Research Article

Adoption of Non-Technological Health Innovations: The Case of Mask Use during the COVID-19 Pandemic in Brazil

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ABSTRACT

The use of masks to prevent COVID-19 infections generated much controversy and disagreements among the population, infectious disease specialists, and government representatives. Western countries were not used to using facial masks, and their adoption can be considered a non-technological innovation. This article explores the determinants of the intention to adopt, the actual use, and the continued intention to use a facemask to prevent COVID-19 infections in Brazil. Through structural equation modeling (SEM), relationships between constructs from the theory of planned behavior (TPB) and the construct of trust in the authorities were applied to test the study's hypotheses. The results suggest that perceived behavior control, subjective norms, and trust in the authorities are significant motivators for the actual use and continued intention to use facial masks in Brazil.

INTRODUCTION

COVID-19, the disease caused by the coronavirus of severe acute respiratory syndrome 2 (SARS-CoV-2) (Hellewell et al., 2020), was first identified in December 2019 after an outbreak of pneumonia in a Chinese city (Rothan & Byrareddy, 2020). In late January 2020, the World Health Organization (WHO) declared that the COVID-19 outbreak constituted a Public Health Emergency of International Importance (Gostin, Friedman, & Wetter, 2020). Less than two months later, WHO would characterize the disease as a pandemic (Cucinotta & Vanelli, 2020). In addition to the health problems generated by COVID-19 (Cadogan & Hughes, 2021), the pandemic also created socio-political and economic crises (Kittel et al., 2021; Mendes, 2020). It is estimated that the pandemic will increase poverty and inequalities on a global scale (Faelli, Johns, Apps, & Almquist, 2021).

The disease is primarily transmitted by respiratory droplets and can be airborne in specific circumstances (Tammaro, Adebanjo, Parisella, Pezzuto, & Rello, 2020). Therefore, facial masks began to be advocated to prevent COVID-19 (Cheng et al., 2020). Initially, the adoption of masks was suggested as a preventive measure for healthcare workers (Howard et al., 2021). The benefits of community masking, on the other hand, remain a controversial topic (Naveed, Scantling-Birch, Lee, & Nanavaty, 2020). Community masking refers to the adoption of masks to prevent the dissemination of respiratory infections in non-medical settings (Brooks, Butler, & Redfield, 2020). Asian societies have adopted and consolidated such practices for many years (Tang, 2020). However, before the COVID-19 pandemic, Western communities had never used masks massively in public places (Liu, Diab, Naveed, & Leung, 2020).

The idea behind the collective use of masks as a means of preventing the disease was not very clear at the beginning of the pandemic; the initial guidance from health officials was mostly confusing (Tang, 2020), stating that only sick people should wear masks in public, or that only a limited variety of masks were effective (Sheluchin, Johnston, & Linden, 2020). At this initial phase of the pandemic, WHO recommended mask usage only by symptomatic individuals and their contacts (Stutt, Retkute, Bradley, Gilligan, & Colvin, 2020).

Since Western populations were not used to wearing masks outside of medical facilities (Liu et al., 2020), there were many doubts regarding mask adoption in public places, which were increased by the health authorities themselves (Naveed et al., 2020). Many questions remained about the efficacy of mask usage to prevent COVID-19 and about the disease itself (Singh & Ravinetto, 2020). It was not clear how asymptomatic or pre-symptomatic patients could infect others, how effective masks were in decreasing the risk of an infectious mask wearer contaminating others, or if wearing a mask would impact the wearer's probability to be infected (Howard et al., 2021).

The issue of community masking worsened with a shortage of healthcare supplies, including surgical masks (He & Laurent, 2020). The escalation of demand for facemasks led to increasing risks of product shortages for health services (Convissar, Berra, Chang, & Bittner, 2020). The alternative was the usage of fabric masks. However, confusing guidelines from health institutions and authorities, and the lack of information on the effectiveness of fabric masks, further confused

the population (Carvalho & Teixeira, 2020; Howard et al., 2021; Oliveira, Lucas, & Iquiapaza, 2020).

As months went by, and as research on the topic progressed, WHO began to recommend mask usage by everyone (Kvalsvig et al., 2020). After the director-general of the Chinese Center for Disease Control pointed out that the lack of community mask usage in Europe and the United States was a mistake, WHO reversed its policy dramatically and released a revised guideline about using non-medical masks. Other health institutions worldwide followed WHO's instructions, stipulating wearing masks in public areas as a protection measure to complement other preventive actions, such as physical distancing and hand hygiene. Gradually, guidelines would change more, and mask usage in public would become mandatory in many Western countries, especially in locations where social distancing would be difficult (Sheluchin et al., 2020).

Despite the changes in policies and guidelines, the damage was done; the effectiveness of the adoption of masks would continue to be controversial (Fodjo et al., 2020) and would eventually become politicized. For instance, in the United States (USA), the narrative surrounding the adoption of masks differed substantially by political party, creating a clear political divide in the country (Lang, Erickson, & Jing-Schmidt, 2021; Young, Rasheed, Bleakley, & Langbaum, 2022).

In Brazil, COVID-19 has been politicized since the beginning of the pandemic. The differences of opinion between ministers of Health and the president of the Republic on COVID-19 prevention measures generated successive exchanges in the ministry's leadership responsible for containing the disease (Verdélio, 2020). Brazilian mayors and governors reacted differently to the pandemic, taking a political stand for or against the president of the Republic (Abrucio, Grin, Franzese, Segatto, & Couto, 2020).

This politicization of COVID-19 led to political attrition about the mandatory use of masks in Brazil (Amaral, Jones, & Nogueira, 2021). In July 2020, amid pressure from the National Congress and other stakeholders, the Brazilian president signed a federal law to make wearing a mask mandatory. However, the law would be sanctioned with several presidential vetoes (Library of Congress, 2020). Some criticized the arbitrary imposition of government authorities, alleging violation of individual freedom (Abud & Souza, 2020); others opposed using masks by spreading fake news about them (Gehrke & Benetti, 2021; Teixeira & Martins, 2022).

Over the past few months, academic papers have been written about community masking in Brazil (Abud & Souza, 2020; Carvalho & Teixeira, 2020; Oliveira et al., 2020) and abroad (Sheluchin et al., 2020; Stutt et al., 2020). However, the authors did not find papers that researched mask adoption as a non-technological innovation from the perspective of its users.

