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Who is motivated to accept a booster and annual dose? A dimensional and person-centered approach

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Abstract

The transmissibility of new COVID-19 variants and decreasing efficacy of vaccines led authorities to recommend a booster and even an annual dose. However, people's willingness to accept new doses varied considerably. Using two independent longitudinal samples of 4596 (Mean age = 53.6) and 514 (Mean age = 55.9) vaccinated participants, we examined how people's (lack of) vaccination motivation for their first dose was associated with their intention to get a booster (Sample 1) and an annual dose (Sample 2) several months later (Aim 1). We also aimed to capture the impact of the motivational heterogeneity on these intentions by capitalizing on participants' different motivational profiles collected at baseline (Aim 2). Across both samples, autonomous motivation, controlled motivation, and distrust-based amotivation were uniquely related to, respectively, higher, lower, and even lower booster and annual dose intentions. Further, a two-step clustering procedure revealed five profiles, with the profiles characterized

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by higher autonomous motivation (i.e. Good Quality and High Quantity profiles) reporting the highest vaccination intentions and the profile characterized by the highest number of obstacles (i.e. Global Amotivated profile) yielding the lowest vaccination intentions. These results stress the critical need to support citizens' volitional endorsement of vaccination to harvest long-term benefits with respect to COVID-19.

KEYWORDS
booster dose, COVID-19, motivation, vaccination intention

INTRODUCTION

Vaccination against COVID-19 was effective to reduce the risk of infection (Riemersma et al., 2021) and to prevent the development of severe symptoms even several months after vaccination (Patalon et al., 2022). At the same time, vaccine efficacy decreased over time, especially as more transmissible variants emerged, like Delta. This situation triggered scientific and public debates in the summer of 2021 about the necessity of a booster and perhaps even an annual dose for the population (Callaway, 2021). The discussion was spurred by studies showing that a booster dose increased people's protection to a level obtained after the second dose, with a significant reduction in the probability to become severely ill (Andrews et al., 2022). With the new wave of COVID-19 infections in November 2021 and the subsequent emergence of the Omicron variant, countries speeded up their booster vaccination campaign, clearly encouraging the adult population to accept a booster.

The first goal of the present contribution was to examine whether people's initial motivation to get their first dose predicted their intention to accept a booster and an annual dose several months later. Second, through a person-centered approach, we aimed to capture the heterogeneity among vaccinated people through the identification of motivational profiles (i.e. with distinct combinations of motivations and obstacles for vaccination commitment), which were then linked to individuals' intention to accept a booster or an annual dose.

Booster and annual dose hesitation

Although one may take for granted that the acceptance of a first dose translates into a long-term commitment to vaccines, this is not necessarily the case. Some vaccinated people later hesitated or even became reluctant to get a new shot (Pal et al., 2021), with a variety of reasons explaining lowered willingness to be vaccinated again. As high expectations for lasting vaccine efficacy failed to materialize, some individuals started doubting the sustainability of the immunity conferred by the vaccine (e.g. Su et al., 2021). To be sure, vaccinated persons who had felt obliged or had been externally convinced into vaccination may experience a lack of energy or resources to persist later (Sprengholz, Henkel, & Betsch, 2022) or even experience reactance towards a new dose (Brehm & Brehm, 2013; Sprengholz, Felgendreff, Böhm, & Betsch, 2022). Individuals may also experience COVID-19 information fatigue and lack the energy to retrieve or process information about new variants, with low COVID-19 knowledge being associated with booster vaccine uncertainty (Paul & Fancourt, 2022). Further, the experience of side effects from previous doses may discourage vaccinated individuals to get booster and annual doses (e.g. Galanis et al., 2022). Last but not least, the lack of trust in governmental information about the booster (Folcarelli et al., 2022), in scientists and medical professionals (Toro-Ascuy et al., 2022), and in the pharmaceutical industry (Al Janabi & Pino, 2021) may also explain reluctance towards a booster dose and annual dose, playing a role even among vaccinated individuals.

In addition to these consideration, high expectations regarding strong and lasting vaccine efficacy may have created the idea among vaccinated participants that a booster is not necessary (Lounis et al., 2022). Furthermore, this may ironically lead to a lower risk perception, and thus a lower motivation for additional doses, with boosted individuals perceiving lower risks of infection (Sprengholz, Henkel, Böhm, & Betsch, 2022). Indeed, people's subjective sense of risk regarding susceptibility and severity plays a crucial role in COVID-19 vaccination (a)motivation and willingness for the first doses (e.g. Schmitz et al., 2022). In all likelihood, risk perception may have the same positive effect among vaccinated participants, although few studies have investigated this link (Qin et al., 2022).

Finally, sociodemographic factors have been shown to play a role in individuals' intention to accept annual and booster shots as well. Various studies suggests that young, minority members and people living alone, being less educated, having suboptimal physical condition, or having lower income are more likely to manifest vaccination hesitancy (e.g. Galanis et al., 2022). As for the impact of gender, results prove inconsistent across studies (e.g. Babicki & Mastalerz-Migas, 2022).

As a set, these findings suggest that the larger group of vaccinated people might be less homogeneous in terms of their attitude towards future booster vaccines than is generally considered. Although motivational factors may well explain the heterogeneity in individuals' intention to accept or refuse a booster or an annual dose, these aspects remain largely overlooked. Herein, we adopt a theory-grounded, motivational approach in examining which types of (lacked) motivation predicted citizens' intention to take up a booster or an annual dose (e.g. Schmitz et al., 2022).

The role of motivation

Within the framework of Self-Determination Theory (Ryan et al., 2021; Ryan & Deci, 2017), types of motivation are not of equal value. Not only the amount but also the type of motivation to engage in a health-relevant behavior (e.g. vaccination) is considered critical (Vansteenkiste et al., 2006). Prior work on vaccination relying on Self-Determination Theory showed contrasting outcomes of various motivations dimensions (Schmitz et al., 2022). In the case of *autonomous motivation*, individuals have accepted or internalized the utility and relevance of vaccination such that they willingly do so. As they perceive vaccination behavior to be relevant and congruent with their personal values and priorities (e.g. solidarity, health, to protect oneself and others), autonomous motivation denotes a volitional form of motivation. In the case of *controlled motivation*, external pressures (e.g. avoiding social criticism) or internal pressures (e.g. feeling guilty) guide one's intentions. As individuals have not or only partially internalized the reason for getting vaccinated, they rather feel forced, seduced, or even manipulated into vaccination. This differentiated approach is equally useful when considering reasons for refusing a vaccine. *Distrust-based amotivation* denotes a reluctance towards vaccination, either because of the perception that the vaccine is inefficient if not unsafe (e.g. due to concerns about side effects or about a lack of rigor in vaccine's research, including lack of sufficient testing) or because the provider or the recommending authorities are not to be trusted (Milošević Đorđević et al., 2021). Finally, *effort-based amotivation* reflects individuals' perception that vaccination is an effortful process for which they lack mental or physical resources, for example, because they perceive that receiving several doses or that going to unfamiliar locations is too costly (Legault et al., 2006; Morbée et al., 2022; Waterschoot et al., 2022).

