	0.30	1.08	(0.60-1.96)	0.12	0.38	1.13	(0.53-2.40)
Perceived Severity					0.51	0.32	1.66	(0.89-3.12)	0.43	0.37	1.54	(0.75-3.18)
Maladaptive Response Rewards					-0.73	0.36	0.48*	(0.23-0.98)	-0.15	0.40	0.87	(0.40-1.89)
Response Efficacy					0.26	0.26	1.29	(0.78-2.14)	0.04	0.29	1.04	(0.59-1.83)
Self-Efficacy					-0.43	0.30	0.65	(0.36-1.18)	-0.77	0.36	0.46*	(0.23-0.93)
Response Costs					-0.83	0.40	0.44*	(0.20-0.95)	-0.60	0.44	0.55	(0.23-1.30)
Injunctive Norms					0.38	0.25	1.47	(0.90-2.39)	0.02	0.31	1.02	(0.55-1.88)
Descriptive Norms					0.26	0.32	1.30	(0.69-2.44)	0.14	0.38	1.15	(0.55-2.42)
3. Intention									1.05	0.35	2.86**	(1.45-5.62)

Note. [a] 0 = Female, 1 = Male. Model 1 $\chi^2(3) = 5.49$, $p = .14$, Naglekerke $R^2 = .04$. Model 2 $\chi^2(11) = 100.25$, $p < .001$, Naglekerke $R^2 = .59$. Model 3 $\chi^2(12) = 111.91$, $p < .001$, Naglekerke $R^2 = .64$. * $p < .05$. ** $p < .01$.

Supplementary File 1. *Survey Items.*

Covid-19 experiences:

1. Have you been diagnosed with COVID-19 or received a positive COVID-19 test result during the coronavirus pandemic?
2. Have you had to self-isolate during the coronavirus pandemic because you have been in close contact with someone diagnosed with COVID-19?

Influenza vaccination:

1. Have you been vaccinated for seasonal influenza (i.e. had the flu vaccine) this winter?

Perceived vulnerability:

1. Without a COVID-19 vaccine, I am vulnerable to contracting COVID-19.
2. Even if I don't get a COVID-19 vaccination, I'm unlikely to get COVID-19.
3. If I don't get a COVID-19 vaccination I am at risk of getting COVID-19.

Perceived severity:

1. The negative impact of the COVID-19 is very severe.
2. COVID-19 can be a life-threatening disease.
3. COVID-19 is a serious illness for someone like me.

Maladaptive response rewards:

1. Not getting a COVID-19 vaccine would have some advantages for me.
2. If I do not get a COVID-19 vaccination, then I won't have to worry about the safety of the vaccine.
3. If I do not get a COVID-19 vaccination, then I won't have to spend time and effort getting vaccinated.
4. Natural immunity lasts longer than a COVID-19 vaccination.
5. Natural exposure to coronavirus gives the safest protection.
6. Being exposed to coronavirus naturally is safer for the immune system than being exposed through vaccination.

Response efficacy:

1. I'm sure that having a COVID-19 vaccine would be effective in reducing my personal risk of getting COVID-19.
2. Having a COVID-19 vaccination would stop me from getting COVID-19.
3. Getting a COVID-19 vaccine would guarantee that I don't get COVID-19.

Self-efficacy:

1. It would be very easy for me to have a COVID-19 vaccination.
2. Getting a COVID-19 vaccination would be difficult for me.
3. Being vaccinated against COVID-19 would be easy.

Response Costs:

1. Being vaccinated against COVID-19 would be painful.
2. Having a COVID-19 vaccine could give me COVID-19.
3. I would be worried about experiencing side effects from a COVID-19 vaccine.
4. I worry about the unknown effects of the COVID-19 vaccines in the future.
5. Although the COVID-19 vaccines appear to be safe, there may be problems with them that we have not yet discovered.

Injunctive Norms:

1. People who are important to me think I would have a COVID-19 vaccine.
2. People who are important to me would approve of me having a COVID-19 vaccine.
3. People who are important to me would want me to have a COVID-19 vaccine.

Descriptive Norms:

1. Most people I know will have a COVID-19 vaccine.
2. Of the people you know, how many will have a COVID-19 vaccine.

Intention:

1. I intend to have a coronavirus (COVID-19) vaccination.
2. I plan to have a coronavirus (COVID-19) vaccination.
3. I expect to have a coronavirus (COVID-19) vaccination.

Uptake of a Covid-19 vaccine at follow-up:

1. Have you received a Covid-19 vaccination?

Supplementary File 2. *Correlations between Demographics, Covid-19 Experiences, Past Influenza Vaccination and Covid-19 Vaccination Intentions and Uptake (N = 438).*

	Age	Sex [ad]	Ethnicity [bd]	IMD Decile [e]	Covid-19 Diagnosis [cd]	Self-Isolated [cd]	Influenza Vaccine [cd]
Perceived Vulnerability	.01	-.09	.09	.08	.01	.04	.25***
Perceived Severity	.05	-.13**	-.03	.01	.03	.05	.20***
Maladaptive Response Rewards	.04	.15**	-.06	-.07	.09	.002	-.30***
Response Efficacy	.08	-.002	.01	.10*	-.13**	-.09	.07
Self-Efficacy	-.02	.00	.05	.12*	-.05	.02	.18***
Response Costs	-.01	-.08	-.21***	-.14**	.06	.003	-.21***
Injunctive Norms	-.01	-.08	.09	.16**	-.03	.02	.22***
Descriptive Norms	-.02	-.17***	.07	.16**	-.03	-.04	.16***
Intention	.02	-.02	.13**	.15**	-.07	-.03	.28***
Covid-19 Vaccination Uptake [cdf]	.01	.02	.10*	.11*	-.01	.02	.25***