Innovation can be understood as an idea, practice, or object perceived as new by the individual (Rogers, 2003). It can be considered a preventive innovation when its adoption seeks to avoid unwanted consequences in the future (Rogers, 2003). It can also be regarded as a non-technological innovation if it includes a non-technical component (Černe, Kaše, & Škerlavaj, 2016). This includes social marketing strategy (Kotler & Zaltman, 1971), which uses marketing

principles and techniques to influence behaviors that will benefit individuals and society and has been long used to promote public health campaigns (Cheng, Kotler, & Lee, 2011).

For Western nations and populations, the collective use of masks is a novelty (Kvalsvig et al., 2020) that seeks to avoid unwanted consequences, and promoting its usage typically characterizes a social marketing strategy. Thus, their adoption can be considered a preventive and non-technological health innovation.

Therefore, from a diffusion of innovations point of view (Rogers, 2003), this paper aims to explore among Brazilians the antecedents of individuals' intention to adopt, their actual use, and their continued intention to use facial masks to prevent COVID-19 infection. The authors seek to expand the academic knowledge about the diffusion of innovations, focusing on a relevant but less explored type of them, the preventive and non-technological health innovations. Additionally, the findings hopefully will help health authorities improve public policies and future campaigns aimed to accelerate the adoption of such innovations for the benefit of our society.

To achieve our purpose, the authors developed a model to apply in this paper, based on Ajzen's theory of planned behavior, TPB (Ajzen, 1991, 2002), also considering other related research, including papers in the context of health products, such as vaccines and organic milk (e.g., Carfora et al., 2019; Caso, Carfora, Starace, & Conner, 2019). The model allowed the analysis of new TPB relationships, being a better instrument for the researched theme. This model was complemented with the 'Trust in Authorities' construct to evaluate its influence on people's intention to adopt masks, as also as 'Actual Use' and 'Continued Intention to Use' constructs, to understand how people are actually using masks, and if they intend to continue using them after their use is no longer mandatory.

THEORETICAL BACKGROUND AND PROPOSED HYPOTHESES

Preventive and non-technological innovation in health

It is essential for healthcare researchers and practitioners to understand health innovations better: what makes a particular innovation diffuse more rapidly, what are the main attributes of the innovation, and how the environmental context can impact health innovation adoption, among other aspects. Innovations are successful in some places and times but fail in others. Healthcare studies seek to analyze the diffusion of major public health innovations to understand how innovation adopters can be influenced by values, laws, religions, ideologies, and political issues (Greenberg, 2006), as also as by psychological aspects (Segaar, Bolman, Willemsen, & Vries, 2006).

Regarding the adoption of innovations, the literature suggests the existence of relevant differences in the adoption of 'general' innovations and preventive innovations (Overstreet, Cegielski, & Hall, 2013). Research about preventive healthcare innovation is encouraged by Rogers (2003)

since prevention is usually a cheaper measure than treatment. However, the author explains that preventive innovations present uncertain rewards. This means there is a low relative advantage in this kind of innovation, characterizing a possible obstacle to its adoption and diffusion. The rewards to the individual from adopting a preventive innovation are often delayed in time, are relatively intangible, and the unwanted consequence may not occur anyway (Rogers, 2002).

Innovation can be considered preventive when it has future benefits or when it intends to avoid a negative consequence (Overstreet et al., 2013). Adopting telemedicine (Guarcelo & Raupp, 2021) and masks to prevent the spreading of COVID-19 (Howard et al., 2021) exemplify the second case. Rogers (1988; 2002) argues that there are three main obstacles to adopting preventive innovation: generally, the motivation to adopt is not related to profit, there is often a need for professional training before the adoption, and future-only benefits can discourage early adopters.

Innovation can also be classified as technological or non-technological, although the innovation process increasingly involves iteration between technological and non-technological initiatives (Mothe & Thi, 2010). Initially, non-technological innovation encompassed only organizational and marketing initiatives, as delimited in the third edition of the Oslo Manual (Organisation for Economic Co-operation and Development [OECD], 2005). This scope has been progressively expanded, and currently, non-technological innovations can be better defined as all those that include a non-technical component (Cerne et al., 2016).

Even considering the initially limited scope of non-technological innovation, adopting a new health habit, like wearing condoms to prevent AIDS infection or facial masks to avoid COVID-19 disease, can be regarded as a non-technological innovation since it is frequently promoted using social marketing strategies (Kotler & Zaltman, 1971). Social marketing uses marketing concepts to influence behaviors that benefit individuals and communities (Cheng et al., 2011). It is commonly used as an intervention strategy in global health (Firestone, Rowe, Modi, & Sievers, 2017).

Theory of planned behavior (TPB)

The theory of planned behavior (TPB) (Ajzen, 1991) has become a conceptual basis widely used in human behavior studies (Ajzen, 2002). The TPB proposes that human behavior is based on relevant information or personal beliefs (Overstreet et al., 2013), being guided by three types of considerations: behavioral beliefs refer to beliefs about likely consequences of behavior; normative beliefs are related to other people's normative expectations; and control beliefs involve beliefs about the existence of factors that can alter the performance of behavior (Ajzen, 2002).

The TPB is an evolution of another of Ajzen's theories, the theory of reasoned action (TRA), which is based on motivational constructs connected to the intention to perform or adopt a determined behavior. According to the TRA, a person's intention can influence the probability of a behavior being performed. The first predictor of intention refers to the degree of favorable or unfavorable evaluation of the behavior under analysis: the attitude towards a particular behavior. The second predictor of intention refers to the perception of social pressure by a person

related to their performance, or lack of performance, of a specific behavior. This predictor is known as subjective norms.

According to the TRA, the behavior must be under volitional control (Ajzen & Fishbein, 1977; 1980), and this was one of the theory's most problematic issues. The TRA could only predict an intention that led to behavior when this behavior depended mainly on will. However, other resources may be needed when someone wishes to adopt a particular behavior, such as time, money, skills, or others. In such cases, the TRA would be insufficient. Ajzen thus proposed the TPB, which, besides attitude and subjective norms, would consider another construct related to the estimation of the extent to which the individual is capable of exercising control over the behavior in question (Ajzen, 1985).