Recent research confirmed the role of these motivational factors to predict concurrent vaccination intention (Van Oost et al., 2022), transition towards greater intended acceptance (Waterschoot et al., 2022), and eventual uptake (Schmitz et al., 2022) of first and second COVID-19 vaccine doses. Autonomous motivation was the most robust predictor across studies, with individuals high in autonomous motivation reporting greater vaccination intentions, displaying a faster transition away from reluctance to intended acceptance, and being more likely to take the vaccine. In contrast, controlled motivation yielded small and mixed effects. Although controlled motivation showed a slight positive relation with concurrent intentions and eventual uptake in one set of studies (Schmitz et al., 2022), this finding was not replicated by Van Oost et al. (2022) and controlled motivation even prevented individuals from transitioning to greater vaccination intentions across time (Waterschoot et al., 2022). Turning to distrust-based amotivation, although it showed an independent negative association with concurrent vaccination intentions (Schmitz et al., 2022; Van Oost et al., 2022) and prevented a transition to greater vaccination intentions (Waterschoot et al., 2022), there was no unique association with eventual uptake after controlling for the other motivational predictors (Schmitz et al., 2022). Finally, the contribution of effort-based amotivation was systematically limited, as there was no unique association with vaccination outcomes, neither concurrently nor longitudinally. Presumably, the effort required for vaccination is rather minimal because it required a limited time investment and the distribution of vaccine was well organized in Belgium.

Motivational profiles

Although a dimensional approach towards motivation involves separating various types of motivation and the lack thereof to examine their unique contribution, these various motivations and obstacles co-occur within people. A person-centered approach towards motivation (Vansteenkiste & Mouratidis, 2016) allows shedding complimentary light on the motivational heterogeneity among individuals by identifying motivational profiles, with a profile consisting of a mix of motivations and obstacles for vaccination. Individuals belonging to the same profile share the same pattern of motivations, while those belonging to different profiles display a distinct make-up of motivations.

Prior research in the domains of education (e.g. Ratelle et al., 2007), physical education (Haerens et al., 2010), work (Van den Broeck et al., 2013), and sports (e.g. Boiché et al., 2008) has adopted this approach, with the number of identified profiles varying between 3 and 6, depending on the number and type of included motivational dimensions. Across studies, profiles characterized by high autonomous motivation yielded the most clear-cut benefits, whereas those characterized by high amotivation came with the poorest outcomes. As for controlled motivation, its effects seem to be largely dependent upon the other types of (a)motivation with which it gets combined and upon the outcomes under investigation. When controlled motivation is present next to amotivation, outcomes are poorer than when controlled motivation combines with autonomous motivation. In the latter case, individuals score high on both these types of motivation (a scenario referred to as "High Quantity" profile; see Vansteenkiste et al., 2009), such that their total amount of motivation surpasses the motivation of a group characterized by high autonomous motivation alone. In contrast, individuals high on autonomous motivation alone, in spite of their lower dose of motivation, seem to fare better on some outcomes (e.g. lower test anxiety). Such a profile has been referred to as the "Good Quality" profile. In some cases, the presence of controlled motivation may also push individuals into action, which explains why students belonging to this "High Quantity" group exert as much effort on their studies as the "Good Quality" groups.

In the current study, we aimed to extend this small body of work given that no prior work examined individuals' motivational profiles in the context of public health. Further, rather than relying on a single source of amotivation (e.g. Haerens et al., 2010), we included multiple types of amotivation (i.e. effort-based and distrust-based amotivation), with the aim of obtaining a more refined insight in the obstacles for vaccination. After all, even vaccinated individuals form a heterogeneous group, with different impediments playing a role in the hesitation to accept a booster or an annual dose of vaccine.

PRESENT STUDY

Although predictors of people's vaccination intention and effective uptake of first and second dose have been extensively investigated, the question whether people's initial motivation relates to the intention to accept a booster or an annual dose has received, little, if any, attention. The present study comprised two samples and offered the unique opportunity to investigate whether people's vaccination (a)motivation at baseline, that is, before September 2021 and thus prior to their first dose, relates to their intention to accept the COVID-19 booster dose during the Autumn of 2021 (Sample 1) and their intention to accept an annual dose in March 2022 (Sample 2). We used dimensional and person-centered approaches, two methods that we combine in order to gain a more complete and refined understanding of the key motivational dimensions (i.e. autonomous motivation, controlled motivation, distrust-based amotivation, and effort-based amotivation). Whereas a dimensional approach guarantees a better understanding of the dimensions that uniquely predict the intention to get a booster or an annual dose (Aim 1), a person-centered approach allows to develop a multivariate understanding of people's (a)motivations (Aim 2).

As for the dimensional approach, based on prior research (Haerens et al., 2010) and theorizing (Ryan & Deci, 2017), we expected that autonomous motivation and distrust-based amotivation for the first and second doses would be, respectively, positively and negatively related to the intention to accept third and annual doses several months later. Because the vaccination commitment of individuals high in controlled motivation may be more conditional (e.g. dependent upon granted freedom due to vaccination) and, hence, short-lived, they may be less likely to commit themselves to future injection if such conditional benefits are no longer attached to vaccination. Similarly, although controlled motivated individuals may give in to the salient pressures in the early stage but feel little ownership over their initial vaccination decision, they may display reactance in the longer run (Brehm & Brehm, 2013). Regarding effort-based amotivation, and based on past studies on vaccination in Belgium, we expected a modest negative contribution, if any.

To provide further evidence for the robust role of motivational differences, we examined in a more explorative way whether sociodemographic (i.e. age, gender, civil status, and education level) and medical (i.e. infection status) factors would interact with motivational factors in the prediction of both vaccination outcomes. We reasoned that the benefits of autonomous motivation might not be dependent on these sociodemographic and medical factors. Rather, the full endorsement and value-based anchoring characteristic of autonomous motivation entails greater commitment and a better handling of encountered obstacles (Bonneville-Roussy et al., 2017) such that getting infected since vaccination would not prevent individuals from accepting additional doses. In contrast, the experience of a post-vaccine infection may prevent individuals who initially scored high on distrust-based amotivation to accept future doses.

As for the person-centered approach, we built on previous research on motivational profiles (e.g. Vansteenkiste et al., 2009). We expected to find a cluster containing only high scores for autonomous motivation (i.e. the "good" motivated profile), a cluster only scoring high on controlled motivation (i.e. the "poor" motivated profile), a cluster having high scores on all types of motivation (i.e. the "high" motivated profile), and a cluster having high scores of amotivation. Overall, we anticipated that profiles characterized by higher autonomous motivation would report the strongest intentions to accept a booster or an annual dose, whereas those reporting elevated distrust-based amotivation would report the lowest scores.

Of note, the present test of the motivation–booster/annual dose intention link is rather conservative because there is a substantial time lag between both measurement moments (i.e. median 265 and 395 days in Samples 1 and 2, respectively). Further, the exclusive sampling of vaccinated persons entails reduced variance and associated predictive power for the motivation measures at baseline compared with the more heterogeneous group used when predicting acceptance of a first dose. Finally, we controlled for the possible impact of various relevant covariates in the motivation–booster/annual dose intention link (Babicki & Mastalerz-Migas, 2022), namely, concurrent risk perception (i.e. individuals perceiving higher risks are more willing), age (i.e. older people are more willing), gender, civil status (i.e. singles are less willing), education level (i.e. higher educated are more willing), and infection history (i.e. having no infection yet is associated with a higher intention).

METHOD

Participants and procedure

The current data collection took place in the context of a nation-wide research project called "the Motivation Barometer" in Belgium. Through an online questionnaire, the project monitored various aspects of people's psychological functioning, including their motivation and intention to get a vaccine in case they did not receive a shot yet. We distributed this survey online through advertisements on social media and national newspapers. After an introduction about the content of the research project, participants completed an informed consent explaining that their participation was voluntary (i.e. no monetary reward would be provided), that the data analysis was anonymous, and that they could end their participation anytime without consequences. In addition, we provided contact information in case of questions or negative feelings. We also offered participants to leave their e-mail address for follow-up surveys. Here, we emphasized that we would only use this information for research-related goals and that, after data collection, any identification information would be replaced by an anonymous code. The project received approval from the ethical committee of Ghent University (N° 2020/37).

