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ORIGINAL ARTICLE

An assessment of the health belief model (HBM) properties as predictors of COVID-19 preventive behaviour

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Abstract

Background Public participation in preventive efforts is crucial in preventing infection and reducing mortality attributed to infectious diseases. The health belief model (HBM) suggests that individuals will likely participate in these efforts when experiencing a personal threat or risk, but only if the benefits of acting outweigh the risk or perceived barriers.

Methods The current study explores the properties of the HBM as predictors of the public's compliance with COVID-19 preventive behaviour. Quantitative data on HBM properties, COVID-19 preventive behaviour, socioeconomic (SES) and demographic characteristics were collected from a sample of 674 adults in Hamburg, Germany. Binary logistic regression was computed to examine the effect of the properties of HBM on COVID-19 vaccination. Multiple linear regression was calculated to investigate the impacts of HBM properties on the likelihood of participants' face mask usage as a protective measure against COVID-19 infection.

Results The logistic regression model was statistically significant, $X^2(13) = 149.096$, $p < .001$. The specificity and sensitivity for the model is 58.1% and 99.4%, respectively. Similarly, the multiple regression model results showed a good fit for the data. $F(13, 650) = 17.093$, $p < .001$, and adjusted $R^2 = .240$, suggesting that HBM properties predict face mask usage.

Conclusion This study's findings provide robust evidence to recommend that the concerned public health professionals consider individuals' health beliefs when designing an effective COVID-19 preventive programme. Public health messaging should consider highlighting the benefits of preventive actions and the potential lethality of COVID-19 to evoke an individual's appropriate concern.

Keywords Health belief model · COVID-19 · Face mask · Socioeconomic Status · Cue for action

Background

Individual participation in preventive efforts is crucial in containing the spread of infection and reducing mortality attributed to infectious diseases such as the COVID-19 pandemic. However, adherence to preventive behaviour depends mainly on individual perception of the risk and benefits of such behaviour (Baek et al. 2022). This hypothesis is further supported by the health belief model (HBM) (Rosenstock 1974; Rosenstock et al. 1988). The HBM suggests that individuals will likely act when experiencing a personal threat or risk, but only if the benefits of acting outweigh the actual or perceived barriers or threats. This model (as presented in Fig. 1 below) consists of six constructs that cover perceived susceptibility (i.e. a subjective evaluation of contracting the disease), perceived severity (i.e. a subjective evaluation of the severity of the disease), perceived benefits (i.e., positive outcomes of practising recommended interventions), cues to action (i.e. stimuli that trigger the decision-making process to undertake the necessary interventions), perceived barriers (i.e. the degree to which people think taking the advised health action will be challenging or have adverse consequences), and self-efficacy (i.e. the level of confidence an individual has in performing recommended health interventions) (Rosenstock 1974; Rosenstock et al. 1988).

The COVID-19 pandemic poses an enormous negative impact on health and the economy worldwide. The practical

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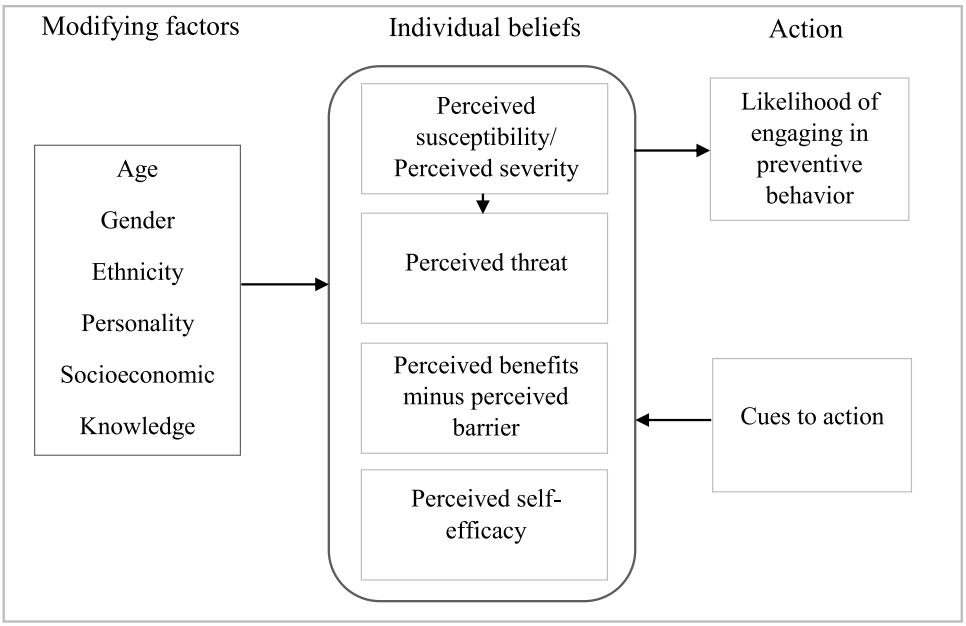