The TPB involves attitude, subjective norms, perceived behavior control (PBC), and their respective beliefs. This way, "attitude (e.g., personal motivation), social norms (e.g., being encouraged or discouraged by relevant others), and perceived behavioral control (e.g., feeling of one's ability to make a difference)" (Overstreet et al., 2013, p. 937) are constructs that influence intention and behavior. Regarding healthcare academic papers, particularly those about adopting preventive innovations related to vaccination, previous studies indicate that trust in authorities has a significant role in predicting adherence to health protection behaviors (Carfora et al., 2019; Caso et al., 2019).

Therefore, in this study, we propose a model to evaluate mask adoption by the general population bringing together constructs from the TPB and trust in authorities. The constructs' definition and the proposed hypotheses' discussion are presented in the following sections.

Constructs definitions and proposed hypotheses

Attitude towards behavior (ATT). Attitude is a person's assessment of a behavior performance (Ajzen, 2002), reflecting beliefs about the possible consequences of behavior outcomes (McEachan, Conner, Taylor, & Lawton, 2011). That is, attitude is a positive or negative assessment of an individual's behavior (Giles, McClenahan, Cairns, & Mallet, 2004). Generally, more favorable attitudes towards a behavior should generate a stronger intention to perform the behavior under scrutiny (Ajzen, 1991).

As it occurs with the other constructs of the TPB, attitude towards a behavior is based on certain beliefs about a particular behavior. For each attitude-related belief, there is an outcome or attribute that has positive or negative value to a person. For instance, a behavior might be someone going on a diet, and possible outcomes might be losing weight, improving one's blood pressure, and restricting one's range of foods. A person will evaluate the outcomes (both negative and positive), and the result of this individual's evaluation will influence that person's attitude concerning that behavior (Ajzen, 1985).

Attitude is a construct that has been applied in healthcare to help explain the adoption of certain preventive behaviors, such as the adoption of AIDS education classes in high school, the adoption

of hormone replacement therapy for menopausal issues, and the adoption of physical activity routine by mothers (Seegar et al., 2006).

Some studies suggest that attitude might show a negative (even if only slightly) synergy with subjective norms. Thus, solid subjective norms might indicate more negative attitudes towards preventive behavior. This has been mainly observed when preventive behavior is already established in society, such as quitting smoking or the need for childhood vaccines. However, when a preventive behavior is genuinely innovative, there is no attitude or subjective norm already in place (Overstreet et al., 2013), and those constructs (attitude and subjective norms) can have a positive synergy (Caso et al., 2019).

Overstreet, Cegielski, and Hall (2013) examined the TPB constructs' effectiveness in predicting the adoption of preventive innovations in 63 studies since the literature suggests significant differences in the adoption rate of traditional versus preventive innovations. The authors found support in their hypothesis that attitude is positively related to the adoption of preventive innovations. Tao et al. (2020) also found support for that hypothesis in 22 papers after conducting a systematic literature review to synthesize studies focused on user acceptance of consumer-oriented health information technologies.

Particularly in the field of new types of vaccination, which can be considered a preventive innovation when applying the TPB (Ajzen, 1991; Rogers, 2002; 2003), various studies have suggested the positive relationship between attitude and people's intention to receive new types of vaccination, or to vaccinate their children (Caso et al., 2019; Catalano et al., 2017; Zimet, Liddon, Rosenthal, Lazcano-Ponce, & Allen, 2006).

Additionally, studies conducted in the last few decades have found that attitude has a significant effect on both the intention to adopt and the continued intention to adopt an innovation (Bhattacherjee & Premkumar, 2004; Hsu, Yen, Chiu, & Chang, 2006; Karahanna, Straub, & Chervany, 1999; Lee, 2010). Therefore, the following hypotheses are proposed:

> **Hypothesis 1a.** Attitude (ATT) is positively related to the intention to adopt (ITA) masks to prevent COVID-19 infections.

> **Hypothesis 1b.** Attitude (ATT) is positively related to the continued intention to use (CIU) masks to prevent COVID-19 infections.

Subjective norms (SNO). Subjective norms refer to the normative beliefs about other people's expectations (Ajzen, 1991). It is thus a function of beliefs, as is an attitude, but in this case, the beliefs have a different meaning. Normative beliefs refer to the social pressure that motivates a person to comply with the performance of a determined behavior. Conversely, if this person's groups of reference are against the performance of a behavior, a person is motivated to avoid the adoption of such behavior (Ajzen, 1985). Therefore, a person might be influenced while exchanging information with relatives, friends, health professionals, colleagues, and peers (Hasan, Lowe, & Petrovici, 2018; Venkatesh & Davis, 2000). Studies suggest that such logic applies to influential information regarding health issues and the adoption of health innovations. That is

why healthcare researchers, practitioners, and health institutions consider it valuable to understand the impact of these external forces in incentivizing or inhibiting the adoption of health-related innovations (Bettiga, Lamberti, & Lettieri, 2020).

Ajzen and Madden (1986), when developing the TPB model, predicted that subjective norms "contribute to the attitude towards the behavior in direct proportion to the strength of the belief" (Ajzen & Madden, 1986, p. 455). Numerous works later tested and validated that prediction (Conner, 2020). In healthcare studies, attitude and subjective norms have also shown positive relationships (Caso et al., 2019).

Some scholars who applied the TPB model to evaluate preventive health innovations have found support pointing to the critical role of subjective norms to explain, for instance, people's intention to receive HPV vaccination or parents' decision towards vaccinating their children (Caso et al., 2019). Additionally, in their meta-analysis study, Overstreet et al. (2013) also found support for their hypothesis that subjective norms are positively related to the intention to adopt a preventive innovation. Tao et al. (2020) found similar results across 18 papers.

Analyzing the adoption of innovations in the educational sector, Lee (2010) encountered studies that adopted TPB and found support for the hypothesis that subjective norms can help explain and predict the users' intentions to continue using the innovation under analysis. Therefore, the authors propose the following hypotheses:

Hypothesis 2a. Subjective norm (SNO) is positively related to the attitude (ATT) towards using masks to prevent COVID-19 infections.

Hypothesis 2b. Subjective norm (SNO) is positively related to the intention to adopt (ITA) masks to prevent COVID-19 infections.

Hypothesis 2c. Subjective norm (SNO) is positively related to the continued intention to use (CIU) masks to prevent COVID-19 infections.