The data collection was carried out in three stages. First, between October 2020 and September 2021, individuals responded to a baseline survey. Then, between October 2021 and January 2022, those who were willing to participate follow-up research were invited to answer a first follow-up survey. Among the participants who answered this follow-up, we retained the participants who received two shots (i.e. those who are eligible for a third dose of the COVID-19 vaccine), forming

Sample 1. In March 2022, we sent another invitation to all participants who completed the baseline survey and were willing to participate follow-up research. Here, we retained only those vaccinated participants (i.e. who received at least who shots) and those who had not responded to the first follow-up survey, aiming to have two independent samples, forming *Sample 2*. Indeed, on the basis of the mail addresses, we selected two unique and non-overlapping sets of participants for Samples 1 and 2. As such, this allowed us to conduct a formal replication of the findings, albeit predicting a different outcome.

In the baseline survey, we assessed a series of background variables (i.e. age, gender, civil status, education level, and history of infection) and the (lack of) motivation to be vaccinated for the first dose. In total, 30,521 participants (M_{age} = 53.58; 63.2% female; 26% being single; 15% being infected) completed this survey. Of these, 27.6% had no education, 38.0% had a Bachelor's degree, and 34.4% had a Master's degree. None were vaccinated, as no vaccine was yet available at that time and motivation was only assessed in those having not received a vaccine.

A total of 5597 participants completed Follow-up Survey 1 (Response Rate = 18.33%) within a median period of 265 days (range = 50–326 days) after the baseline survey. It included measurements of infection history, risk perception, and the intention to get the booster dose for those who reported that they had taken the vaccine in the meantime (82%). Among all participants of Follow-up Survey 1, vaccinated participants (n = 4596, *Sample 1*) had a mean age 53.6 years (63.8% female; 23% single), from which 28% had no education or secondary graduation, 38% had a bachelor's degree, and 34% had a master's degree. In terms of infection history, 81% reported to have not been infected with COVID-19 yet, 9% already was infected at the baseline assessment, and 10% had been infected in the period between the baseline and follow-up surveys.

A total of 732 participants completed Follow-up Survey 2 (RR = 2.4%), tapping the same set of background variables, risk perception, and intention to get an annual dose for those who reported to be vaccinated in the meantime (70%). Here, the median number of days between both surveys was 395 days (range = 253–247 days). Vaccinated participants of Follow-up Survey 2 (n = 514, *Sample 2*) had a mean age of 55.9 years (63.7% female; 28% single), from which 27% had no more than secondary school degree, 37% had a bachelor's degree, and 36% had a master's degree. Further, 66% reported not having been infected with COVID-19 earlier, 11% had been infected at the time of the baseline survey, and 23% had been infected in the meantime. In Sample 2, 90% reported having taken the booster dose.

Materials

Sociodemographic variables

In the baseline survey, we assessed participants' age, gender (i.e. male vs. female), civil status (i.e. having a partner or being single), and education level (i.e. from 1 = "No diploma/secondary graduation," 2 = "Bachelor's degree," and 3 = "Master's degree/more"). Both follow-up surveys assessed whether they had been infected by COVID-19 and, if so, whether this was before or after their vaccination (i.e. 1 = "no infection," 2 = "pre-vaccine infection," and 3 = "post-vaccine infection").

(Lack of) Motivation to get vaccinated

Similar to previous studies (e.g. Schmitz et al., 2022), a total of 12 items captured participants' (a) motivations, with three items measuring autonomous reasons to become vaccinated (e.g. "Getting vaccinated aligns with my personal values") and three items tapping controlled reasons to get vaccinated (e.g. "I feel pressured to get vaccinated"). Further, three items also measured people's distrust-based amotivation (e.g. "I am concerned about possible side effects of the vaccine") and three items assessed people's effort-based amotivation (e.g. "I will be criticized if I don't get vaccinated"). Participants rated all items on a 5-point scale ranging from 1 (*totally disagree*) to 5 (*totally agree*). We calculated internal consistencies using Cronbach's alpha. These were acceptable for each variable (see Table 1).

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 symptoms (from 1 = "Not at all serious" to 5 = "Very serious"). They did so for themselves and for the general population, making four items in total (i.e. risk for oneself, risk for others, severity for oneself, and severity for others). Following explanatory factor analysis results (see Table S1), we averaged the items to form a total score of risk perception, showing good internal consistency (see Table 1).

Vaccination intention

For *Sample 1*, participants answered the item "If you were invited for a third shot (or booster vaccination), how would you respond to the invitation?" using a 5-point scale: (1) "I would refuse without any hesitation," (2) "I would probably refuse," (3) "I would doubt," (4) "I would probably accept," (5) "I would accept without any hesitation." The same response scale was used for *Sample 2*, where participants had to answer the item "If you were invited for an annual shot to vaccinate against COVID-19, how would you respond to that invitation?"

Plan of analysis

We performed all analyses in R (R Core Team, 2022). The syntax is available on https://osf.io/gz64w/?view_only=3d7c926ffac640ce9851392003030a98. To check for selectivity, we first conducted a set of comparison analyses among measurements of the baseline survey to compare participants comprising Samples 1 and 2 (i.e. those who had taken part to at least one of the Follow-up Surveys, 1 or 2, and were vaccinated at the moment of the follow-up survey) and those who had not taken part to these follow-up surveys. For the sake of clarity, these were all unvaccinated participants as their motivation to be vaccinated was assessed at baseline. To this end, we used multivariate analysis of variance (MANOVA) for the continuous variable *age* and chi-square tests for the other categorical variables. In a following step, we calculated a Pearson correlation matrix for each sample, including all continuous background variables and the study variables (i.e. types of [a]motivation, vaccination intention). We relied on a MANOVA with univariate analyses to check for the role of *gender* in the study variables.

As part of the dimensional approach, we performed hierarchical linear regression modeling to examine the associations between vaccination (a)motivation and the intentions to get the booster dose (i.e. in Sample 1) or the annual dose (i.e. in Sample 2). Of note, we centered all continuous

TABLE 1 Pearson correlations between study variables for Sample 1 (below diagonal) and Sample 2 (above diagonal).

	Sample 1			Sample 2										
	M	*SD*	α	M	*SD*	α	1.	2.	3.	4.	5.	6.	7.	8.
1. Age	53.58	12.83	-	55.90	13.09	-		−.21***	.16***	.16**	−.07	−.03	−.12*	.30***
2. Education level	2.10	0.85	-	2.22	0.86	-	−.17***		−.20***	.09	.05	−.07	−.10*	−.10*
3. Risk perception	3.19	0.69	.72	2.89	0.72	.80	.22***	−.11***		.32***	−.02	−.12**	−.15***	.44***
4. Autonomous motivation	4.10	1.10	.72	4.02	1.21	.73	.08***	.10***	.29***		.00	−.43***	−.74***	.69***
5. Controlled motivation	3.05	0.69	.84	3.06	0.69	.81	−.10***	.07***	−.06*	.05**		.07	.08	−.07
6. Effort-based amotivation	1.46	0.64	.69	1.52	0.71	.71	−.03	−.10***	−.11***	−.41***	.09***		.50***	−.35***
7. Distrust-based amotivation	2.56	1.15	.74	2.55	1.14	.76	−.15***	−.12***	−.10***	−.70***	.11***	.43***		−.57***
8. Vaccination intention	4.49	0.98	.77	3.86	1.26	.74	.19***	.02	.40***	.59***	−.05**	−.28***	−.44***	

