Predicting Vaccine Uptake during COVID-19 Crisis: A Motivational Approach

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Highlights

- Infection-related risk perception predicts vaccination intention and uptake
- Autonomous motivation positively contributes to vaccination intention and uptake
- The contribution of infection-related risk perception on vaccination is fully mediated by motivations to get vaccinated
- Distrust in the vaccine undermines vaccination intention and uptake
- We discuss implications in terms of communication strategies

Abstract

The present research examined which motivational factors contribute to individuals' intention to take a vaccine that protects against SARS-CoV-2-virus and their self-reported vaccine uptake several months later. The role of different types of motivation was investigated (i.e., autonomous and controlled regulation) as well as vaccine distrust and effort to obtain a vaccine. Across two large-scale cross-sectional (N = 8887) and longitudinal (N = 6996) studies and controlling for various covariates, autonomous motivation and distrust-based amotivation contributed positively and negatively, respectively, to a) concurrent vaccination intentions, b) self-reported vaccination and c) subsequent subscription to a waitlist to obtain a vaccine. Participants' infection-related risk perception predicted more positive vaccination outcomes through fostering greater autonomous motivation for vaccination and lower distrust, whereas pandemic-related health concerns failed to yield such adaptive effects. The results emphasize the importance of fostering autonomous motivation for vaccination and handling distrust, both at the societal and face-to-face level.

Keywords: motivation, risk perception, pandemic concerns, COVID-19, vaccination, vaccination hesitancy

Predicting Vaccine Uptake during COVID-19 Crisis: A Motivational Approach

To overcome the COVID-19 crisis, governments worldwide faced the challenge to motivate their citizens to accept a vaccine to protect themselves and society against infection by the SARS-CoV-2-virus (Fontanet & Cauchemez, 2020). While some citizens were eager to get vaccinated, others were hesitant and still others indicated they would refuse the vaccine (Lazarus et al., 2021; Sallam, 2021). The present research examined in a large sample of Belgian participants the predictive validity of a various motivations related to COVID-19 vaccination as predictors of individuals' vaccination intention (Study 1) and eventual vaccine uptake or subscription to a waitlist (Study 2). In addition, we examined perceived risks to be infected with COVID-19 as precursors of individuals' (lack of) motivation to get vaccinated and investigated whether motivation would act as a mediating mechanism in the link between infection-related risk perception and critical vaccination outcomes on the one hand and general pandemic-related health concerns on the other hand. To achieve this dual goal, we drew upon theoretical traditions, striving for cross-fertilization between the literatures on self-determination theory and vaccination uptake.

(Lack of) Motivation for Vaccine Uptake

People may hold different reasons both for accepting and refusing a vaccine. Grounded in Self-Determination Theory (SDT; Ryan & Deci, 2017; Vansteenkiste et al., 2006), a broad theory on human motivation, a qualitative distinction can be made between controlled and autonomous reasons for vaccine uptake. When motivation is controlled, individuals would take a vaccine because they feel pressured to do so, either to avoid the criticism and disapproval from others or to obtain a contingently offered reward in exchange for the effort made. When autonomously motivated, individuals accept a vaccine because they can identify with the necessity and benefit of vaccination (e.g., to protect themselves and

close others). Autonomous motivation denotes high volitional commitment to vaccination because the reasons for vaccine uptake have been internalized and fully endorsed. Although the differential predictive role of autonomous and controlled motivation has been well-established for various recurrent health behaviors (e.g., Ng et al., 2012; Ryan et al., 2008), prior work on vaccine acceptance from the SDT-perspective is limited (Denman et al., 2016; Moon et al., 2021).

Much as individuals' motivation for vaccination constitutes a multifaceted concept, also their lack of motivation can be driven by different reasons. Specifically, we distinguished two types of amotivation, one being distrust- and the other effort-based. Distrust-based amotivation reflects people's general doubts to accept a vaccine, which can stem from different sources, including doubts about vaccine safety and efficiency as well as doubts vis-à-vis the virtues and the competency of health professionals and authorities that promote vaccination (Brownlie & Howson, 2005; Milošević Đorđević et al., 2021). In the present study we focus specifically on distrust regarding vaccine efficacy and its potential side effects because these appear as the chief drivers of vaccine hesitancy (Brewer, 2021; Lane et al., 2018; MacDonald, 2015).

Effort-based amotivation is at stake when citizens may trust the promoted vaccine, but may not have sufficient resources available (e.g., physical, or mental energy) to engage in behaviors required for vaccination (Legault et al., 2006; Pelletier et al., 1999). Notably, this effort-based form of amotivation is conceptually different from self-efficacy, which received prior attention in the vaccination literature (Chu & Liu, 2021). Individuals may know how and feel efficacious to engage in a required activity, yet they may lack the energetic resources needed to perform the behavior. Because self-efficacy for vaccine uptake was found to be unrelated to vaccination intention (Chu & Liu, 2021), the present study sought to examine whether effort-based amotivation would play a significant role.

Role of Infection-Related Risk Perception and Pandemic-Related Health Concerns

Furthermore, we considered the specific role of individuals' perceived infection risk with COVID-19 and pandemic-related health concerns as predictors of individuals' (a)motivation to accept the vaccine. Risk perception has been defined as the "anticipated likelihood and magnitude of potential health-specific harms" (Brewer et al., 2007, p. 136). Two facets of risk perception are typically distinguished, with the first describing the probability of the harmful event (i.e., likelihood; see Brewer et al., 2007), and the second facet describing the severity of the event. With regard to COVID-19, several studies have identified a positive link between infection-related risk perception and better adherence to health-protective behaviors (de Bruin & Bennett, 2020; Siegrist et al., 2021) as well as greater vaccination intentions (Allington et al., 2021; Caserotti et al., 2021; Detoc et al., 2020; Reiter et al., 2020; Shmueli, 2021; but see Faasse & Newby, 2020; Williams et al., 2020).

In addition, we examined the role of people's health concerns during the pandemic as a potential additional driver to uptake a vaccine. Unlike infection-related risk perception the role of pandemic-related health concerns in the prediction of vaccine intentions has received little attention and the results are inconsistent. While Faasse and Newby (2020), found a positive link between concerns regarding a COVID-19 outbreak and vaccine intention, Williams et al. (2020) and Pastorino et al. (2021) did not find an association between concerns an COVID-19 vaccination intentions.

Note that perceived infection-related risk represents a future-oriented assessment, while pandemic-related health concerns are retrospectively assessed. Presumably they go hand in hand (Williams et al., 2020), but we sought to examine and understand whether they have a specific role in the prediction of vaccination intention through a differentiated pattern of vaccination motivations. Individuals high in infection-related risk perception would more easily endorse the decision to be vaccinated and feel less pressured to do so, thus contributing

to more autonomous and lower controlled motivation for vaccination. Also, when risk for infection is perceived as high with serious consequences, people would want to do the necessary efforts to get vaccinated while giving less consideration for potential side-effects. For this reason, infection-related risk perception was expected to relate negatively to both effort-based and distrust-based amotivation. Although pandemic-related health concerns may yield a similar pattern of correlations, their contribution after controlling for infection-related risks may be less clear-cut.