Perceived behavior control (PBC). Perceived behavior control refers to a person's perception of how easy or difficult it is to engage in a particular behavior and the confidence to perform such behavior (Ajzen, 1991). Therefore, PBC is necessary to form the intention to adopt a specific behavior (Hasan et al., 2018), even if insufficient. A person must believe they can perform a behavior (McEachan et al., 2011), but they also must be inclined to adopt such behavior. Hence, PBC interacts with attitude and subjective norms to form the intent to adopt a behavior. PBC will be relevant when the predicted behavior is not under complete volitional control (in this case, one could adopt TRA instead of TPB). Additionally, the person's perceptions of their control should have at least some degree of accuracy (Ajzen, 1985).

The TPB model predicted that PBC contributes to the attitude towards behavior (Ajzen & Madden, 1986). The model has been tested, and this relation has been validated by various studies, as shown by Conner (2020). Ajzen and Madden (1986) also predicted that PBC has an

"independent effect on behavioral intention" (Ajzen & Madden, 1986, p. 458). Tao et al. (2020) found support for this theory through a comprehensive meta-analysis.

Overstreet et al. (2013) found support for the hypothesis that PBC influences the adoption of behaviors in the specific case of preventive innovations, suggesting that PBC can be increased by clear training and explaining how the behavior can prevent negative consequences. Further, "the training should focus on how the adopter can affect a positive outcome through appropriate behaviors. Through training, anxiety about the difficulty of the task can be reduced" (Overstreet et al., 2013, p. 942).

Caso, Carfora, Starace, and Conner (2019) suggest that PBC is a relevant predictor of mothers' intention to vaccinate their children against HPV. Finally, studies have indicated that PBC positively relates to the continued intention to adopt a determined behavior (Hsu et al., 2006; Lee, 2010). Considering the pieces of evidence exposed, we propose:

>   **Hypothesis 3a.** Perceived behavior control (PBC) is positively related to attitude (ATT) towards using masks to prevent COVID-19 infections.

>   **Hypothesis 3b.** Perceived behavior control (PBC) is positively related to the intention to adopt (ITA) masks to prevent COVID-19 infections.

>   **Hypothesis 3c.** Perceived behavior control (PBC) is positively related to the continued intention to use (CIU) masks to prevent COVID-19 infections.

Trust in authorities (TIA). Trust in authorities has been reported to have a predictive role in individuals' decisions when they consider information and directives of food authorities, health authorities, and government authorities to explain the adoption of certain behaviors (Carfora et al., 2019; Cembalo et al., 2019; Giampietri, Verneau, Giudice, Carfora, & Finco, 2018; Nuttavuthisit & Thøgersen, 2017), particularly in the case of health-related preventive behaviors (Caso et al., 2019; Prati, Pietrantoni, & Zani, 2011).

Government has an important role when it comes to trust in authorities. In such cases, trust is more related to 'system trust' than personal relationships among individuals (Carfora et al., 2019). In the last few years, numerous studies in healthcare have reported that trust is positively related to the intention to adopt preventive behaviors (Caso et al., 2019). Therefore:

>   **Hypothesis 4.** Trust in authorities (TIA) is positively related to the intention to adopt (ITA) masks to prevent COVID-19 infections.

Intention to adopt (ITA). When an individual intends to adopt a specific behavior, there is an indication that they are willing to perform such behavior (Tao et al., 2020). So, the intention is assumed to be the antecedent of behavior (Ajzen, 2002). Typically, "the stronger the intention to engage in a behavior, the more likely should be its performance" (Ajzen, 1991, p. 181).

According to this theory, intentions control actions, even though not all intentions will necessarily be carried out and become behaviors. For instance, when circumstances change, an intention might be abandoned, and a person might never perform that particular behavior. The longer the interval between intention and behavior performance, the less accurate the prediction is (Ajzen, 1985).

Studies generally suggest that intention is positively related to actual use, finding support for such a hypothesis (Overstreet et al., 2013; Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh, Thong, & Xu, 2012). Therefore, we propose the following:

   Hypothesis 5. Intention to adopt (ITA) is positively related to the actual use (AUS) of masks to prevent COVID-19 infections.

Figure 1 shows the study's proposed model, and its relationships and correlated hypotheses are discussed in more detail next.
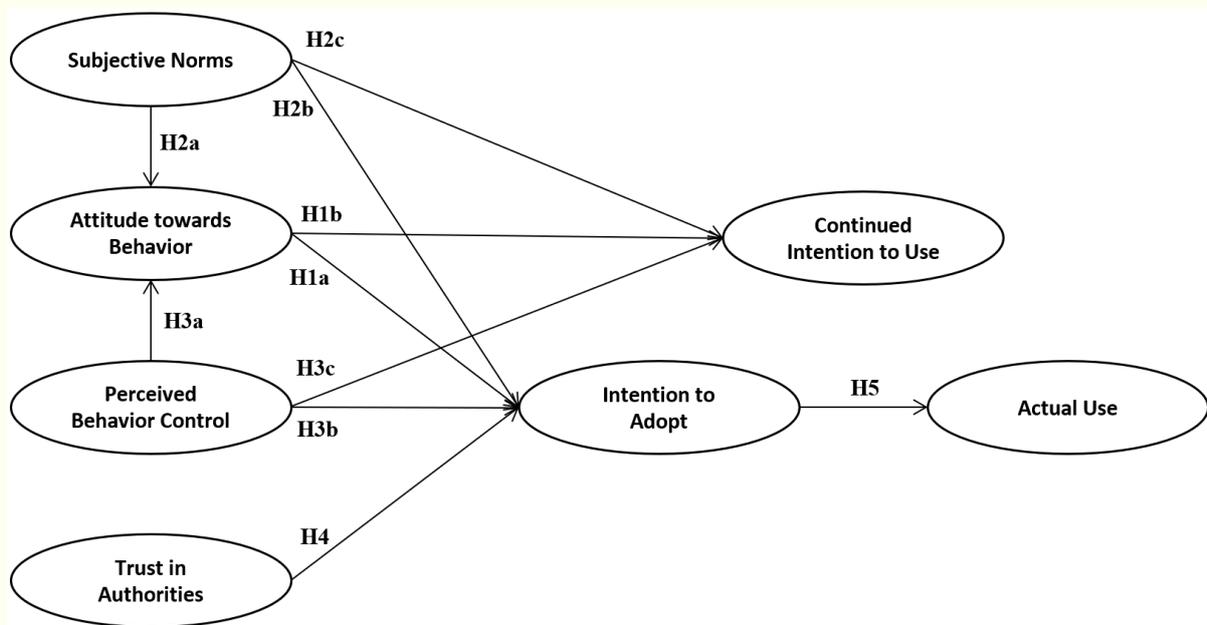
Figure 1. The conceptual model with the study's hypotheses.
Source: Elaborated by the authors.