***$p < .001$.

**$p < .01$.

*$p < .05$.

predictors and used effect coding for the categorical variables (i.e. contrast codes −1 and +1) before computing interaction terms. As a first step, we built a model that included background variables age, education level, gender, civil status, and infection history as predictors, with time difference between both surveys (in days) and risk perception at the follow-up survey as covariates. When predicting the annual dose, we also included whether participants had received their booster dose or not as a covariate. In the second step of the modeling, we added the (a)motivation types as predictors. In the third step, we added two-way interactions between each type of (a) motivation and the other variables of interest. Models were compared by analysis of variance (ANOVA). For each model, we checked the diagnostics (i.e. linearity, normality, heterogeneity, and independence) as well as multicollinearity by means of the variance inflation factor (VIF). In addition, we calculated partial eta-squares to obtain an effect size next to the estimated coefficients with *p* values. When an interaction term proved significant, we visualized the moderation effect by calculating the predicted values for different levels of the categorical moderator or by relying on standard deviations from the mean in case of a continuous moderator. For each level, we calculated standardized simple slope coefficients.

We performed person-centered analysis on the types of (a)motivation by using the two-step clustering procedure, which entails using the output of a hierarchical clustering procedure (Step 1) as a starting point of the K-Means clustering procedure (Step 2; Gore, 2000). For the sake of practicality, we explain all steps regarding data preparation, validation techniques of the cluster numbers (i.e. before, during, and after the clustering procedure), and between-cluster differences in the Supplementary Materials (see Appendix S1).

RESULTS

Preliminary analyses

A baseline comparison between participants of Sample 1 and baseline participants who did not take part in Follow-up Survey 1 (Wilks' lambda = .98, $F(1, 23{,}345) = 52.73$, $p < .001$) showed that Sample 1 participants were older ($F(1, 23{,}345) = 281.39$, $p < .001$), had higher education levels ($F(1, 23{,}345) = 6.75$, $p = .001$), reported higher autonomous motivation ($M_{sample1} = 4.08$ vs. $M_{no\_followup} = 3.89$, $F(1, 23{,}345) = 17.38$, $p < .001$), lower effort-based ($M_{sample1} = 1.47$ vs. $M_{no\_followup} = 1.53$, $F(1, 23{,}345) = 6.29$, $p = .01$), and distrust-based ($M_{sample1} = 2.56$ vs. $M_{no\_followup} = 2.75$, $F(1, 23{,}345) = 27.27$, $p < .001$) amotivation. Further, no differences were found in terms of gender ($\chi^2(1) = 0.25$, *Cramer's V* = .00, $p = .61$) and infection history ($\chi^2(2) = 0.65$, *Cramer's V* = .00, $p = .72$). Similarly, participants of Sample 2 were significantly older ($F(1, 23{,}345) = 73.64$, $p < .001$) and had lower scores for distrust-based amotivation ($M_{sample2} = 2.54$ vs. $M_{no\_followup} = 2.72$, $F(1, 23{,}345) = 9.24$, $p = .002$) than baseline participants who did not complete Follow-up Survey 2. Also here, no differences were found in terms of gender ($\chi^2(1) = 0.10$, *Cramer's V* = .00, $p = .75$) or infection history ($\chi^2(2) = 7.39$, *Cramer's V* = .00, $p = .10$).

As for the role of sociodemographic variables within Sample 1, we found a significant multivariate effect for gender (Wilks' lambda = .97, $F(1, 3351) = 17.63$, $p < .001$) and infection history (Wilks' lambda = .99, $F(2, 4109) = 4.72$, $p < .001$) with female participants scoring higher on distrust-based amotivation ($M_{female} = 2.77$ vs. $M_{male} = 2.46$, $F(1, 3351) = 57.61$, $p < .001$) and those having not been infected yet scoring higher on autonomous motivation ($M_{not\_infected} = 4.15$ vs. $M_{infected\_earlier} = 3.93$ versus $M_{recently\_infected} = 4.06$, $F(2, 4109) = 6.88$, $p < .001$) and on booster dose intention ($M_{not\_infected} = 4.54$ vs. $M_{infected\_earlier} = 4.28$ vs. $M_{recently\_infected} = 4.29$, $F(2, 4109) = 18.21$, $p < .001$). No effects emerged for civil status (Wilks' lambda = .99, $F(1, 3351) = 1.17$, $p = .29$).

In Sample 2, female participants had higher distrust-based amotivation compared to males ($M_{female}=2.70$ vs. $M_{male}=2.35$, $F(1, 370)=8.74$, $p=.003$; Wilks' lambda = .95, $F(1, 372)=4.31$, $p<.001$) and those having not been infected yet scoring higher on their intention for an annual dose ($M_{not\_infected}=4.02$ vs. $M_{infected\_earlier}=3.48$ vs. $M_{recently\_infected}=3.72$, $F(2, 446)=5.91$, $p<.001$; Wilks' lambda = .95, $F(2, 446)=3.17$, $p<.001$). No effects emerged for civil status (Wilks' lambda = .95, $F(1, 372)=1.79$, $p=.24$).

Table 1 shows the descriptive statistics and Pearson correlations, with Sample 1 represented below the diagonal and Sample 2 above the diagonal. A breakdown of the sample according to participants' intentions to accept a booster dose (5.5% totally refusing, 4.8% refusing, 11.6% doubting, 17% accepting, and 61.1% totally accepting) and an annual dose (7.9% totally refusing, 7.0% refusing, 17.1% doubting, 25% accepting, and 43% totally accepting) shows that most participants would accept the additional doses, with a higher acceptance rate for the booster dose. Other variables seem to be quite comparable in terms of their averages. The pattern of correlations is comparable in both samples, with autonomous motivation being related to stronger intention to get the booster/annual dose and controlled motivation, effort-based amotivation, and distrust-based amotivation being related to lower intention. Older participants report higher levels of risk perception, autonomous motivation and vaccination intention, and lower controlled motivation and distrust-based amotivation. The higher participants' risk perception, the higher their scores for both autonomous motivation and vaccination intention, and the lower their scores for both effort-based amotivation and distrust-based amotivation. One difference between the two samples is that a significant relation between controlled motivation and both types of amotivation emerged only in Sample 2.

Aim 1: Dimensional approach

Turning to our two linear regression models, we encountered no multicollinearity problems (all VIFs < 1.62) and obtained satisfying model diagnostics. The right part of Table 2 has the intention for a booster dose as the criterion, whereas the left part considers the intention to accept an annual dose as the criterion. The findings of both sets of analyses were similar. First, whereas age showed a positive relation with both outcomes, none of the other socio-demographics yielded a unique association, except for time difference, risk perception, and booster uptake. Specifically, the higher the levels of risk perception, the higher the intention to accept a booster dose or an annual dose. For the latter outcome, the intention was also higher for those who got their booster dose in the meantime.

Second, the motivational predictors yielded a similar pattern of unique contributions, with autonomous motivation showing a positive and controlled motivation and distrust-based amotivation showing a negative association with both the intention to get the booster and an annual dose. The contribution of distrust-based amotivation was much stronger in the prediction of the annual dose.

Third, concerning the interaction effects, their contribution to the models were only significant in predicting booster dose acceptance but proved very modest in terms of effect sizes. For instance, a significant interaction effect emerged between levels of autonomous motivation and infection history, showing that individuals who got infected were less willing to accept a booster dose when levels of autonomous motivation were low (see Figure 1). Simple slope analyses revealed no noticeable differences whether this infection was before or after one's vaccination. Second, a significant interaction effect between distrust-based amotivation and infection history

TABLE 2 Standardized beta-coefficients and Partial eta-squared of linear regression models.