Note. [a] 0 = Female, 1 = Male. [b] 0 = Non-white, 1 = White. [c] 0 = No, 1 = Yes. [d] Point-biserial correlations. [e] $n = 437$. [f] $n = 420$.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Supplementary File 3 – Table 1. *Correlations between the Study Variables and Covid-19 Vaccination Intentions and Uptake using Pooled Data from Imputed Datasets (N = 438).*

	Intention	Covid-19 Vaccination Uptake [c]
Age	.02	.01
Sex [a]	-.02	.02
Ethnicity [b]	.13**	.10*
IMD Decile	.15**	.11*
Covid-19 Diagnosis [c]	-.01	-.01
Self-Isolated [c]	.02	.03
Influenza Vaccine [c]	.25***	.24***
Perceived Vulnerability	.59***	.38***
Perceived Severity	.37***	.29***
Maladaptive Response Rewards	-.64***	-.44***
Response Efficacy	.43***	.27***
Self-Efficacy	.62***	.25***
Response Costs	-.58***	-.36***
Injunctive Norms	.73***	.49***
Descriptive Norms	.55***	.36***
Intention	-	.66**

Note. [a] 0 = Female, 1 = Male. [b] 0 = Non-white, 1 = White. [c] 0 = No, 1 = Yes.
* p < .05. *** p < .001.

Supplementary File 3 – Table 2. *Summary of Hierarchical Regression Analysis Predicting Covid-19 Vaccination Intentions using Pooled Data from Imputed Datasets (N = 438).*

Model	*B*	*SE*		*B*	*SE*	
1. Age	-0.01	0.02		0.003	0.01	
Sex [a]	0.01	0.13		0.13	0.08	
Ethnicity [b]	0.73	0.31	*	0.25	0.19	
IMD Decile	0.07	0.02	**	0.01	0.01	
Covid-19 Diagnosis [c]	-0.17	0.38		0.01	0.22	
Self-isolated [c]	-0.06	0.21		-0.12	0.12	
Influenza Vaccination [c]	0.68	0.12	***	0.13	0.08	
2. Perceived Vulnerability				0.09	0.04	*
Perceived Severity				0.04	0.05	
Maladaptive Response Rewards				-0.22	0.04	***
Response Efficacy				0.09	0.03	**
Self-Efficacy				0.24	0.05	***
Response Costs				-0.11	0.04	**
Injunctive Norms				0.44	0.05	***
Descriptive Norms				0.08	0.05	

Note. [a] 0 = Female, 1 = Male. [b] 0 = Non-White, 1 = White. [c] 0 = No, 1 = Yes.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Supplementary File 3 – Table 3. *Summary of Hierarchical Logistic Regression Analysis Predicting Covid-19 Vaccination Uptake using Pooled Data from Imputed Datasets (N = 438).*

Model	*B*	*SE*	*OR*	(95% *CI*)	*B*	*SE*	*OR*	(95% *CI*)	*B*	*SE*	*OR*	(95% *CI*)
1. Age	0.01	0.05	1.01	(0.91-1.11)	0.05	0.07	1.05	(0.91-1.21)	0.03	0.08	1.03	(0.88-1.21)
Sex [a]	0.18	0.43	1.20	(0.51-2.79)	1.14	0.74	3.12	(0.73-13.31)	0.87	0.81	2.38	(0.49-11.58)
IMD Decile	0.18	0.08	1.20*	(1.03-1.40)	0.06	0.11	1.06	(0.86-1.32)	0.00	0.12	1.00	(0.79-1.27)
2. Perceived Vulnerability					0.02	0.30	1.02	(0.56-1.84)	0.04	0.38	1.05	(0.49-2.21)
Perceived Severity					0.50	0.31	1.64	(0.89-3.04)	0.40	0.36	1.49	(0.73-3.04)
Maladaptive Response Rewards					-0.86	0.35	0.43*	(0.21-0.85)	-0.25	0.40	0.78	(0.36-1.69)
Response Efficacy					0.24	0.25	1.27	(0.78-2.08)	0.03	0.28	1.04	(0.59-1.80)
Self-Efficacy					-0.57	0.32	0.57	(0.31-1.05)	-0.91	0.38	0.41*	(0.19-0.86)
Response Costs					-0.61	0.38	0.54	(0.26-1.15)	-0.39	0.43	0.68	(0.29-1.56)
Injunctive Norms					0.43	0.25	1.53	(0.94-2.50)	0.05	0.32	1.05	(0.56-1.96)
Descriptive Norms					0.27	0.32	1.31	(0.70-2.46)	0.21	0.38	1.23	(0.59-2.56)
3. Intention									1.06	0.36	2.89**	(1.44-5.79)

Note. [a] 0 = Female, 1 = Male. * $p < .05$. ** $p < .01$.