The Present Study

The announcement that effective COVID-19 vaccines had been developed was both a source of hope but also of preoccupation in the population. Vaccine hesitant individuals saw different reasons not to accept a vaccine, whereas others were eagerly waiting to get vaccinated. This context therefore offered a great opportunity to test the predictive validity of different motivations for both vaccine uptake and vaccine refusal. Study 1 was cross-sectional and included an assessment of vaccination intention, whereas Study 2 was prospective and included an assessment of self-reported vaccination and vaccination waitlist subscription. In an attempt to strive for cross-fertilization between different literatures, we examined an integrated process model, with infection-related risk perception and pandemic-related health concerns feeding into different vaccination motivations, which, in turn, were expected to predict vaccination outcomes.

Study 1

We conducted Study 1 in November-December 2020, at a moment when the roll out of vaccines was announced. At that time, our critical outcome was necessarily intentional rather than actual behavior. We formulated the following three hypotheses. First, we expected infection-related risk perception to be positively related to vaccination intention beyond the effect of health concerns (Hypothesis 1). Second, as a sense of personal choice for

vaccination is critical, we predicted that only individuals with a high level of autonomous motivation would express a greater vaccination intention than those with high controlled motivation. As for a lack of motivation, especially distrust-based amotivation and - less so - effort-based amotivation would prevent individuals from accepting the vaccine (Hypothesis 2). Third, in an integrated model, we examined whether these different motivations and the lack thereof would account for the direct association between infection-related risk perception and vaccination intention (Hypothesis 3).

Method

Participants

The collected data are part of the Motivation Barometer project, a long-term, broad online study that began during the first outbreak of COVID-19 in Belgium. The data included in the present study were collected through social media from November 25 to December 19, 2020. This is a crucial period since at that time it became gradually clear that the vaccination campaign would be started in early 2021. The sample comprised 8887 non-vaccinated Belgian inhabitants. The mean age was 49.93 (*SD* = 14.58), 61% were females, 71% had a higher degree (i.e., bachelor, master, or Ph.D.), and 75% reported that they had no comorbidity factors associated with CODIV-19.

Measures

Pandemic-related health concerns. We assessed pandemic-related health concerns using a scale inspired by the measures for environmental safety (Chen et al., 2015). Participants indicated their agreement (from 1 = “Strongly disagree” to 5 = “Strongly agree”) to two items: “Over the past week, during the COVID-19 crisis I have been concerned about my health” and “Over the past week, during the COVID-19 crisis I have been concerned about the health of my close relatives” (α = .66).

Infection-related risk perception. We measured perceptions related to the COVID-19 by asking participants to rate two aspects, namely the estimated risk of infection (from 1 = "Very small" to 5 = "Very high") and the perceived severity of the associated consequences (from 1 = "Not at all serious" to 5 = "Very serious"), for themselves and for the general population, making four items in total (i.e., risk for oneself, risk for others, severity for oneself, severity for others). Similar to previous research (Wolff et al., 2019), we created two indicators of risk perception by separately multiplying the perceived odds and consequences of infection, one for themselves and one for others, and rescaled the scores to a 1–5 range to ease interpretability (α = .63).

Motivation to get vaccinated. We relied on 12 items[1] (3 for each dimension) to capture participants' (lack of) motivations towards vaccination that were scored on a 5-point scale (from 1 = "Strongly disagree" to 5 = "Strongly agree"). Autonomous motivation (α = .94) assesses the extent to which one is fully convinced of the benefit and necessity of vaccination ("Getting vaccinated is consistent with my personal values", "It personally is meaningful for me to get vaccinated", "I fully concur to get vaccinated"). Controlled motivation (α = .69) reflects the degree to which one feels obliged to be vaccinated ("I feel pressured to get vaccinated", "I will be criticized if I don't get vaccinated"[2]). Distrust-based amotivation (α = .91) assesses the extent to which one distrusts the secondary effects of the vaccine or its efficacy ("I am concerned about possible side effects of the vaccine", "I don't trust the vaccine", "I don't think the research on the vaccine's effectiveness is rigorous enough"). Effort-based amotivation (α = .79) relates to the extent to which one perceives getting vaccinated as effortful due to various practical obstacles ("The vaccine takes too much

[1] We used a larger sample of items in the initial steps of the Motivation Barometer project. We reduced the number of items throughout the various data collections based on their construct relevance and in order to shorten the survey completion time.

[2] The item "I feel compelled to get vaccinated" was removed to improve reliability.

effort for me", "I can't make the effort to get the vaccine", "I don't feel like I can take the necessary steps to get the vaccine").

Vaccination intention. To get a sense of participants' stance on the COVID-19 vaccination, we used the following item "If you had the opportunity to be vaccinated against COVID-19 next week, what would you decide?". The response options comprised: (1) "I would refuse without any hesitation", (2) "I probably would refuse", (3) "Doubting", (4) "I probably would accept", (5) "I would accept without any hesitation".

Sociodemographic variables. We assessed participants' age, gender, education level (seven levels, from 1 = "No diploma" to 7 = "Master's degree or more"). Participants were also asked whether they had any comorbidity factors associated with COVID-19 (i.e., respiratory disease, diabetes, arterial hypertension, immunity deficiency, or any other comorbidity factor that may put them at risk).

Procedure

The adult population (over the age of 18) living in Belgium was eligible for participation. Respondents were recruited via paid and unpaid social media advertisements (e.g., Facebook, Instagram, Twitter), by reaching different organizations and media (e.g., local newspapers), and mailing lists. Participants were told that the collected data would remain strictly anonymous and confidential. All participants provided consent. Practical information (e.g., websites, phone number, mail address) was provided in case of questions or provoked negative feelings.

Data Analyses

We conducted the data analyses using R (R Core Team, 2013). Whenever possible, we used latent constructs in our structural equation models (SEMs). We tested these models with the *lavaan* R package (Rosseel, 2012). We estimated indirect effects in mediation SEM via the Delta method (the default method used in *lavaan*). We used the following cut-off to assess

goodness of fit of our structural equation models: *RMSEA* ≤ .05, *SRMR* < .08, *CFI* > .90, and *TLI* > .90 (based on Hu & Bentler, 1999; see also Marsh et al., 2004).