	Booster dose intention			Annual dose intention		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Age	.12*** (.02)	.05* (.00)	.06** (.00)	.18*** (.04)	.12 ** (.03)	.14*** (.15)
Education	.10*** (.01)	.01 (.00)	.02 (.00)	.03 (.00)	−.07 (.01)	−.06 (.04)
Gender	−.12* (.00)	.00 (.00)	.00 (.00)	−.08 (.01)	−.02 (.00)	−.01 (.00)
Civil status	.08 (.00)	.09 (.00)	.08 (.00)	−.01 (.00)	.04 (.00)	.03 (.00)
Infection history (post-vaccine)	.09 (.00)	.05 (.00)	.05 (.00)	.05 (.00)	.02 (.00)	.02 (.02)
Infection history (pre-vaccine)	−.02	−.04	−.05	−.02	.02	.02
Time difference	.09*** (.01)	.06** (.01)	.06** (.01)	.02 (.00)	.04 (.01)	.04 (.01)
Risk perception	.37*** (.13)	.24*** (.08)	.24*** (.08)	.32*** (.11)	.19*** (.06)	.16*** (.00)
Booster (received)				.30*** (.11)	.10** (.02)	.09* (.00)
Autonomous motivation (AM)		.43*** (.12)	.48*** (.11)		.45*** (.14)	.46*** (.00)
Controlled motivation (CM)		−.07** (.02)	−.06** (.02)		−.09** (.00)	−.08** (.01)
Effort-based Amotivation (EB AM)		.00 (.00)	.01 (.00)		−.00 (.00)	.04 (.01)
Distrust-based Amotivation (DB AM)		−.13** (.01)	−.17** (.01)		−.24*** (.04)	−.28*** (.04)
AM * age			−.03 (.00)			.00 (.00)
CM * age			−.01 (.00)			.00 (.00)
EB AM * age			−.01 (.00)			.03 (.00)
DB AM * age			.04 (.00)			−.01 (.00)
AM * education			.02 (.00)			−.03 (.00)
CM * education			.01 (.00)			.05 (.00)
EB AM * education			.00 (.00)			.11 (.02)
DB AM * education			.05 (.00)			−.07 (.00)
AM * gender			.05 (.00)			−.02 (.00)
CM * gender			−.01 (.00)			.06 (.00)
EB AM * gender			−.03 (.00)			−.06 (.00)
DB AM * gender			.03 (.00)			.13 (.00)
AM * civil status			−.04 (.00)			−.06 (.00)
CM * civil status			.05 (.01)			.03 (.00)
EB AM * civil status			−.02 (.00)			.03 (.00)
DB AM * civil status			−.05 (.00)			.00 (.00)

TABLE 2 (Continued)

	Booster dose intention			Annual dose intention		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
AM * infection history (after vaccination)			−.11* (.00)			.03 (.01)
AM * infection history (before vaccination)			−.04			−.02
CM * infection history (after vaccination)			−.04 (.00)			−.02 (.00)
CM * infection history (before vaccination)			.02			.04
EB AM * infection history (after vaccination)			.02 (.00)			.09 (.00)
EB AM * infection history (before vaccination)			−.02			.07
DB AM * infection history (after vaccination)			.03 (.00)			.15** (.01)
DB AM * infection history (before vaccination)			−.09			−.11**
R^2	.19/.19	.44/.44	.45/.45	.31/.30	.57/.55	.60/.59
Comparison test		$F(4) = 154.12$, $p < .001$	$F(24) = 1.84$ $p < .001$		$F(4) = 140.78$, $p < .001$	$F(24) = 1.10$, $p = .34$

***$p < .001$.

**$p < .01$.

*$p < .05$.

showed that those who had not been infected showed a less marked effect of distrust-based amotivation (see Figure S1).

Aim 2: Person-centered analyses

Identification of clusters

The *H* index for cluster tendency showed evidence for meaningful clusters in both samples ($H_{sample1} = .76$; $H_{sample2} = .73$). The *ac* indicates the *Ward*'s method as the best linkage method in both Sample 1 (*Ward* = .99; *complete* = .98; *average* = .97; *single* = .94) and Sample 2 (*Ward* = .99; *complete* = .96; *average* = .94; *single* = .84).

Next, we calculated the four validation techniques, of which the results are presented in Figure S2. Results are equivalent in both samples. The *Elbow method* (upper left) showed evidence for three clusters because there is a balance between the amount of between- and within-cluster variance. The average silhouettes method (upper right) points to six as the most optimal number. However, both the *Gap statistic* (bottom left) and the *majority rule* (bottom right) deemed five clusters as the most optimal number. Taking into account that the *average silhouette method* also provides five as the second-best option, we concluded that five clusters stand as the optimal

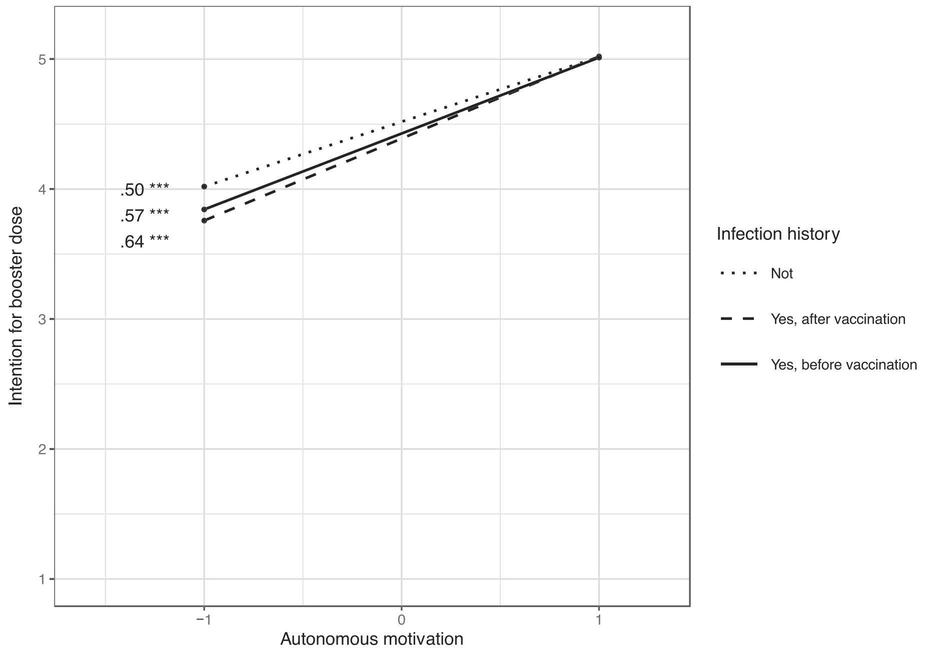

FIGURE 1 Autonomous motivation in prediction of booster dose intention by infection history with standardized simple slope coefficients.

number of clusters in both Samples 1 and 2. For this solution, the standardized values for all cluster variables are presented in Figure 2a (for Sample 1) and Figure 2b (Sample 2).