METHODOLOGY

The study applied a cross-sectional survey to a non-probabilistic sample, administering a structured questionnaire to the sample population. The selected method could be applied to any preventive innovation in healthcare. However, the authors elected to evaluate the adoption of facial masks due to their relevance during the COVID-19 pandemic. Such a theme is particularly pertinent in Brazil, where the adoption of masks has become highly controversial (Carvalho & Teixeira, 2020).

The scales adopted in this study were selected according to their adherence to the survey's constructs. From the thirty items of the questionnaire, twenty-three measured the proposed model's constructs (attitude, subjective norms, PBC, trust in authorities, intention to adopt, actual use, and continued intention to use). Seven additional questions were included to cover demographics and other general areas of interest.

For the constructs, the study used the following scales: for attitude towards behavior (ATT), perceived behavior control (PBC), and trust in authorities (TIA), the study adopted scales from Caso et al. (2019); for subjective norms (SNO), the authors adopted a scale found in Bettiga, Lamberti, and Lettieri (2020); for intention to adopt (ITA), the authors used a scale validated in Caldeira (2016); for actual use (AUS), a scale tested and validated by Venkatesh, Thong, and Xu (2012) was adopted; and finally, for continued intention to use (CIU), the authors used a scale from Lee (2010).

All items related to the constructs were measured on five-point Likert scales. For the scales that were initially developed in English (Bettiga et al., 2020; Caso et al., 2019; Lee, 2010; Venkatesh et al., 2012), the questionnaire was translated into Portuguese by three separate translators and was later back-translated into English by a fourth translator, guaranteeing its integrity.

To be easier to understand, the instrument was pre-tested twice, with minor wording and formatting changes in two constructs: trust in authorities and continued intention to use. The first pre-test was applied to 12 respondents, and the second to 42 respondents.

The final survey took place for two weeks in September 2020. At that moment, approximately five months have elapsed since most of the Brazilian population began wearing masks, initially following recommendations from health professionals and media vehicles, later being forced by local authorities. Considering that, at the time of the data collection, the use of facial masks was mandatory in almost all municipalities of Brazil and recommended by the Ministry of Health. The study's population was not limited to a specific geographical area within the country and could be associated with the whole Brazilian society.

Respondents' recruiting was performed initially by general invitations on social media (LinkedIn, WhatsApp, Facebook, Instagram) with a hyperlink to the self-administered questionnaire on Qualtrics online platform. Applying a 'snowball' strategy, the invitation encouraged the respondents to share the survey link with others to amplify its coverage and reach a broad sociodemographic sample. The participation was voluntary, and respondents' anonymity was guaranteed. The questionnaires included a short introductory explanation about the research's objectives and the usage of facial masks for disease prevention.

Despite several guidelines regarding minimum sample sizes for SEM (Wolf, Harrington, Clark, & Miller, 2013), no simple rule of thumb works across all studies (Kline, 2016). Some simplified ratios of observations per variable or estimated parameter, varying from 5:1 to 20:1, are usually suggested. Still, the minimum sample size for a particular SEM model should consider some aspects, including the model complexity and the communalities (average variance extracted among items) in each factor. Hair, Black, Babin, and Anderson (2019) suggested 150 as the

minimum sample size for models with up to seven constructs (like the one we are testing), modest communalities (0.5), and no under-identified constructs. If the communalities are lower (below 0.45) or if there are up to three under-identified constructs, the minimum sample size raises to 300.

Data collection lasted two weeks, and a total of 353 answers were received. Conditions for validation included a 100% response rate for the construct items and other consistency checks, as recommended in research of this kind. After these checks, 40 questionnaires were discarded due to incomplete responses (95%) or inconsistent answers (5%). Hence, 313 responses were considered valid for further statistical analyses.

Data were treated and analyzed using software IBM® SPSS® Statistics version 23 to perform descriptive analyses, and IBM® SPSS® Amos version 23 to test the measurement and the structural models through confirmatory factor analysis/structural equations modeling (CFA/SEM).

RESULTS

Valid answers came from 13 out of the 27 Brazilian states, being Rio de Janeiro (54.0%), Bahia (21.1%), São Paulo (9.3%), Minas Gerais (6.7%), Santa Catarina, and Federal District (2.6% each) the most representative ones. Approximately 99% of respondents reported that they had used masks or were still using masks during the COVID-19 pandemic. Respondents' ages ranged from 15 to 66 years (mean of 32.6 and standard deviation of 12.6 years). Most of them have a higher educational level: 65.2% are undergraduate, 24.3% have a master's or Ph.D. degree, 9.9% only finished high school, and 0.6% only finished elementary school.

Test for common method bias

Relationships among variables and constructs are influenced by the data collection method. Using information from a single source (the respondent) for both independent and dependent variables could generate common method bias (CMB). Harmon's one-factor test was applied to assess such a risk (Podsakoff & Organ, 1986), resulting in seven factors with eigenvalues above 1.0 and with no single factor explaining most of the variance: the factor with the most substantial influence corresponds to only 36.4% of the total. The results suggest that CMB is not a problem in the collected data.

Measurement model

A confirmatory factor analysis (CFA) was performed to test the validity, dimensionality, and reliability of the scales employed in the model. After iterations for model refining, results for the measurement model reached satisfactory fit indexes while maintaining at least three items per construct, avoiding under-identification in any of them. The final 21-item measurement model (after the exclusion of two items during the refinement process) presented the following indexes: $\chi2 = 449.175$ and df = 165 (p < 0.001); IFI = 0.92; TLI = 0.90; CFI = 0.92; RMSEA = 0.074;

χ2/df = 2.722. Such results suggest a good fit between the study's proposed measurement model and the data collected (Hair, Black, Babin, & Anderson, 2019; Hu & Bentler, 1999).