Results

Preliminary Analyses

Table 1 shows the descriptive statistics and bivariate Pearson-correlations of the control variables and the variables of interest. Concerning the control variables, age was positively associated with COVID-19 vaccination intention, pandemic-related health concerns, infection-related risk perception, and autonomous motivation, but negatively with controlled motivation, distrust-based amotivation, and effort-based amotivation. A higher level of education was positively related to vaccination intention, autonomous and controlled motivation, but negatively to pandemic-related health concerns, infection-related perceived risks, distrust-based amotivation, and effort-based amotivation. Differences between the variables of interest as a function of gender and comorbidity are available in the supplementary materials (Table 1S).

Because of these associations between the control variables and constructs of interest, we tested our structural equation model (SEM) with and without these control variables. The inclusion of the control variables in the model did not change the conclusions. Therefore, for the sake of parsimony, the results presented in the next sections leave out the control variables.

Turning to the variable of interest, the outcome variable ‘vaccination intention’ was positively related to concerns, perceived risks and autonomous motivation, but negatively to controlled motivation, distrust-based amotivation, and effort-based amotivation. Concerns and perceived risks were positively correlated, and both were positively associated with autonomous motivation, but negatively with the other motivations. Autonomous motivation

was negatively related to controlled motivation, distrust-based amotivation, and effort-based amotivation, whereas the latter were all positively associated with each other.

[Table 1 here]

Measurement Models

We performed several nested confirmatory factor analyses (CFA) with our variables of interest and compared the fit indices of a seven-factor model, i.e., the one that specifies a single factor for each of our constructs of interest, to six-, five-, four-, or one-factor models. The seven-factor model provided the best fit to the data and overall good fit indices (see Table 2S). All standardized loadings were larger than .40, and no cross-loadings or within-factor error correlations had to be tolerated.

Integrated Model

In a structural equation model presented in Figure 1, we assessed the joint contribution of pandemic-related health concerns and infection-related risk perception on vaccination intention through vaccination motivations using latent variables. The model provided good fit statistics.

[Figure 1 here]

In the first step, we assessed the total contribution of pandemic-related health concerns and infection-related risk perception on vaccination intention without taking into account motivations to get vaccinated. As can be seen, the total contribution of concerns did not reach significance (c_1) when controlling for infection-related risk perception, despite the aforementioned positive correlation between pandemic-related health concerns and vaccination intention. In contrast, there was a significant and positive total contribution of infection-related risk perception (c_2) on vaccination intention when controlling for pandemic-related health concerns.

In the second step, we examined the contribution of concerns and infection-related risk perception on the motivations to get vaccinated. Mirroring the findings observed for vaccination intention, when controlling for infection-related risk perception, the contribution of health concerns on all four motivations deviated from what the correlation table shows (Table 1). Pandemic-related health concerns were positively related to autonomous motivation (a_{11}), but also with controlled motivation (a_{12}), distrust-based amotivation (a_{12}), and effort-based amotivation (a_{12}) (despite their negative relation at the correlational level). In other words, the relations between pandemic-related health concerns and motivations appear to change direction when controlling for infection-related risk perception. As for the relation of infection-related risk perception with motivations when controlling for pandemic-related health concerns, there was a significant positive contribution of infection-related risk perception on autonomous motivation (a_{21}), and a significant negative contribution on controlled motivation (a_{12}), distrust-based amotivation (a_{12}), and effort-based amotivation (a_{12}).

In the third step, we examined the contribution of pandemic-related health concerns and infection-related risk perception on vaccination intention while controlling for motivations to be vaccinated. Regarding the mediators, autonomous motivation (b_1) had a significant positive contribution on vaccination intention while controlling for the other motivations as well as for pandemic-related health concerns and infection-related risk perception, whereas distrust-based amotivation had a significant negative contribution to vaccination intention (b_3). Both controlled motivation (b_2) and effort-based amotivation (b_4) had a positive, although negligible effect on vaccination intention. Importantly, the direct contribution of infection-related risk perception (c'_2) on vaccination intention while controlling for pandemic-related health concerns and the mediators was non-significant. As for pandemic-related health concerns, its direct contribution (c'_1) on vaccination intention

remained non-significant when controlling for infection-related risk perception and the four motivational mediators. Finally, in line with expectations, motivations fully mediated the contribution of infection-related risk perception on vaccination intention while controlling for pandemic-related health concerns. Indeed, the indirect contribution ($a_2 \times b$) was positive and significant while the direct effect proved non-significant (c'_2) when controlling for the mediators. More specifically, the mediation took mostly place through the autonomous motivation ($a_1 \times b_1$) and distrust-based amotivation ($a_3 \times b_3$).

Brief Discussion

This large-scale cross-sectional study delivers three important insights with respect to the motivational factors underlying people's positive attitude towards vaccination intention, thereby confirming our three key hypotheses. First, although people's pandemic-related health concerns and infection-related risk perception go largely hand in hand, only infection-related risk perception related to vaccination intention. Second, the use of a differentiated approach towards individuals' vaccination motivation and lack thereof is fruitful as only autonomous (and not controlled) motivation and only distrust-based amotivation (and not effort-based amotivation) yield, respectively, a positive and negative relation to vaccination intention. Third, the positive contribution of infection-related risk perception to vaccination intention can be accounted for by distrust-based amotivation and autonomous motivation, implying that individuals who perceive a higher risk to be infected perceive vaccination as more valuable and are less distrusting towards the vaccine, which, in turn, relate to more favorable attitudes towards vaccination.

Study 2

Although the findings of Study 1 are informative, the cross-sectional nature of the study assessing self-reported intention entails clear limitations. Study 2 aimed to overcome these shortcomings by using a longitudinal design and examining whether the different

motivations predict individuals' self-reported behavior and not just their initial vaccination intentions. We assessed two types of behavior. In the first set of analyses, among individuals who received an invitation to be vaccinated, we contrasted those who accepted the invitation and were vaccinated with those who refused the invitation. Secondly, among individuals who did not get an invitation letter yet, we contrasted those who had subscribed to a vaccination waitlist named 'Qvax' with those who did not do the effort to put themselves on the list. We tested the same set of three hypotheses as in Study 1, this time examining whether individuals' initial vaccination motivations or the lack thereof would relate to their actual vaccination status several months later.

Method

Participants

The data collected in this study were again part of the Motivation Barometer and included two measurement points: December the 20th 2020 to January 31st, 2021 (T1) and May 21 until May 31, 2021 (T2). The timeframe for T1 was determined as not to overlap with Study 1 and corresponds to a period when vaccination was only available for selected persons (e.g., old and/or ill people). The timeframe for T2 was a critical period in which vaccination rate was increasing and waitlist subscription for vaccination were available.

At T1, 46592 participants completed the Motivation Barometer questionnaire, from which 14655 participants were contacted (31.45%) and 6996 participants (15.01%) took part in the follow-up questionnaire (M_{age} = 54.3, SD_{age} = 13.7, 63% females). From this sample, 65.7% reported to have no comorbidity factors considered relevant for COVID-19 and 71.1% had a higher education degree (i.e., bachelor, master, or Ph.D.). At T2, 4828 (69%) participants had received at least one dose of the vaccine. From the sample of non-vaccinated participants (n = 2168; 31%), 974 participants (45%) had received an invitation for

vaccination. Of those who did not receive an invitation yet (n = 1194; 55%), 641 participants were registered on a waitlist (54%).