The between-cluster comparison in terms of the cluster variables can be found in Table 3 for Sample 1 and Table 4 for Sample 2. We labeled the clusters by drawing on Vansteenkiste et al.'s (2009) classification. Herein, we notice a comparable output across both samples, with the *Overall Amotivated* cluster having the lowest scores on autonomous and controlled motivation and the highest scores for both distrust- and effort-based amotivation. The *Controlled + distrust (a)motivation* cluster showed the highest scores on both controlled motivation and distrust-based amotivation, with lower scores for autonomous motivation. The *Effort-based Amotivated* cluster showed intermediate scores for autonomous motivation, controlled motivation, and distrust-based amotivation along with the highest scores for effort-based amotivation. The *Good Quality motivation* cluster contained the highest scores for autonomous motivation, while having the lowest scores for controlled motivation and both types of amotivation. Similarly, the *High Quantity motivation* cluster had the lowest scores for both types of amotivation but significantly higher scores for both autonomous and controlled motivation.

Also, the proportion of participants assigned to a particular cluster seemed roughly comparable across the two samples, with both the *Good quality motivation* and *High quantity motivation* as the two biggest clusters in Sample 1 (resp. 35% and 22%) and Sample 2 (resp. 29% and 33%). The *Effort-based amotivated* cluster contains an intermediate proportion of participants (resp. 19% and 17%), followed by the *Controlled + distrust-based (a)motivated* cluster (resp. 14% and 13%) with the *Overall amotivated* cluster as the smallest cluster (resp. 10% and 8%).

One difference between the two samples was that the *High quantity motivation* cluster had significantly higher scores for autonomous motivation in Sample 1, compared with the cluster differences in Sample 2. Also, the *Overall amotivated* cluster showed higher scores on

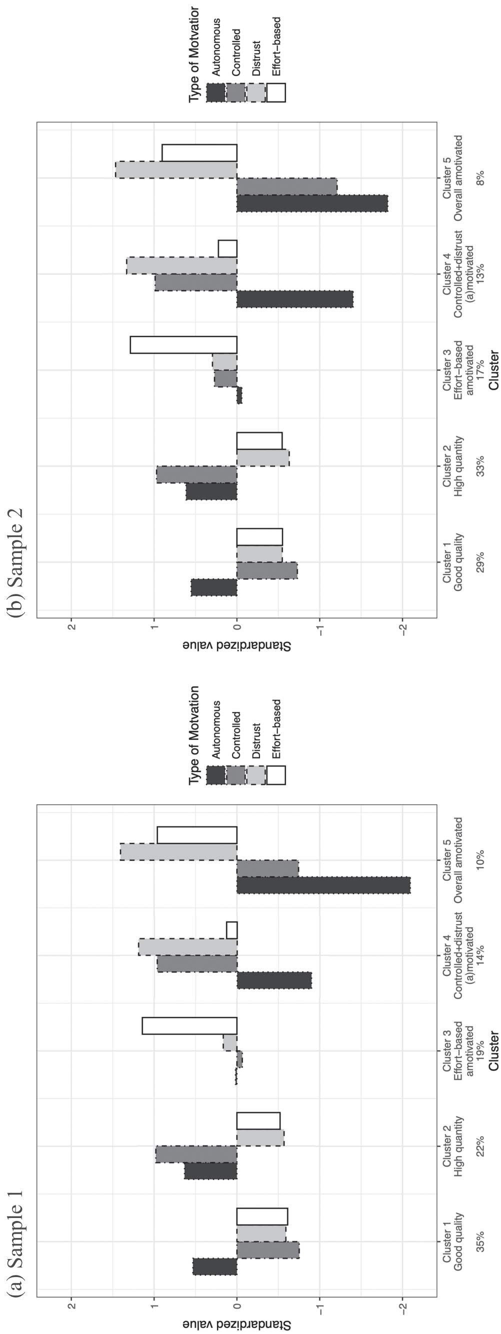

FIGURE 2 Visualizations of standardized cluster variables across clusters in both samples. (a) Sample 1; (b) Sample 2. [Corrections made on 19 June 2023, after first online publication: In this version, Figure 2 has been replaced to correct errors in the previous version.]

TABLE 3 Descriptives and output of univariate analyses of between-cluster comparisons in Sample 1.

	Motivational profiles					*F*	*p* value	η^2_p
	Good quality motivation	High quantity motivation	Effort-based amotivation	Controlled + distrust-based (a)motivation	Overall amotivated			
Cluster variables (raw scores)								
Autonomous motivation	4.69[d]	4.81[e]	4.11[c]	3.10[b]	1.77[a]	1088.4	<.001	.73
Controlled motivation	2.54[a]	3.72[c]	3.01[b]	3.71[c]	2.53[a]	1648.5	<.001	.59
Distrust-based amotivation	1.87[a]	1.90[a]	2.75[b]	3.93[c]	4.20[d]	1696.01	<.001	.60
Effort-based amotivation	1.07[a]	1.13[b]	2.20[e]	1.54[c]	2.10[d]	1308.84	<.001	.53
Cluster variables (*z* scores)								
Autonomous motivation	0.53	0.63	0.02	−0.90	−2.09			
Controlled motivation	−0.75	0.98	−0.07	0.97	−0.74			
Distrust-based amotivation	−0.59	−0.57	0.16	1.19	1.41			
Effort-based amotivation	−0.61	−0.52	1.14	0.13	0.96			
Covariates								
Age	54.78[b]	54.97[b]	53.82[b]	49.11[a]	52.76[b]	19.66	<.001	.02
Education level	2.14[c]	2.22[c]	2.01[b]	2.12[bc]	1.83[a]	14.38	<.001	.02
Time difference	272.22[a]	273.94[ab]	278.64[b]	276.1[ab]	279.02[ab]	2.80	.02	.00
Risk perception	3.30[c]	3.28[c]	3.26[c]	3.08[b]	2.78[a]	51.13	<.001	.06
Outcome								
Booster vaccination intention	4.57[d]	4.61[d]	4.31[c]	3.62[b]	3.02[a]	160.75	<.001	.24

[Corrections made on 19 June 2023, after first online publication: The values for 'Cluster variables (z-scores)' related to 'High quantity motivation' and 'Controlled + distrust-based (a)motivation' have been corrected in this version.]

TABLE 4 Descriptives and output of univariate analyses of between-cluster comparisons in Sample 2.

	Clusters					F	p value	η^2_p
	Good quality motivation	High quantity motivation	Effort-based amotivation	Controlled + distrust-based (a)motivation	Overall amotivated			
Cluster variables (raw scores)								
Autonomous motivation	4.64[d]	4.77[d]	3.94[c]	2.29[b]	1.88[a]	338.61	<.001	.73
Controlled motivation	2.38[a]	3.48[c]	3.26[b]	3.73[d]	2.22[a]	239.75	<.001	.66
Distrust-based amotivation	1.89[a]	1.88[a]	2.90[b]	4.07[c]	4.19[c]	218.62	<.001	.63
Effort-based amotivation	1.15[a]	1.12[a]	2.44[c]	1.68[b]	2.21[c]	159.86	<.001	.56
Cluster variables (z scores)								
Autonomous motivation	0.55	0.61	−0.06	−1.40	−1.82	0.55		
Controlled motivation	−0.73	0.97	0.27	0.99	−1.21	−0.73		
Distrust-based amotivation	−0.55	−0.63	0.30	1.33	1.47	−0.55		
Effort-based amotivation	−0.55	−0.55	1.29	0.22	0.90	−0.55		
Covariates								
Age	56.95[b]	56.73[b]	58.05[b]	49.20[a]	55.18[ab]	4.09	<.001	.04
Education level	2.29	2.27	2.19	2.20	1.94	1.22	.30	.01
Time difference	386.19[ab]	382.67[ab]	388[ab]	368.78[a]	397.64[b]	2.71	.03	.02
Risk perception	3.39[b]	3.28[b]	3.20[b]	2.81[a]	2.70[a]	10.08	<.001	.11
Outcome								
Annual dose intention	4.36[c]	4.37[c]	3.74[b]	2.71[a]	2.89[a]	61.09	<.001	.32

[Corrections made on 19 June 2023, after first online publication: The values for ‘Cluster variables (z-scores)’ related to ‘Controlled + distrust-based (a)motivation’ and ‘Overall Amotivated’ have been corrected in this version.]

distrust-based amotivation than the *Controlled + distrust (a)motivation* cluster in Sample 1, whereas both had equal scores in Sample 2.