The constructs' face validity was reached by: (a) using scales already developed, tested, and used in similar areas of research (i.e., public health); (b) observing best practices from literature in the translation process; and (c) applying two pre-tests before releasing the final instrument to respondents. Previous literature reviews (e.g., Carfora et al., 2019; Overstreet et al., 2013; Tao et al., 2020) in public health, health care, marketing, and preventive innovations studies predicted positive correlations among the employed constructs. Table 1 shows positive correlations in all cases, indicating nomological validity (Hair et al., 2019).

Table 1

Correlation matrix of constructs

	SNO	ATT	PBC	CIU	AUS	TIA	ITA
SNO	**0.62**	0.45	0.53	0.31	0.34	0.37	0.51
ATT	0.20	**0.72**	0.88	0.37	0.36	0.46	0.62
PBC	0.28	0.77	**0.40**	0.49	0.52	0.60	0.77
CIU	0.10	0.14	0.24	**0.58**	0.37	0.29	0.48
AUS	0.11	0.13	0.27	0.14	**0.66**	0.46	0.50
TIA	0.14	0.21	0.36	0.08	0.21	**0.55**	0.55
ITA	0.26	0.38	0.59	0.23	0.25	0.30	**0.68**

Note. AVE on diagonal; correlations above and squared correlations below main diagonal. SNO (Subjective Norms); ATT (Attitude); PBC (Perceived Behavior Control); CIU (Continued Intention to Use); AUS (Actual Use); TIA (Trust in Authorities); ITA (Intention to Adopt). Source: Elaborated by the authors.

To measure the variables' fit to the model proposed in this study, convergent validity and reliability were further examined for each construct. Table 2 presents results for construct reliability (CR), average variance extracted (AVE), Cronbach's alpha coefficients, and descriptive statistics (mean and standard deviation).

Table 2

Validity indexes and descriptive statistics of the study's constructs

Construct	Composite reliability	Cronbach's alpha	Avg. variance extracted (AVE)	Mean	Standard deviation
SNO	0.83	0.81	0.62	4.49	0.83
ATT	0.88	0.89	0.72	4.53	0.82
PBC	0.65	0.66	0.40	4.58	0.66
CIU	0.80	0.77	0.58	4.93	0.28
AUS	0.85	0.82	0.66	3.84	1.14
TIA	0.78	0.77	0.55	3.90	1.05
ITA	0.86	0.85	0.68	4.70	0.71

Note. SNO (Subjective Norms); ATT (Attitude); PBC (Perceived Behavior Control); CIU (Continued Intention to Use); AUS (Actual Use); TIA (Trust in Authorities); ITA (Intention to Adopt). Source: Elaborated by the authors.

Reliability tests for each construct reached the minimum required thresholds (CRs and alphas higher than 0.7), indicating consistency and reliability among items within each construct (Hair et al., 2019), except for PBC, which presented a CR value below 0.7 (0.65). Regarding convergent validity, all constructs but PBC reached the minimal value of 0.5 in average variance extracted (AVE) suggested by Fornell and Larcker (1981). AVE is critical for structural equation modeling (SEM) since it expresses the average variance in items explained by the model's constructs. Nonetheless, although PBC has an AVE below the 0.5 desired threshold, an AVE with less than 0.5 (at least 0.4) coupled with a CR above 0.6 (PBC's CR is 0.65) can still be considered adequate in terms of convergent validity (Fornell & Larcker, 1981). Other studies have adopted such standards (Cheung & Wang, 2017; Huang, Wang, Wu, & Wang, 2013).

Discriminant validity of the latent constructs was also assessed through the measurement model results. According to Fornell and Larcker (1981), constructs achieve discriminant validity when all the AVEs are higher than the corresponding squared inter-construct correlations with the other constructs present in the model. Table 1 presents the AVE value for each construct in the main diagonal and the squared correlation coefficients between each pair of constructs in the cells below the main diagonal.

The table shows that almost all shared variances are lower than the variance extracted by the items measuring the constructs, except the pairs PBC/ATT and PBC/ITA. Given those exceptions to Fornell and Larcker's (1981) criteria, we performed an additional test to ensure discriminant validity as indicated by Anderson and Gerbing (1988): for each problematic pair of constructs (PBC/ATT and PBC/ITA), we calculated the difference between the original model with correlations allowed to be free, and one constrained model that fixed each problematic correlation to unity (i.e., perfectly correlated). All cases showed that statistically significant and lower χ^2 values were found for the unconstrained models, providing evidence that discriminant validity was achieved for PBC, ATT, and ITA.

The validation tests on the measurement model achieved satisfactory results, allowing advancing to estimate the study's structural model to test the proposed hypotheses.

Additionally, Table 2 shows that, except for PBC, most of the average variance extracted among items in each factor has values between 0.55 and 0.72, indicating modest to good communalities. This, together with the fact that none of the seven constructs of the model is under-identified, validates the sample size used since it exceeds the minimum suggested by Hair et al. (2019).

Structural model

Structural equation modeling (SEM) was used to test the proposed model and the study's hypotheses. SEM verifies the model's fit to the collected data and the significance levels for the hypothesized relationships between the study's constructs, attesting their potential veracity or not (Byrne, 2016). Applying the proposed model to the collected data generated indexes that indicate a good fit between model and data (Hair et al., 2019; Hu & Bentler, 1999): χ^2 = 458.749, with df = 166, generating a χ^2/df ratio of 2.764. Additionally, IFI = 0.92, TLI = 0.90, CFI = 0.92, and RMSEA = 0.075.