Fig. 1 Health belief model (Adapted from (Rosenstock 1974))

effects of the pandemic are evident in the shortage in food systems, increased public health problems, and the increased threat of extreme poverty due to economic and social disruption (World Health Organization 2020). To reduce these burdens, various health-promotive behaviours were implemented in Germany; this includes vaccination and wearing face masks in public spaces.

The vaccination process confers immunity to a large proportion of the population. Therefore, since the authorisation of the COVID-19 vaccine, there has been a mandate to increase vaccine acceptance, especially among those most vulnerable to the severe course of COVID-19 infections. Nevertheless, various research has contended that the rapid development of the vaccine is linked with vaccine hesitancy among Germans, primarily due to safety and efficacy concerns (Fiske et al. 2022; Fobiwe et al. 2022). On the other hand, it is argued that the acceptance of the COVID-19 vaccine was influenced mainly by the possible health-related consequences of the COVID-19 virus (Bendau et al. 2021). Vaccine acceptance has been argued to substantially alter the pandemic course by decreasing morbidity and mortality (Haas et al. 2021; Meslé et al. 2021; Watson et al. 2022). However, recent studies suggest that vaccination alone is unlikely to stop the pandemic, thereby arguing the appropriateness of other precautionary measures such as wearing a face mask as effective for containing the virus spread (Gettings et al. 2021; Lyu and Wehby 2020; Sharif et al. 2021).

In the absence of vaccination, precautionary measures such as social distancing and face masking were employed as the primary means to contain COVID-19 outbreaks. These measures were gradually lifted as vaccination coverage increased, given their adverse effects on societal and economic functioning, as well as overall public well-being. Nevertheless, the resurgence of new daily infections indicates a need to reconsider the mandatory use of face masks, in conjunction with vaccination efforts, to effectively manage the ongoing pandemic and prevent potential future outbreaks.

A face mask is a covering worn on the face to shield it from coarse and fine droplets (Kinyili et al. 2022). Wearing a mask is believed to ensure that fewer SARS-CoV-2 particles are emitted into the surroundings by the infected person on the one hand while offering partial protection to the wearer on the other (Bartsch et al. 2022). Recent findings further suggest that a face mask is one of the most effective, fair and socially responsible strategies to mitigate the spread of the pandemic (Bearth and Siegrist 2022; Howard et al. 2021).

Although the multifaceted benefits of face masks are sufficiently known, the frequency and acceptance of wearing masks remain controversial among the general population due to the challenges posed by wearing face masks for long periods. According to recent studies, the most common reported hurdles to face mask adherence were physical and social discomfort, difficulty breathing, glasses fogging, financial reasons, headache, perioral dermatitis, facial itching and rash/irritation (Abid et al. 2022; Fikenzer et al. 2020; Scarano et al. 2020). Furthermore, face masks hindered face recognition and communication, both verbal and non-verbal, affecting emotional signalling, especially between teachers and students in educational facilities (Carbon 2020; Spitzer 2020).

Many people must adhere to focused behaviours to contain the pandemic. Howbeit, a considerable percentage of people in Germany remain unvaccinated against COVID-19

(Robert Koch Institut 2022). Similarly, the inconvenience and other side effects attributed to face mask usage have remained popular in social discourse among German adults (Carbon 2021; Niesert et al. 2021). From this point of view, an exploration of adherence to COVID-19 preventive measures is indispensable.