The double-split cross-validation procedure to determine cluster stability revealed a weighted k of .86 (z = 111.06, p < .001) for subset A and a weighted k of .85 (z = 110.30, p < .001) for subset B in Sample 1. In Sample 2, we found a weighted k of .98 (z = 120.3, p < .001) for subset A and a weighted k of .94 (z = 51.26, p < .001) for subset B. When checking this between samples, we found a weighted k of .98 (z = 491.8, p < .001) for Sample 1 and a weighted k of .99 (z = 546.1, p < .001) for Sample 2. As a set, these analyses indicate good cluster stability.

Between-cluster differences

Background variables

When comparing the clusters in terms of background variables in Sample 1, a significant chi-square test for gender ($\chi^2(4)$ = 31.40, *Cramer's V* = *.19*, p < .001) confirmed that the *High quantity motivation* cluster comprised more male participants and the *Controlled + distrust (a) motivation* cluster comprised more females, compared with the proportions observed in the other clusters (see Table S2). No effects emerged for civil status ($\chi^2(4)$ = 2.14, *Cramer's V* = *.01*, p = .32) and infection history ($\chi^2(8)$ = 14.11, *Cramer's V* = *.06*, p = .09). In Sample 2, we found no significant chi-square tests ($\chi^2_{gender}(4)$ = 3.81, *Cramer's V* = *.00*, p = .43; $\chi^2_{civil\ status}$ (4) = 5.43, *Cramer's V* = *.01*, p = .25; $\chi^2_{infection\ history}$ (8) = 10.89, *Cramer's V* = *.02*, p = .21). In both samples, the *Controlled + distrust (a)motivation* sample was significantly younger and had the lowest scores for risk perception. Remarkably, both the *Good quality motivation, High quantity motivation* and *Effort-based amotivated* clusters had equal scores for risk perception. Only in Sample 1, a significant effect for education level shows that the *Good quality motivation* and *High quantity motivation* clusters had the highest education levels.

Vaccination intention

To examine between-cluster differences in terms of the intention to accept a booster or an annual dose of the COVID-19 vaccine, we performed linear regression modeling to calculate the between-cluster means and differences, while controlling for the covariates. The means and multiple comparison test (in Tables 3 and 4, respectively) reveal that both the *Good quality motivation* and the *High quantity motivation* clusters displayed the highest intentions in both samples, followed by the *Effort-based amotivated* cluster. The *Controlled + distrust (a)motivation* and *Overall amotivated clusters* had the lowest intentions, with the *Overall amotivated* cluster scoring significantly the lowest in Sample 1.

DISCUSSION

The waning of COVID-19 vaccine immunity after the initial doses of vaccine, together with the emergence of more infectious and vaccine-resistant variants, prompted the need for additional doses in order to keep the pandemic under control and to prevent an excessive burden on the national healthcare system (Callaway, 2021). In spite of clear benefits, not everyone expressed a willingness to get a new shot, let alone, an annual shot. This situation triggered the question regarding the factors underlying the heterogeneity in continued vaccine acceptance among vaccinated persons. Although a large body of the research on COVID-19 vaccination intentions, including the acceptance of booster dose and annual doses, points to the role of sociodemographic, medical, and political factors, other work has been focusing on psychological factors, like the perception of risk or the motivation to be vaccinated (e.g. Murphy et al., 2021). Indeed, previous findings confirmed the role of motivational factors (e.g. Schmitz et al., 2022), pointing to autonomous motivation and distrust-based amotivation as key determinants of one's intention to accept the COVID-19 vaccine. Yet, very little research focused on people's intentions regarding a booster dose and an annual dose (e.g. Reifferscheid et al., 2022), and to our knowledge, no study has examined the effect of motivations on these important outcomes. In the present study, we questioned the robustness of motivational effects towards the acceptance of a booster and an annual dose in light of the latest pandemic phases and of the role of other factors influencing intention for a new or annual dose. We examined this issue using two samples in which we linked participants' motivation and amotivation for a first dose with their intention to get a booster dose or an annual dose.

A dimensional approach

In line with previous findings, initial autonomous motivation and distrust-based amotivation predicted, respectively, positively and negatively respondents' intention to accept both a booster dose and an annual dose. This was the case even among vaccinated individuals and even when controlling for the number of days between both measurements and participants' risk perception. Interestingly, controlled motivation had a unique negative contribution, a finding that is partially discrepant and partially consistent with prior work focusing on the first dose (e.g. Van Oost et al., 2022; Waterschoot et al., 2022). Indeed, research in other life domains like sports (Pelletier et al., 2001) or education (Vansteenkiste et al., 2005) has shown that the effects of controlled motivation are rather short-lived and may backfire over time. The acceptance of a booster or an annual dose depends on continued commitment. Understandably, feeling initially seduced into vaccination through controlling forces may lead people to give up or even resist on later occasions (Ryan et al., 2021).

Next to motivation, there were also other factors influencing people's intention for a booster or an annual dose, including the perceived risk for (severe) illness at the time of the follow-up assessment. This is in line with findings from Sprengholz, Henkel, Böhm, and Betsch (2022) who showed that individuals who received the booster also reported more severity risk perception. Further, similar to previous research, the older people were, the more they were willing to envision a booster dose or an annual dose. Interestingly, interaction effects with both factors underscore the robust role of autonomous motivation, such that whether or not people already experienced a COVID-19 infection, and whether this infection took place before or after their vaccination, higher autonomous motivation was systematically associated with higher continued vaccination intention whereas higher distrust-based amotivation materialized into lower continued vaccination intention. Finally, effort-based amotivation had no unique effect on the target outcomes. Because people thought that vaccination required little effort and time as the distribution of vaccines was made logistically easy (e.g. by implementing numerous vaccination centers), it seems logical that effort-based amotivation played no role.

A person-centered approach

In line with our second aim, we adopted a person-centered approach using a two-step procedure of clustering analyses in both samples. A set of validation techniques suggested the presence of five meaningful clusters and indeed similar clustering patterns in the two samples. Interestingly, the same set of clusters emerged with most of the participants being assigned to the *Good* and *Highly* motivated clusters. These two groups had, respectively, uniquely high scores on autonomous motivation and a combination of autonomous and controlled motivation. Although the dimensional analyses revealed a negative effect of controlled motivation, the combination of autonomous motivation with controlled motivation did not reveal any significant differences in terms of the intentions to get the booster and an annual dose. Presumably, the presence of autonomous motivation helps to offset possible negative effects of controlled motivation. Alternatively, the negative effect of controlled motivation depends more on the presence of other motivational factors.

Indeed, controlled motivation had a negative effect when combined with high levels distrust-based amotivation, resulting in low levels of vaccination intentions in both samples. As expected, this is a group of people who experienced feelings of distrust towards the vaccine, while feeling externally pressured to accept their first shots. Furthermore, this cluster did not differ significantly in terms of vaccination intention from the group with high scores on both distrust- and effort-based amotivation. In line with the dimensional approach, this finding suggests that distrust, even in combination with a sense of obligation towards the vaccine, had a strong negative influence on people's intention to get a booster or an annual dose. This is particularly clear when observing the effects for the *Effort-based amotivated* cluster. This cluster shows intermediate scores for the other types of motivation and for people's acceptance towards a booster or an annual dose. As such, this cluster comprises a group of people who remains largely undecided with respect to taking additional doses.