Estimated path coefficients were verified to validate the study's hypotheses in terms of significance, magnitude, and direction (Byrne, 2016). Figure 2 and Table 3 show that all tested relationships were significant. Finally, the total variance explained for each of the four dependent variables of the model was: 70% for ATT, 83% for ITA, 30% for AUS, and 29% for CIU.
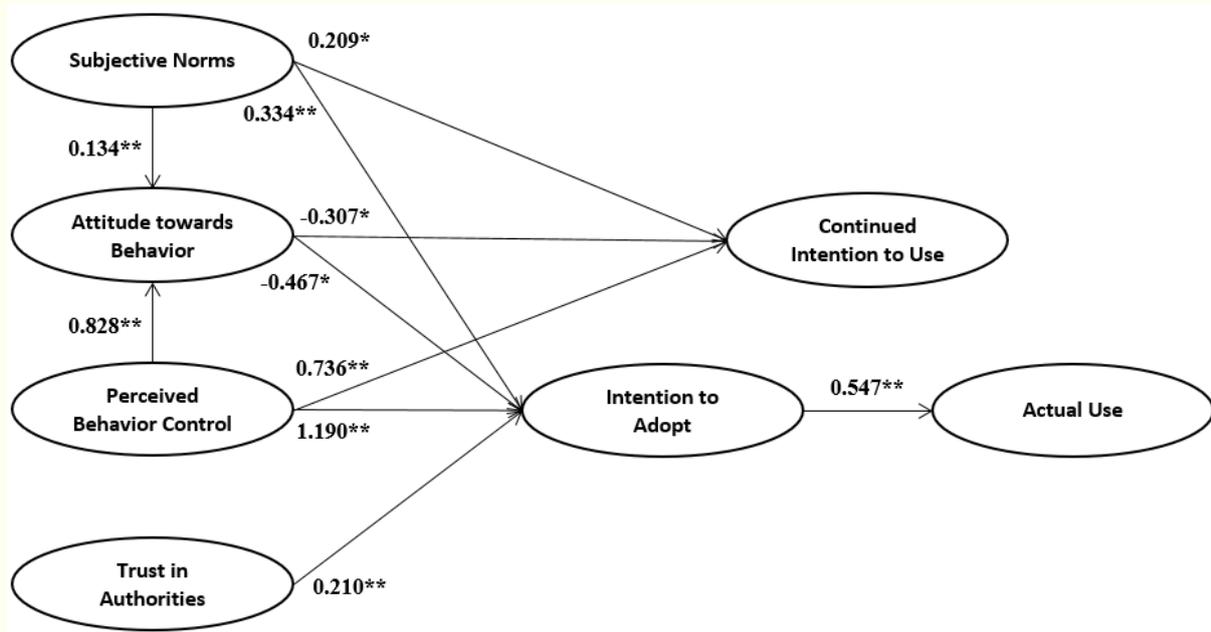
Figure 2. Standardized path coefficients for the study's proposed model.
Note. * p < 0.05, ** p < 0.01. Source: Elaborated by the authors.

Table 3

Hypotheses, standardized path coefficients, and significances

Hypotheses	Standardized path coef.	p-Value	Hypothesis supported
H1a: Attitude towards behavior → Intention to adopt	-0.467	0.023	No
H1b: Attitude towards behavior → Continued intention to use	-0.307	0.038	No
H2a: Subjective norm → Attitude towards behavior	0.134	<0.001	Yes
H2b: Subjective norm → Intention to adopt	0.334	<0.001	Yes
H2c: Subjective norm → Continued intention to use	0.209	0.003	Yes
H3a: Perceived behavioral control → Attitude towards behavior	0.828	<0.001	Yes
H3b: Perceived behavioral control → Intention to adopt	1.19	<0.001	Yes
H3c: Perceived behavioral control → Continued intention to use	0.736	<0.001	Yes
H4: Trust in authorities → Intention to adopt	0.21	<0.001	Yes
H5: Intention to adopt → Actual use	0.547	<0.001	Yes

Note. Source: Elaborated by the authors.

DISCUSSION

This study aims to explore the determinants of the intention to adopt, the actual use, and the continued intention to use facial masks for COVID-19 prevention in Brazil. Thus, it tested whether there would be positive relationships between some constructs, as specified in the hypotheses shown in Figure 1. As stated in Table 3, except for H1a and H1b, the other hypotheses were statistically supported. That is, except for attitude, the constructs analyzed have a significant and positive influence on intention to adopt, actual use, and continued intention to use.

Even though they were statistically significant, H1a and H1b were not supported because the relationships between attitude and intention to adopt, and between attitude and continued intention to use, were negative instead of positive, contradicting the theoretical background and the hypotheses concerning attitude (Caso et al., 2019; Catalano et al., 2017; Seegar et al., 2006). However, according to Fishbein and Ajzen (1975), attitude can positively or negatively impact the intention to adopt a specific behavior and the behavior itself. A recent study about attitudes towards a machine learning system found a negative relation from most respondents, also contradicting literature on the subject (Azman et al., 2020). However, the authors did not find similar results within the theme adopted in this study. Considering the global pandemic context and the controversy regarding mass masking (Naveed et al., 2020), including in Brazil (Amaral et al., 2021), the authors believe perhaps contradictory information about mass masking (Gehrke & Benetti, 2021) and the lack of information about the effectiveness of mass masking to control the contamination of COVID-19 (Fodjo et al., 2020; Sheluchin et al., 2020) might have impacted respondents' attitude towards the intention to adopt masks. The authors also believe this might impact the future usage of masks after it is no longer mandatory in Brazil.

The present study also suggests that subjective norms positively influenced users' attitude (H2a), intention to adopt masks (H2b), and continued intention to use masks (H2c). This is aligned with the theory and with the results of recent studies involving the COVID-19 pandemic (Barile et al., 2021; Gaube, Fischer, & Lermer, 2021; Trifiletti, Shamloo, Faccini, & Zaka, 2021; Wollast, Schmitz, Bigot, & Luminet, 2021). Despite at least one divergent result in a recent study (Pan & Liu, 2022), a meta-analysis covering 83 papers about TPB and COVID-19 confirmed subjective norms as a significant predictor of both behavioral intention and behavior (Fischer & Karl, 2022). Subjective norms are influenced by normative beliefs considering the expectations of relatives, friends, and peers (Ajzen & Madden, 1986). Therefore, people might be influenced to perform a determined behavior to comply with others' expectations, reflecting social pressure (McEachan et al., 2011). Health professionals, health authorities, and other health specialists could be forces promoting/inhibiting the adoption of health innovations (Bettiga et al., 2020), including mass masking. Our results suggest that media and health institutions' recommendations regarding mass masking (Kvalsvig et al., 2020) served as a social pressure on users' intentions and actual adoption of the mask and its continued usage.