Measures

Pandemic-related health concerns. We assessed pandemic-related health concerns (α = .67) using the same scale as in Study 1.

Infection-related risk perception. We used the same four items as in Study 1 to assess this construct (α = .71).

Motivation to get vaccinated. We measured four types of motivation using the same items as in previous study. All four types of motivation provided an acceptable level of reliability: autonomous motivation (α = .91), controlled motivation (α = .74), distrust-based amotivation (α = .90) and effort-based amotivation (α = .78)

Self-reported vaccination behavior. Participants indicated whether they were already vaccinated or not (at least with one dose). Those who were not yet vaccinated received an item assessing whether they already received an invitation to be vaccinated. Already invited participants were asked what they had done/were planning to do with the invitation, using a response scale going from (1) 'I have refused without any hesitation (or will do so again)', (2) 'I have refused (or will do so in the future)', (3) 'I am still in doubt', (4) 'I have accepted (or will accept)' and (5) 'I have accepted (or will accept) without hesitation'. A binary outcome was created labeled *vaccination uptake,* which contrasted individuals who were either vaccinated (N = 4828) or indicated that they had accepted the invitation for vaccination (N = 680) with those who refused or were still in doubt of accepting the vaccination invitation (N = 294).

Participants who were not invited yet (N = 1194) received the same item regarding vaccination intention as used in Study 1, with the response scale going from 1 = "I would refuse without any hesitation" to 5 = "I would accept without any hesitation". These as-yet

uninvited participants were then asked to indicate whether they had already subscribed to the waitlist (i.e., “yes” / “no”, with *N*s being, respectively, 641 and 551). This measure is referred to as *waitlist subscription.* For the sake of clarity, this structure has been plotted in a decision tree along with relevant sample sizes (see Figure 1S in the supplementary materials).

Demographic variables. Demographic variables were identical to the ones in Study 1.

Procedure

Participants who had taken part in the study at T1 and who had provided a valid email address to participate in follow-up studies were invited to take part in a longitudinal study using a personalized link. We sent a reminder email less than a week later. In addition to the same ethical guidelines as in Study 1, participants learned that the new data would be combined with their data of the first questionnaire. All participants provided consent. Again, we provided relevant practical information and contact information in case of questions or provoked negative feelings. Data analyses were performed using R (R Core Team, 2013), with a comparable procedure for the mediation SEM as Study 1.

Results

Preliminary Analyses

We performed the analyses on two subsamples, respectively one with participants who received an invitation (Sample 1; n_1 = 5802, including those who were already vaccinated) and one comprising participants who did not receive an invitation yet (Sample 2; n_2 = 1194). Comparisons in terms of sociodemographics show that Sample 1 includes significantly less women (62% versus 69%; $\chi^2(1) = 24.81$, $p < .001$), people with higher education ($M_{sample1}$ = 2.05 versus $M_{sample2}$ = 2.24; $t(2139.7) = -7.35$, $p < .001$), people without comorbidity (41% versus 7%; $\chi^2(1) = 581.1$, $p < .001$) and younger participants ($M_{sample1}$ = 57.26 versus $M_{sample2}$ = 36.34; $t(5202.9) = 35.64$, $p < .001$). Differences between the variables of interest as a

function of gender and comorbidity are available in the supplementary materials (Table 3S and 4S).

Table 2 shows the descriptive statistics and correlations for both samples. In both samples, age was associated with more perceived infection-related risk and less controlled motivation. In Sample 1, older people reported more autonomous motivation and less distrust-based amotivation, whereas these correlations occurred in the opposite direction in Sample 2. Participants' education level in both samples was negatively associated with infection-related risk perception. Additionally, in Sample 1, education level was negatively associated with pandemic-related health concerns and distrust-based amotivation, while being positively associated with autonomous and controlled motivation. Sample 2 showed one additional positive correlation between education level and effort-based amotivation.

[Table 2 here]

As Table 2 reveals, vaccination behavior (i.e., vaccination uptake in Sample 1 and waitlist subscription in Sample 2) was positively related to participants' levels of pandemic-related health concerns (only in Sample 1), infection-related risk perception, and autonomous motivation, such that higher scores on these variables at Time 1 predicted positively individuals' vaccination uptake at Time 2 in both samples. In contrast, higher scores on controlled motivation, distrust-based amotivation, or effort-based amotivation were negatively related to vaccination behavior. Also in both samples, infection-related risk perception was positively associated with autonomous motivation, while being negatively related to controlled motivation. In Sample 1, infection-related risk perception was additionally negatively correlated with distrust-based and effort-based amotivation. In both samples, all types of motivation were strongly associated, showing a comparable pattern to the one observed in Study 1.

Integrated Model

We assessed two SEM models in order to examine the mediating role of vaccination motivations on the associations between pandemic-related health concerns and infection-related risk perception at Time 1 and participants' vaccination uptake (Sample 1) and waitlist subscription (Sample 2) at Time 2. The six-factor measurement model (similar to Study 1) was good for Sample 1 (χ^2 = 385, df = 89, CFI = .978, TLI = .970, $RMSEA$ = .046, $SRMR$ = .044) and acceptable for Sample 2 (χ^2 = 274, df = 89, CFI = .963, TLI = .950, $RMSEA$ = .062, $SRMR$ = .063). For the sake of parsimony, we did not include covariates because doing so did not result in marked changes in the contribution of the motivational factors to the model. Figure 2 and Figure 3 show the two models, respectively. Both models demonstrated good statistical fit.

[Figure 2 here]

[Figure 3 here]

We first tested the total effects, with a significant positive association only for infection-related risk perception (c_2) with vaccination uptake but not for waitlist subscription. No total effects emerged for pandemic-related health concerns in both samples (c_1). In the second step, infection-related risk perception and pandemic-related health concerns were included as predictors of the motivation types, showing significant associations between infection-related risk perception and all types of motivation (a_{21} - a_{24}), while pandemic-related health concerns were significantly associated only with controlled motivation (a_{12}) in Sample 1. Accounting for all types of motivation, infection-related risk perception, and pandemic-related health concerns as predictors of the outcomes, autonomous motivation appeared a systematic positive predictor of both behavioral outcomes (b_1), while neither distrust-based (b_3) nor effort-based amotivation (b_4) yielded any predictive validity for either vaccination uptake (Figure 2) or waitlist subscription (Figure 3) at Time 2 beyond the other

two motivations. As for controlled motivation, significant but small positive contribution emerged in the prediction of vaccine uptake (b_2) emerged in Figure 2. In a final step, our mediation analyses showed that, for vaccination uptake, the contribution of infection-related risk perception through motivations to get vaccinated was fully mediated ($a_2 \times b$) and the indirect effect did reach significance in the case of pandemic-related health concerns ($a_1 \times b$) despite the absence of a significant total effect (c_1). Turning to waitlist subscriptions, the total effects suggested that no mediation effects could be tested.