The variability in the vaccinated individuals' profiles suggests that adopting a more profiled-tailored approach may prove appropriate in the context of a vaccination campaign. Interestingly, a recent crowd-funding study called upon panels of experts and citizens with the aim to identify and evaluate 40 potential strategies (Böhm et al., 2022). Results showed that both experts and citizens appraised strategies relying on rewards positively in terms of efficacy and acceptability. Similarly, Sprengholz, Henkel, Böhm, and Betsch (2022) found that money incentives increased vaccination willingness among vaccinated participants who had not received the booster. While such strategies might prove effective for participants experiencing effort-based amotivation (i.e. the *Effort-based amotivated* cluster), the effectiveness of incentives remains inconsistent across studies (e.g. Morbée et al., 2022; Thirumurthy et al., 2022) and likely elicits reactance among citizens characterized by high distrust-based amotivation (Betsch & Böhm, 2016). Such individuals, who experience strong reluctance towards vaccination, may benefit more from other types of interventions. Participants who experience a moderate sense of distrust may take relatively more advantage of educational programs that focus on the science and safety behind vaccination. In contrast, as argued by Hornsey and Fielding (2020), "repeating the science" is not always enough. As a matter of fact, people often tend to start with a conclusion (e.g. vaccines are not to be trusted) and then select information to validate their initial negative attitude (i.e. motivated reasoning; Kunda, 1990). In this case, attending to people's underlying type of motivation (e.g. holistic approach to health) might be done through adopting an autonomy-supportive counseling approach (Morbée et al., 2022).

Finally, in light of the findings for the High Quantity and Good Quality profiles, both characterized by autonomous motivation and both manifesting the best outcomes with respect to our criteria, it is clear that interventions boosting autonomous motivations are key. One major lesson is that vaccinated participants should be reminded from the very start that vaccine protection and with it, the ability to protect oneself and others, wanes over time. Likely, this should allow keeping alive the willingness to embrace additional steps towards the adoption of a booster or an annual dose.

Limitations

The present study suffers from a number of limitations. Although we relied on several national newspapers and social media ads to reach our participants, our initial baseline sample is not representative of the population. In particular, it comprises an excess of female participants and of higher educated people. The number of people in Sample 2 who took the booster shot (90%) also illustrates this limitation, given that only 62% of the [blinded for review] population have actually accepted the invitation. Moreover, because we included only those already vaccinated in the current study, the present samples are rather committed and, therefore, selective. For instance, the comparison analyses between those who participated in follow-up surveys and those who did not do so showed higher levels of autonomous motivation among those who took part in the follow-up surveys. These contingencies mean that the associations in the current findings may be over- or underestimated in case there would be more variance in scores on the different subtypes of motivation (e.g. more lower scores).

Second, our results may in part reflect the cultural context in which they were collected. For instance, the Belgian infrastructure that supported the vaccination campaign effort may account for the non-significant role of effort.

Third, one cannot exclude the possibility of a so-called "recall bias," such that the participants of both samples were those who were motivated enough to participate after being contacted. It might be that these individuals held overall different attitudes towards vaccination than other people. Along similar lines, we do not account for possible changes in people's (lack of) motivation to be vaccinated. As the literature suggests, several factors like one's history with COVID-19 or exposure to types of information may trigger a shift across time when it comes to one's motivation to get the vaccine.

Fourth, the reported results concern participants' intention. Admittedly, on top of being possibly tainted by social desirability, intention does not automatically translate into behavior per se. However, prior research found that the same motivational processes as those studied herein predict people's self-reported vaccine uptake (Schmitz et al., 2022). Moreover, hardly any studies investigate the issue of the acceptance of a vaccination booster and annual doses. We thus believe that there is a need for more work to that pins down antecedents of such intentions, both on a variety of samples and for a range of delays. Even more important, we make a plea for future work that examines predictors of actual behavior related to vaccine boosters and annual doses.

Practical implications

In spite of the available evidence showing the effectiveness and critical role of boosters against circulating variants, acceptance rates for boosters remain well below those observed for the first dose, even among vaccinated adults. Yet, the emergence of new COVID-19 variants is an ever-present risk. More generally, the increased danger of emergence of new infectious epidemics (Morse et al., 2012), and the current presence of monkeypox, suggests that successful and long-lasting vaccination campaigns will continue to be a challenge for years to come. In this context, identifying predictors of vaccine booster and annual dose acceptance is crucial. Our study highlights the critical role of autonomous motivation in fostering intention to accept a booster dose over the long run. Autonomous motivation shows a protective role against some factors associated with lower vaccination intentions (gender, young age). It also remains important to inform the public adequately about the benefits (and potential caveats) of booster vaccines and to provide an adequate perception of the risks involved (despite its volatile nature) in order to dispel potential distrust and to foster an internalized sense of willingness.

The clear lesson emanating from the existing research emphasizes the greater effectiveness of autonomy-supportive rather than coercion-based communication style to encourage vaccine uptake (e.g. Morbée et al., 2022). In line with this message, we found that controlled motivation had a unique negative influence on booster acceptance, thus suggesting that sanctions and rewards come as a perilous game because they can backfire after a few months. In sharp contrast, several authors underline the positive effect of prosocial motives for vaccination (e.g. Motta et al., 2021).

At the same time, the choice of a booster and access to vaccination in general is by no means a socioeconomic neutral issue. Whereas our results suggest that older, female adults are more reluctant to take a booster injection, other results also indicate that adults from lower socioeconomic backgrounds are more reluctant (Reifferscheid et al., 2022). This is in spite of the fact that these segments of the population are most likely to suffer from serious indirect consequences from the virus (Paul & Fancourt, 2022). Similarly, and although it is crucial to foster vaccination for everyone, experts legitimately warn against the major inequalities in vaccine availability beyond borders, with a number of countries delivering booster doses while southern, low-income countries are still severely under-vaccinated (e.g. Juno & Wheatley, 2021). Future research could examine whether this perceived inequality of access might also be a possible concern for vaccinated people and as such a cause for booster and repeated vaccination amotivation.

CONCLUSION

Building upon Self-Determination theory, we presently explored motivational predictors of booster acceptance and annual COVID-19 vaccination dose, using longitudinal data collected between October 2020 and March 2022. Our results highlight the strong beneficial role of autonomous motivation, such that participants who were autonomously motivated to take their initial dose reported higher rates of booster and annual dose acceptance months later. Conversely, controlled motivation had a negative contribution, especially when being combined with distrust-based amotivation. The present data offer strong evidence that autonomous motivation plays a sustainable positive effect and that controlling strategies, such as sanctions or rewards, are potentially counterproductive over time. In light of the continued risk of future outbreaks, our findings point to the importance of attending to the promotion of autonomously endorsed vaccination for all.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The project was approved by the ethical committee of Ghent University, Belgium (N° 2020/37). Informed consent was obtained from all the participants. All methods/protocols were performed in accordance with the relevant guidelines and regulations.

DATA AVAILABILITY STATEMENT

The R scripts to carry out the analyses are publicly available on Open Science Framework: https://osf.io/gz64w/?view_only=3d7c926ffac640ce9851392003030a98 [anonymized view-only link]. Datasets are hosted in Zenodo (a public repository) and are available upon request and for replication purposes only (after contacting responsible researcher).

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