The HBM presents a behavioural framework that fits the trend in COVID-19 preventive behaviour. This social and psychological theoretical model may help understand the individual decision to adhere to COVID-19 preventive measures. For example, Barakat and Kasemy (2020) identified perceived susceptibility, benefits, barriers and self-efficacy as predictors of preventive behaviours. In another study, Karimy et al. (2021) found that the supposed advantages and disadvantages were significant predictors of COVID-19 preventive behaviours. A considerable number of other studies have also demonstrated that the properties of HBM are a crucial predictive component of preventative measures during the pandemic (Jadil and Ouzir 2021; Shmueli 2021; Zewdie et al. 2022).

In Germany, the influence of HBM properties on COVID-19 preventive behaviour is rarely investigated. Few available studies have focused on individual aspects, for example, risk perception, self-efficacy, and barriers, while others have explored socio-demographic predictors of adherence to protective measures (Lüdecke and Knesebeck 2020; Kojan et al. 2022; Mahdavian et al. 2022). There is, however, a lack of relevant knowledge in the collective about individuals' health beliefs regarding COVID-19 infection and preventive measures. The current study, therefore, focuses on investigating determinants that stimulate the public's compliance with vaccine and face mask behaviour using the HBM.

Methods

Quantitative data on HBM properties, COVID-19 preventive behaviour, socioeconomic (SES) and demographic characteristics were collected from a sample of adults in Hamburg, Germany. Participants in this study were persons between the ages of 19 and 59 years whose primary residence was in Hamburg during the fifth COVID-19 Pandemic wave (June 2022).

Procedure

Data were collected in Germany's second-most populous city, Hamburg. Online questionnaires were administered using the LimeSurvey Platform. The sample size was determined using Cochran's formula, n = (Z) 2 * (p)(1-p)/e2. An estimated prevalence of 77% was used based on data on the vaccine acceptance rate in Hamburg (Stand: 31. May 2022) (Robert Koch Institut 2022). A minimum sample of 272 was required for the current study. A convenience sampling technique was applied to select the participants; this active recruitment involved snowball sampling techniques. Information about the survey was shared on social media (e.g. Facebook, Twitter, and WhatsApp) and social and professional networks in Hamburg. All procedures were by the ethical standards of the institutional and national research committee and comparable ethical standards. Participants were required to provide informed consent before filling out the study questionnaire. Eight hundred fifteen respondents clicked the survey link; 674 completed the online questionnaire between 10 June and 30 June 2022. The questionnaire uses existing validated and reliable scales. The questionnaire was available in German and English.

Measures

Dependent variable

Participants' vaccine behaviour was assessed using a dichotomous measure that asked if the participant was vaccinated against COVID-19 (Kumari et al. 2021). face mask usage, on the other hand, was measured using the Face Mask Usage Scale (FMUS), which was adapted from the research conducted by Lam et al. (2020). FMUS employs six items to assess the usage of face masks in both self-protection and safeguarding others under three prevalent circumstances, namely 'public areas', 'clinics' and 'home'. The survey used a five-point response scale ('never', 'rarely', 'sometimes', 'frequently' and 'always'). This scale was utilized to gauge the frequency of face mask usage (FMU) practices. Scores were assigned to options in ascending order from 0 to 4. Subsequently, an additional option labeled 'not acceptable' was incorporated into response options of the present study. This addition was made in light of the prevailing circumstances during data collection, as mask-wearing policies were then only advised in specific area such as hospitals, trains and buses. None of the participant in the current study selected this option. The sum score for FMU ranges from 0 to 24, with a higher score indicating a high frequency of face mask usage. The sum score was used for the regression and correlation computations. Furthermore, the aggregate scores were then transformed into a standardised 0–100 scale in which 20 was taken as the percentile to allow for descriptive analysis. Scores 0–20 = never; 21–40 = rarely; 41–60 = sometimes; 61–80 = frequently; 81–100 = always. The Cronbach's alpha for the current sample was 0.74.

Independent variable

The properties of HBM were measured by assessing participants' perceptions of the model's seven subconstructs

(Rosenstock 1974). That is, perceived susceptibility, perceived severity, perceived threat, cues to action, perceived benefits, perceived barrier, and self-efficacy concerning the COVID-19 pandemic. All items were rated on a five-point Likert scale from 1 to 5.