Brief Discussion

The findings of Study 2 largely confirm those obtained in Study 1, with a few exceptions. First and as in Study 1, infection-related risk perception related positively to people's vaccination uptake several months later but appeared unrelated to their decision to subscribe to a waitlist to get vaccinated earlier in case vaccines would become available. Second, also similar to Study 1, autonomous motivation emerged as a critical predictor, this time positively relating to both behaviors. The finding that autonomous motivation predicted waitlist subscription is remarkable as only a homogeneous group of convinced individuals answered this question. Yet, even with this subgroup, the differences in autonomous motivation did have predictive validity. Different from Study 1, though, distrust-based amotivation did not predict self-reported behavior over time, while controlled motivation yielded a small positive contribution to vaccination uptake. Third, an integrated model test revealed that infection-related risk perception related positively to both self-reported behavioral outcomes through autonomous motivation, a finding also observed in Study 1.

General Discussion

The present cross-sectional and longitudinal studies provide a valuable insight into the motivational factors underlying individuals' vaccination intention and acceptance. Drawing upon the self-determination and vaccination literature, we sought to examine the specific role

of different motivations and psychological obstacles for vaccination among two large groups of Belgian citizens. Three key findings stand out.

First, infection-related risk perception is a critical predictor of people's vaccination intentions and acceptance whereas pandemic-related health concerns are not. That is, despite the positive association between these two aspects, only infection-related risk perception, a variable reflecting the estimation of the probability and the severity of a future COVID-19 infection for oneself and others, matters when controlling for their shared variance. In contrast, pandemic-related health concerns during the past week assesses tendencies to worry and repetitively think about their consequences of infection for one's own and other's health. Recent Covid-related studies show that the latter types of concerns and worries have more impact on mental health and are moderated by individual differences in health anxiety, intolerance for uncertainty, media exposure and their interactions (Sauer et al., 2020; Schmidt et al., 2021). Thus, the present findings converge with other work showing that infection-related risk perception is positively associated with future COVID-19 vaccination intentions (Allington et al., 2021; Caserotti et al., 2021; Detoc et al., 2020; Reiter et al., 2020; Shmueli, 2021), whereas retrospective pandemic-related health concerns may be more critical for individuals' mental health and well-being rather than for their motivation to take action.

Second, the findings clearly indicate that not all types of motivation to get vaccinated are created equal. The more people see the necessity and benefit of vaccination and concur with its importance (autonomous motivation), the more they express stronger intentions to be vaccinated (Study 1), and the more they are also likely to accept the vaccine (vaccination uptake) or even take pro-active action to subscribe to a waitlist to get vaccinated earlier in time (vaccination subscription) (Study 2). In contrast, being externally pressured to be vaccinated (controlled motivation) failed to yield similar benefits. Although controlled motivation yielded a small positive contribution to vaccine uptake in the integrated model, it

should be noted that it was negatively related to vaccination uptake at the correlational level, implying that the observed contribution in the integrated model should be interpreted with caution.

Only distrust-based amotivation emerged as a vaccination-impeding factor, although a significant contribution (beyond the effect of other covariates) emerged solely in Study 1 with respect to vaccination intentions. Although distrust-based amotivation yielded the expected negative relation with the self-reported behavioral outcomes in Study 2 (vaccination uptake and waitlist subscription), it failed to yield a significant contribution when competing for shared variance with the other motivational factors. Two reflections help to contextualize these findings. First, we should note that autonomous motivation and distrust-based amotivation were highly negatively correlated. Conceptually then, the value attributed to vaccination may be partially rooted in people's trust in the efficacy of the vaccine. A different source of perceived importance may stem from the perception that getting vaccinated constitutes a prosocial act. For instance, some people may decide to get vaccinated because it facilitates the transition to normal life for everyone. Second, it may be that the dissipation of distrust-based amotivation regarding vaccination may help to move initially refusing individuals to a hesitancy status, thus overcoming their doubts. Yet, the full endorsement of vaccination may be critical to translating one's intentions into eventual behavior. Indeed, for a person to take the initiative to subscribe to a waitlist instead of passively waiting to be informed when to get vaccinated, one needs to be fully convinced of the benefit of vaccination. A more fine-grained analysis of individuals' transition along the vaccination readiness continuum as a function of different motives may provide a better insight into the role of different (de)motivating factors.

A third finding showing across both studies was that the pattern of relations between infection-related risk perception and pandemic-related health concerns and the different

(de)motivating factors is remarkably similar. Infection-related risk perception related to a more adaptive pattern of motivations (higher autonomous motivation, and lower distrust-based amotivation, controlled motivation, and effort-based amotivation), while pandemic-related health concerns was associated with a more maladaptive pattern (increased controlled motivation and distrust-based amotivation). Moreover, our analyses revealed that the positive effect of infection-related risk perception on vaccination intention (Study 1) and vaccination uptake (Study 2) was mediated by (de)motivating factors related to vaccination. That is, those high in infection-related risk perception tend to report a greater sense of ownership and endorsement of the decision to be vaccinated (autonomous motivation) and lower levels of distrust-based motivation towards vaccination, which in turns helps explain why they report greater intentions to be vaccinated and greater vaccine uptake.

Practical Implications

The present findings have a series of practical implications. For instance, autonomous motivation to get vaccinated should be fostered in the population given its positive contribution on both vaccination intention and self-reported uptake. To foster greater ownership and a sense of initiative around vaccination (autonomous motivation), it is critical to highlight the benefits of vaccination, both as a way to protect oneself and those around them, but also as a key strategy to preserve the mental health of the population over time (Vindegaard & Benros, 2020). In the same vein, the detrimental effect of distrust-based amotivation on vaccination-related outcomes could be dealt with by providing clear and transparent information about the vaccine (e.g., its secondary effects, effectiveness) and countering fake news as well as conspiracy theories (see Van Bavel, et al., 2020; Van Oost et al., 2021). For instance, information could be debated and provided by the most trusted professionals (e.g., general practitioners, pharmacists, experts; Motivation Barometer, 2021)

and authorities and media could report the probability of infection as a function of vaccination status to increase trust in the vaccine.