In the case of H3a, H3b, and H3c, the study found a positive relationship between perceived behavior control and attitude, intention to adopt, and continued intention to use, aligned with the literature. Perceived behavior control was an extension of Ajzen's theory as an additional determinant of intention and behavior, successfully tested and validated in numerous studies and

various settings (Venkatesh et al., 2003). In their recent meta-analysis, Fischer and Karl (2022) identified PBC as having a substantial effect on intentions and behaviors to protect individuals and communities and help them deal with the COVID-19 pandemic (Fischer & Karl, 2022). Hasan, Lowe, and Petrovici (2018) highlight that when the user faces constraints in using any innovation, PBC should have even a significant influence, as this study also suggests. However, even though the effectiveness of mask usage is still debated, and people can be exposed to confusing information from different sources (Tang, 2020), the correct form to use masks (covering the nose and mouth) has been disseminated in Brazil objectively and clearly by Brazilian health authorities and institutions (Ministério da Saúde, 2020; Taniguchi, 2020). Therefore, it seems logical that users' perceived behavioral control is significantly and positively related to users' intention to adopt masks, actual mask use, and continued intention to use them.

Results also support H4, which establishes that trust in authorities has a positive and significant impact on Brazilian users' intention to adopt masks usage. Other studies reached similar results when analyzing the impact of trust in authorities in the willingness to adopt preventive innovations, such as hand washing, social distance, and vaccine during the 2009 H1N1 outbreak (Caso et al., 2019) or vaccines to prevent HPV (Prati et al., 2011). Another study with 13,426 respondents from 19 countries showed that people with higher levels of trust in information from government sources were more likely to accept a COVID-19 vaccine (Lazarus et al., 2021). Trust is believed to significantly impact both the intention to adopt a particular behavior and its actual adoption (Menozzi, Halawany-Darson, Mora, & Giraud, 2015). There was some controversy regarding mask usage in Brazil (Carvalho & Teixeira, 2020). However, health institutions and authorities made mass masking mandatory, including at the federal level (Library of Congress, 2020).

Finally, H5, which predicted a positive relationship between intention to adopt mask usage and its actual use, was supported. Users who intended to adopt a determined behavior usually ended up using it if their experience showed it could prevent an unwanted consequence (Rogers, 2003). The same positive relationship between behavioral intention and actual behavior was found in recent studies done in Western societies about innovative behaviors to prevent COVID-19 infections, like frequent hand hygiene and social distancing (Gaube et al., 2021; Trifiletti et al., 2021), and the use of face coverings (Barile et al., 2021). In Brazil, despite initial controversial information regarding the efficacy of mask usage (Carvalho & Teixeira, 2020; Oliveira et al., 2020), most of the population adopted this practice (Fernandes, Riguetti, & Kirsztajn, 2021).

FINAL CONSIDERATIONS AND FUTURE STUDIES

Despite the possibility of avoiding unwanted events (Bertrand, 2004), preventive innovations are commonly undervalued because of users' difficulty in perceiving the absence of events (Rogers, 2003). For instance, if someone avoids being infected with COVID-19 because of the adoption of masks, this person might never know their reward for wearing masks constantly. Such context is aggravated by the fact that mask usage effectiveness against COVID-19 is still controversial (Naveed et al., 2020), besides the lack of conclusive studies (Sheluchin et al., 2020). Our research offers a theoretical contribution by proposing and testing an original model to evaluate the

adoption of a preventive innovation. Despite their importance (Rogers, 2003), there aren't many studies focused on preventive innovations (Overstreet et al., 2013) and even fewer works that study preventive non-technological innovations (Tao et al., 2020).

Additionally, this study further validates the theory of planned behavior, with trust in authorities as a significant construct. Trust is a construct in itself complex, including in marketing studies (Johnson & Grayson, 2005), and can have even different nuances depending on the context (Carfora et al., 2019; Caso et al., 2019; Goel, Bell, & Pierce, 2005). In specific healthcare settings, considering the relationship between patient and healthcare professional, trust is defined as "the patient's confidence that the physician and the emergency department staff will do what is in the patients' best interests" (Kelly, Njuki, Lane, & McKinley, 2005, p. 147). Trust in authorities also has specific characteristics and challenges (Carfora et al., 2019). For instance, trust in authorities can relevantly impact economic recovery, citizens' compliance with rules, regulations, and institutions' decision-making (Organisation for Economic Co-operation and Development [OECD], 2013). Regarding specifically trust in authorities in COVID-19 settings, some studies have already analyzed how the population reacts to their governments' rules and guidance (Almutairi, BaniMustafa, Alessa, Almutairi, & Almaleh, 2020; Lohiniva, Sane, Sibenberg, Puumalainen, & Salminen, 2020). Our study contributes by adding an analysis of people's trust in Brazilian health authorities about mask usage policies.

Other relevant constructs not usually found in Ajzen's TPB model (Ajzen, 1985; 1991; 2002) are actual use and continued intention to use a determined service or good. In its most specific context, actual use means effectively adopting a particular behavior (Averweg, 2008; Davis, Bagozzi, & Warshaw, 1989). Continued intention to use is different from initial use since the user is revisiting a specific experience based not on peers' suggestions and recommendations but more on their own experiences with and evaluation of a particular service or good (Lee & Choi, 2013; Tawafak, Romli, & Arshah, 2018). In the context of COVID-19, mass masking has been recommended by many health authorities (Kvalsvig et al., 2020) and, despite some criticism towards its effectiveness (Sheluchin et al., 2020), it is considered an essential tool against the disease (Kvalsvig et al., 2020). Considering this context, besides knowing people's intention to adopt masks, it is crucial to understand if they are actually using and if they plan to keep using them.

The main limitation of this study refers to the respondents themselves. Even though mass masking was implemented in Brazil as a whole (Library of Congress, 2020) — while regulations varied from city to city (U.S. Embassy & Consulates in Brazil, 2020) — the present study is based on 313 respondents, and approximately half of them were from Rio de Janeiro state. Therefore, the authors suggest further studies focused on mask usage with a broader sample and increased participation of people from other regions of Brazil. Future studies could, for instance, compare mask usage in different cities, states, and regions in Brazil and check if trust in health authorities changes across the country. An exciting study might analyze the various sources of social pressure that might influence the usage of masks (social media, journalistic articles, health institutions, celebrities, etc.). Another study should focus on masks usage by Brazilians after they are no longer mandatory. Considering the context of a global pandemic, the authors also suggest applying the

proposed model in other countries. Additionally, the authors suggest more studies evaluating the adoption of other non-technological preventive innovations.

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