Participants' *perceived susceptibility* and *perceived severity* to COVID-19 infection were measured with three items. The sum score ranged from 3 to 15. A higher score suggests higher perceived susceptibility/severity to COVID-19. The Cronbach's alpha for the current sample was 0.47 for perceived susceptibility and 0.83 for perceived severity. *The perceived threat* was measured with a single question: 'I engage in activities that I believe expose me to COVID-19 infection'. Higher scores indicate that participants have elevated perceptions of threats from COVID-19 infection. Participants' *cues to action* were assessed with four items. The sum score ranged from 4 to 20. Higher scores indicated great awareness of environmental cues for adopting COVID-19 preventive behaviour. The Cronbach's alpha for the current sample was 0.44. *The perceived barrier* was measured through three questions. A higher score indicated a more significant perceived barrier to engaging in preventive behaviour. The Cronbach's alpha for the current sample was 0.44. *The perceived benefit* was assessed primarily through two questions. Each core question was further divided into two parts to obtain insight into the targeted behaviour i.e. face mask and COVID-19 vaccination. The questionnaire covered the following concepts: (a) adopting preventive behaviours reduces stress in daily activities, and (b) adopting preventive behaviours protects against COVID-19 infection. All items were rated on a 5-point Likert scale. The higher score indicated the higher perceived benefits of implementing suggested preventative measures. The Cronbach's alpha for the current sample was 0.73. The final subconstruct of the model, known as *self-efficacy*, was measured using a single item measuring participants' perception of their capacity to carry out a task to shield themselves from COVID-19. Higher scores implied a greater likelihood of implementing the required interventions. The computed sum scores from these constructs were transformed into a standardised 0–100 scale in which 20 was taken as the percentile to form five categories: 1 (0–20)– very low, 2 (21–40)– low, 3 (41–60)– neutral, 4 (61–80)– high, 5 (81–100)– very high.

Covariates

Data on participants' age in years and gender in four categories (male/female/prefer not to say/other) were collected. Five education levels were used to evaluate educational attainment, which were later categorized as less than a bachelor's degree, bachelor's degree and master's or higher degree.

Statistical analysis

Descriptive statistics were presented using frequencies (n), percentages (%) for categorical variables, and mean with standard deviations (S.D.) for continuous variables. The bivariate correlation between outcome measures and HBM constructs was examined using Pearson's correlation coefficient. Based on Cohen's standard, the correlation was interpreted as r = 0 = no relationships; r = 0.10–0.29 = weak correlation; r = 0.30–0.49 = moderate correlation; and r = 0.50–1.0 = strong correlation (Cohen 1988). Binary logistic regression was computed to examine the effect of the properties of HBM on COVID-19 vaccination. This method uses odds ratios (OR) to measure association (Szumilas 2010). The adjusted odds ratio (AOR) with 95% confidence intervals (CI) was calculated to examine the strength and significance of the association between vaccine behaviour and multiple independent variables (i.e. HBM properties, age, gender and education). The Omnibus Tests of Model Coefficients is used to test the model fit of the logistic regression analysis. A p-value of <0.05 was considered statistically significant in the study. Multiple linear regression was performed to identify the predictors for masking behaviour. The F-test and R^2 were used to assess the model's fit to the data. The analysis treated face mask use as the dependent variable, HBM constructs as independent variables, and age, sex and education as covariates. The outcomes were considered statistically significant at <.05 and a CI of 95%. Data were analysed using IBM SPSS Statistics for Macintosh, version 28.0.

Results

Descriptive analysis shows that more than half of the participants were female, 382 (56.7%). The age of participants ranged from 19 to 59 years, with a mean of 31.20 years (SD = 10.86).

Among all surveyed, almost half of all respondents (47%) hold less than a bachelor's degree, while around 29.1% hold a bachelor's degree, which is around 5% more than those with a master's or higher degree. The socio-demographic characteristics of the surveyed respondents are presented in Table 1.