Along similar lines, pandemic-related communications (e.g., by authorities, the medias) should avoid using threatening and anxiety-inducing language that increases people's worries, but instead send out objective and clear information so people get a realistic insight in their perceived risk for infection. Specifically, factual information on the contagiousness of the virus (e.g., the reproduction rate of the virus) and potential severity of illness from the virus (e.g., number of hospitalization or deaths among infected people) allows them to better gauge the likelihood of being infected and the severity of the illness. At the same time, it is important to regulate the information provided (i.e., not overfeeding people with negative information) to avoid raising pandemic-related health concerns, given their undermining impact on motivations. Taken together, this information could also allow people to infer by themselves the benefits of vaccination (Motta et al., 2021) and thus promote autonomous motivation to get vaccinated.

Limitations and Future Research

First, the present set of studies only included self-reported data, as the actual vaccine uptake was not validated with objective reports of behavior. Although it is unlikely that vaccinated people would lie about this issue, future research should confirm the present pattern of findings with objectively recorded outcomes.

Second, although a variety of (de)motivating factors was addressed, some potentially relevant factors were not included. Competence-related constructs (e.g., outcome expectancies, self-efficacy, or action and coping planning; Schwarzer & Fuchs, 1996) may yield unique predictive validity or strengthen the observed role of some of the herein studied variables. For instance, infection-related risk perception may predict durable behavior (e.g., uptake of additional dose) if people anticipate detailed plans, imagine success scenarios

(action planning), and develop preparatory strategies for tackling a challenging task (coping planning; Schwarzer, 2016).

Third, the generalizability of the current findings is limited to populations that share similar characteristics to the current sample and are thus not (and is not intended to be) representative of the Belgian population as a whole. In this regard, the present sample is characterized by middle-aged females who mostly self-reported no health conditions that would put them at risk for severe COVID-19 disease. Despite the fact that the present findings hold when controlling for these variables, further studies should broaden the characteristics of the sample (e.g., include young or old men with comorbidity factors) to allow generalizing our findings.

Conclusion

Knowing which motivational factors facilitate and which motivational obstacles impede vaccine uptake is of critical importance to overcome of the COVID-19 crisis. The present study sheds a nuanced light on this question, by showing that autonomous motivation to be vaccinated is a key factor underlying vaccination intention and uptake whereas distrust-based amotivation underlies much of the hesitancy of individuals. Furthermore, as individuals who perceive greater infection-related risk more strongly endorse the decision to accept the vaccine, it is critical to indicate how vaccination substantially reduces people's risks for (severe) infection to foster their autonomous motivation.

Data Availability Statement

The R scripts to carry out the analyses are publicly available on Open Science Framework: https://osf.io/casqh/?view_only=d76551252d9b441f82508c66dd292899. Datasets are hosted in Zenodo (a public repository) and are available upon request and for replication purposes only: https://doi.org/10.5281/zenodo.5595727.

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Tables

Table 1

Descriptives statistics and correlations for the variables of interest – Study 1

		M	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1.	Age	49.93	14.58	–										
2.	Gender	–	–	-.04***	–									
3.	Education	5.37	1.37	-.26***	-.03**	–								
4.	Comorbidity	–	–	.31***	-.05***	-.15***	–							
5.	Vaccination intention	3.47	1.47	.15***	-.09***	.04***	.10***	–						
6.	Pandemic-related health concerns	3.08	0.98	.13***	.09***	-.11***	.19***	.24***	–					
7.	Infection-related risk perception	2.55	0.67	.26***	.11***	-.16***	.22***	.32***	.47***	–				
8.	Autonomous motivation	3.70	1.31	.11***	-.07***	.09***	.11***	.88***	.26***	.35***	–			
9.	Controlled motivation	2.51	1.11	-.22***	.05***	.03**	-.10***	-.45***	-.06***	-.22***	-.47***	–		
10.	Distrust-based amotivation	3.04	1.22	-.15***	.15***	-.10***	-.06***	-.79***	-.06***	-.17***	-.76***	.50***	–	
11.	Effort-based amotivation	1.63	0.70	-.04***	.04***	-.12***	-.02*	-.43***	-.06***	-.14***	-.43***	.32***	.44***	–

Note. $N = 8887$. M = Mean, SD = Standard Deviation. Gender was coded "Men" = 0 and "Women" = 1. Comorbidity was coded "Absent" = 0 and "Present" = 1. $^{**}p < .010$; $^{***}p < .001$.

Table 2

Correlation matrix of sample with invitation (below the diagonal – Sample 1) and without invitation (above the diagonal – Sample 2) – Study 2

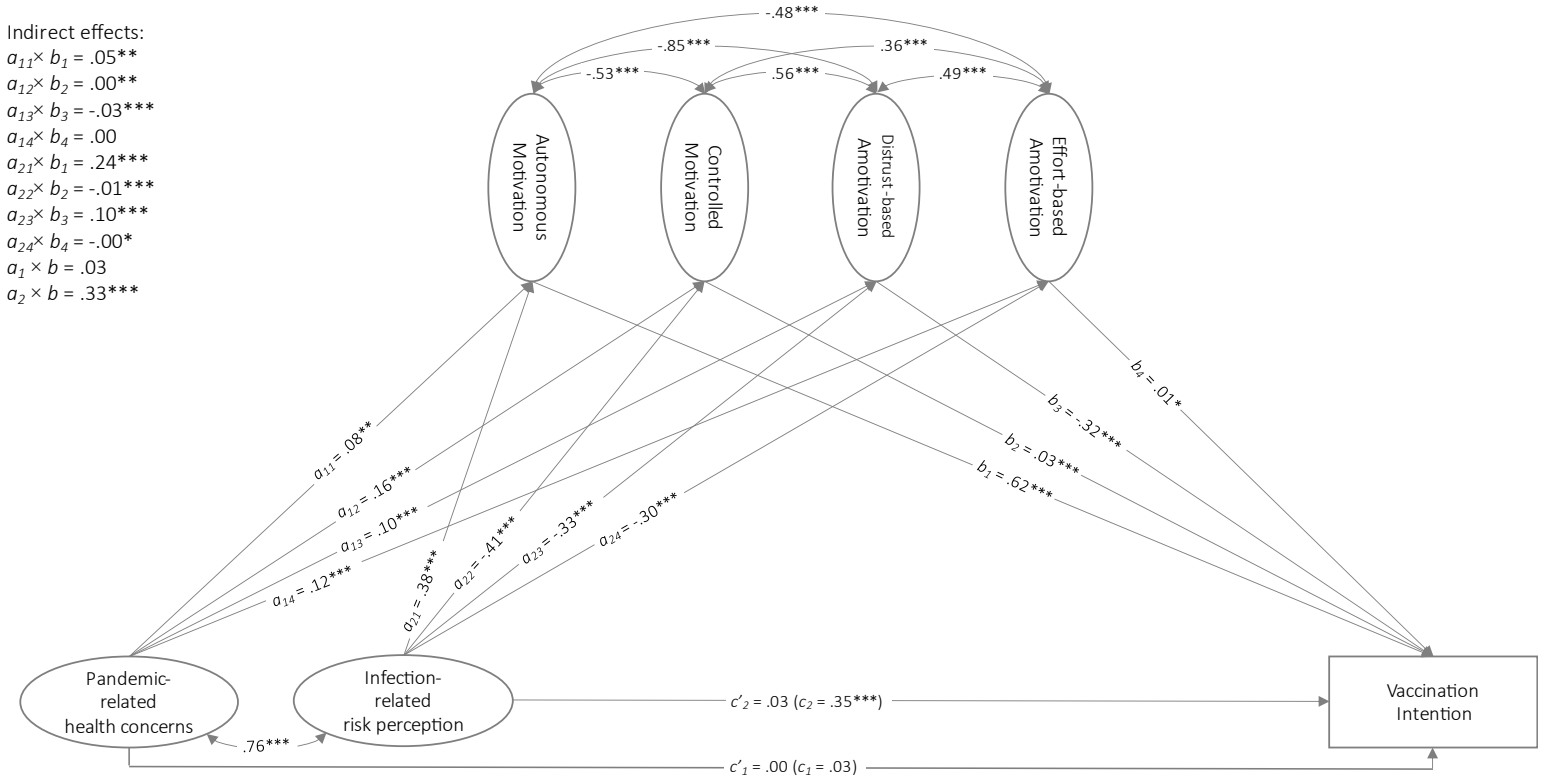
				1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
			M	36.34	-	2.19	-	1.50	3.23	1.96	4.19	2.68	2.49	1.46
			SD	11.57	-	0.85	-	0.50	0.77	0.72	1.13	0.94	1.18	0.61
	M	*SD*												
1. Age	54.28	13.69			.13**	.16***	.11*	.04	-.04	.11**	-.18***	-.09*	.17***	.08
2. Gender	-	-		-.16***		.05	-.02	.12**	.11*	.17***	.00	-.09*	.08	-.02
3. Education	2.09	0.84		-.12***	.03**		-.13**	.05	-.05	-.10*	.05	-.02	-.07	.13**
4. Comorbidity	-	-		.30***	-.09***	-.12***		-.04	.09*	.07	-.06	.04	.12**	.14**
5. Outcome (T2)	1.96	0.19		.02	.00	.02	.04		.08	.11*	.30***	-.13**	-.26***	-.13**
6. Pandemic-related health concerns	3.35	0.91		.02	.06***	-.10**	.20***	.19***		.43***	.26***	-.06	-.04	-.06
7. Infection-related risk perception	2.26	0.79		.20***	.07***	-.14***	.21***	.20***	.41***		.27***	-.13**	-.06	.05
8. Autonomous motivation	4.29	1.05		.06***	-.06***	.07***	.08**	.51***	.13***	.30***		-.35***	-.74***	-.43***
9. Controlled motivation.	2.40	0.97		-.19***	.04**	.02*	-.07**	-.09***	.03	-.13***	-.30***		.39***	.22***
10. Distrust-based amotivation	2.38	1.11		-.14**	.15***	-.07***	.00	-.35***	.06**	-.11**	-.72***	.36***		.46***
11. Effort-based amotivation	1.39	0.59		-.02	-.03*	.02	.00	-.13***	-.03	-.10***	-.39***	.24***	44***	

Note. Gender was coded "Men" = 0 and "Women" = 1. Comorbidity was coded "Absent" = 0 and "Present" = 1. Outcome refers to 'vaccine uptake vs. lack thereof' in Sample 1 (below the diagonal) and 'Waitlist subscription vs. lack thereof' in Sample 2 (above the diagonal). $p < .050$; **$p < .010$; ***$p < .001$.

Figures

Figure 1

Contribution of pandemic-related health concerns and infection-related risk perception on vaccination intention mediated by the motivations to get vaccinated - Study 1

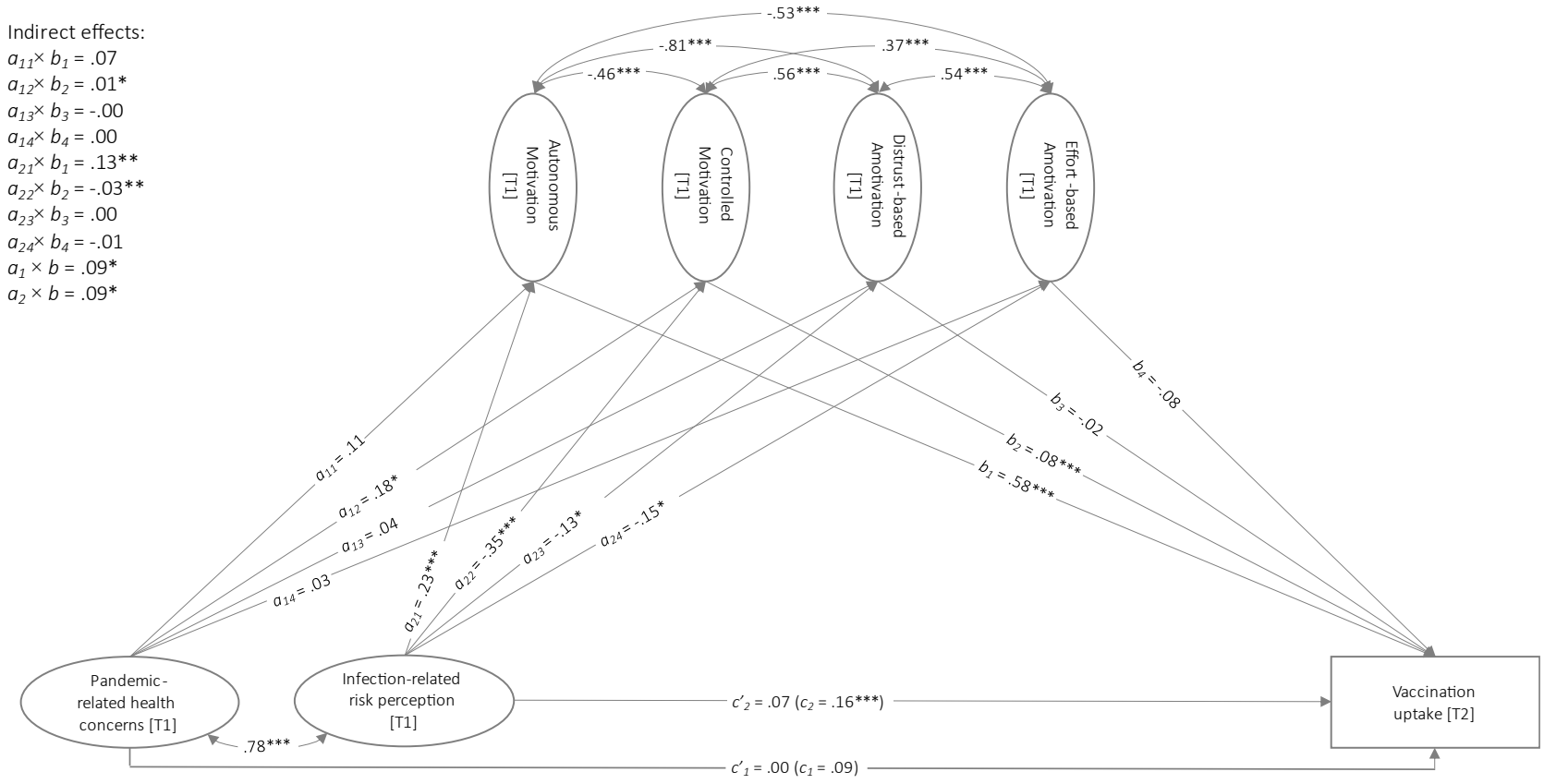


$\chi^2 = 1974, df = 84, N = 8887, CFI = .980, TLI = .971, RMSEA = .050, SRMR = .036$