Descriptive distribution of participants' vaccine acceptance and face mask usage

Using a simple single item, an overwhelming 95% of participants reported receiving at least one shot of the COVID-19 vaccine. Data on face mask usage suggest that approximately 40% of participants always adhere to

Table 1 Frequency and percentage distribution of sample demographic features, vaccine and face mask usage

	Frequency (n)	Percentage (%)
Gender		
Male	266	39.5
Female	382	56.7
Prefer not to say	16	2.4
Other	10	1.5
Education		
Less than a bachelor's degree	317	47.0
Bachelor's degree	196	29.1
Master's or higher degree	161	23.9
Vaccine behaviour		
Vaccinated	641	95.1
Not vaccinated	33	4.9
Face mask usage		
Never	54	8.0
Rarely	76	11.3
Sometimes	168	24.9
Frequently	274	40.7
Always	102	15.1

frequently wearing face masks. Consequently, around 11% reported rarely wearing a mask, while 8% said to have never worn a face mask.

Descriptive percentage distribution of properties of HBM towards COVID-19

Approximately half of the participants reported high to very high perceived susceptibility to COVID-19 infection. At the same time, about 15% had low to very low susceptibility. Almost half (45.5%) of the participants believed that the severity of health problems caused by the SARS-CoV-2 virus was high or very high. Slightly more than two-fifths of respondents (42.6%) reported a high perceived threat of COVID-19, almost double the number of participants (20.8%) who responded with a low-risk perception. Nearly half of the participants indicated they have higher cues to undertake necessary measures (49.9%) to prevent COVID-19 infection. A minority (4.7%) reported low cues for adopting recommended interventions. Approximately 33% of the respondents reported low perceived barriers to performing indicated health measures.

On the other hand, about 21% reported high or very high perceived barriers. Only about 45% of those surveyed believed that recommended pandemic interventions have very high benefits. Another 33% considered the measures to be highly beneficial. A high proportion of participants concluded that it is very likely that they will be protected from the pandemic when they wear a face mask (55.5%) or get vaccinated (37.4%). For self-efficacy, approximately 64% of the participant rated themselves as good or very good at protecting themselves from COVID-19 infection (see Fig. 2 below).

Correlation between vaccine behaviour, face mask usage and properties of HBM

The result as presented in Table 2 below, revealed that perceived severity (r =.324, $p < .001$), cues to action (r = .311, $p < .001$), perceived benefit (r = .463, $p < .001$) and self-efficacy (r =.134, $p < .001$) were positively and significantly associated with COVID-19 vaccine behaviour. On the other hand, the perceived barrier (r =–.322, $p < .001$) was negatively correlated with vaccine practice. Perceived susceptibility and perceived threat did not significantly correlate with COVID-19 vaccine behaviour. Correlation between face masking and HBM constructs showed

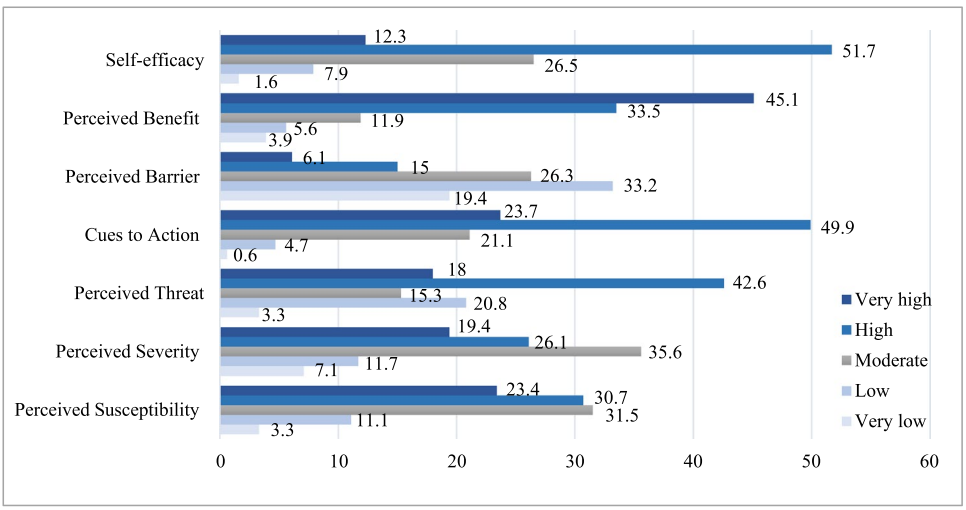

Fig. 2 Percentage distribution of properties of HBM concerning the COVID-19 pandemic