Note. Ovals represent latent variables and rectangles manifest variables Coefficients are standardized. The total effects are in parenthesis. *p < .050, **p < .010, ***p < .001

Figure 2

Contribution of pandemic-related health concerns and infection-related risk perception on vaccination uptake mediated by the motivations to get vaccinated - Study 2

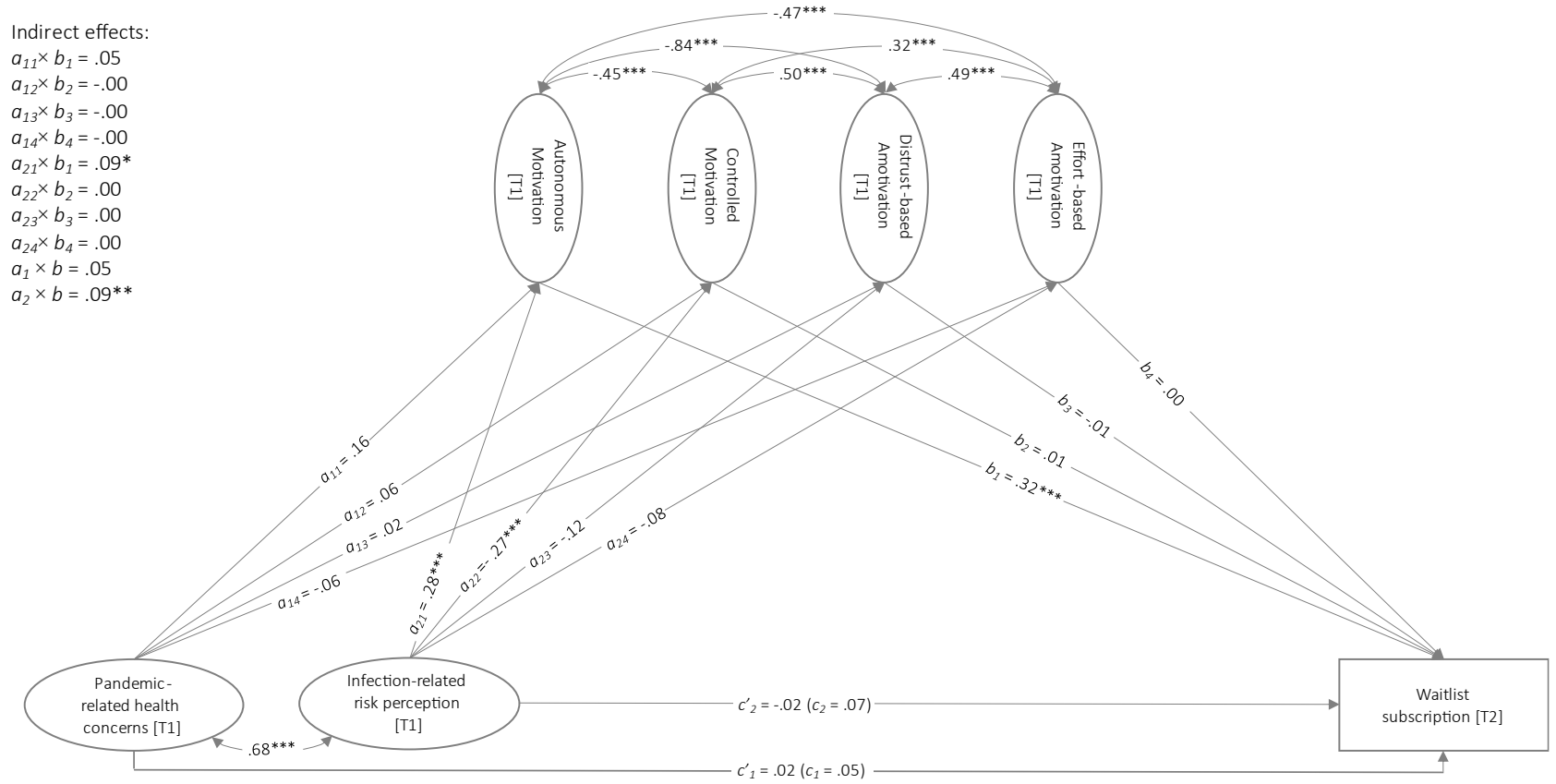


$\chi^2 = 562.53, df = 84, N = 6996, CFI = .988, TLI = .982, RMSEA = .032, SRMR = .036$

Note. Ovals represent latent variables and rectangles manifest variables. Coefficients are standardized. The total effects are in parenthesis. *p < .05, **p < .010, ***p < .001

Figure 3

Contribution of pandemic-related health concerns and infection-related risk perception on waitlist subscription mediated by the motivations to get vaccinated - Study 2



$\chi^2 = 317.51, df = 84, N = 1414, CFI = .978, TLI = .968, RMSEA = .044, SRMR = .054$

Note. Ovals represent latent variables and rectangles manifest variables. Coefficients are standardized. The total effects are in parenthesis. *p < .05, **p < .010, ***p < .001

Credit Author Statement

Mathias Schmitz: Analyses of Study 1, methodology, writing, reviewing, editing. **Olivier Luminet**: Writing, reviewing, editing. **Olivier Klein**: Writing, reviewing, editing. **Sofie Morbée**: Data acquisition, writing, reviewing, editing. **Omer Van den Bergh**: Writing, reviewing, editing. **Pascaline Van Oost**: Data acquisition, methodology, writing, reviewing, editing. **Joachim Waterschoot**: Analyses of Study 2, methodology, writing, reviewing. **Vincent Yzerbyt**: Writing, reviewing, editing. **Maarten Vansteenkiste**: Writing - original draft, reviewing, editing. All authors have approved the final version of the final manuscript and meet the ICMJE criteria for authorship.

Declaration of Competing Interest

The authors declare that they have no personal or financial conflict of interest that could have influenced the work reported in this paper.