Table 2 Pearson correlation matrix of the health belief properties concerning the COVID-19 pandemic, vaccine behaviour and face mask usage (n = 674)

	1	2	3	4	5	6	7	8	9
1. Perceived susceptibility	1								
2. Perceived severity	–.071	1							
3. Perceived threat	.509**	–.002	1						
4. Cues to action	.117**	.341**	.065	1					
5. Perceived barrier	.025	–.181**	–.074	–.242**	1				
6. Perceived benefit	–.016	.385**	.048	.296**	–.528**	1			
7. Self-efficacy	–.185**	.316**	–.199**	.335**	–.185**	.311**	1		
8. Vaccine behaviour	–.046	.324**	.024	.311**	–.322**	.463**	.134**	1	
9. Masking behaviour	.007	.367**	–.139**	.331**	–.224**	.314**	.235**	.261**	1

**Correlation is significant at the 0.01 level (2-tailed)

a positive correlation of mask-wearing with perceived severity (r = .367, $p < .001$), cues to action (r = .331, $p < .001$), perceived benefits (r = .314, $p < .001$) and self-efficacy (r = .235, $p < .001$). The results confirmed the moderate correlations of face masking with perceived severity, cues to action and perceived benefits. In contrast, a weak positive correlation was found with self-efficacy. Wearing a face mask had a weak negative correlation with a perceived threat (r = –.139, $p = <.001$) and perceived barrier (r = –.224, $p < .001$). Among the HBM constructs, only perceived susceptibility was not correlated with face masking.

Regression model exploring the association between the health belief model properties and COVID-19 vaccine behaviour

A logistic regression was performed to ascertain the impacts of HBM constructs on the likelihood that participants get a vaccine against SARS-CoV-2. The logistic regression model was statistically significant, $X^2(13) = 149.096$, $p < .001$. The specificity and sensitivity for the model is 58.1% and 99.4%, respectively. As shown in Table 3 below, the adjusted odds ratio with the given CI and p-value of 1 and > 0.05 identified no significant association between demographic variables (i.e. age, gender, and education) and COVID-19 vaccine behaviour.

Similarly, from the HBM, perceived severity, threat and self-efficacy had no significant association with COVID-19 vaccine behaviour. However, the likelihood of being vaccinated against the COVID-19 virus was higher when cues to action were strong and perceived benefits were high. The results show that the odds of getting vaccinated against COVID-19 increase by 1.839 times (95% CI (1.366, 2.475), $p = <.001$) and 1.489 times (95% CI (1.226, 1.807), $p = <.001$) for each additional score in a person's cues and perceived advantages, respectively. Contrary to Pearson's correlation test, perceived susceptibility was significantly associated with COVID-19 vaccine adoption in the adjustment

Table 3 Logistic regression analysis for the assessment of health beliefs and COVID-19 vaccine behaviour

Variables	B	S. E	EXP (B)	95% C. I for EXP (B)		P-value
				L.B	U. B	
Age	–.025	.027	.976	.925	1.029	.364
Gender (male)	–.745	.598	.475	.147	1.532	.213
Education (bachelor's degree)	–.619	.350	.538	.271	1.069	.077
Master's or higher	–.336	.271	.715	.420	1.214	.214
Perceived susceptibility	–.496	.150	.609	.453	.817	**<.001**
Perceived severity	.143	.113	1.154	.926	1.439	.203
Perceived threat	.243	.256	1.275	.772	2.107	.343
Cues to action	.609	.152	1.839	1.366	2.475	**<.001**
Perceived barriers	–.269	.133	.764	.589	.991	**.043**
Perceived benefit	.398	.099	1.489	1.226	1.807	**<.001**
Self-efficacy	–.549	.315	.577	.312	1.070	.081

Bold in the table denotes significance <0.05

measurement (95% CI (0.453, 0.817), $p = <.001$). Nevertheless, the odds ratio for the relationship was less than 1 (OR = 0.609), which suggested that perceived susceptibility is less likely to induce vaccine behaviour among the study participants. Furthermore, the results also indicated that increasing perceived barriers was associated with a decrease in the likelihood of getting a vaccine against SARS-CoV-2 (OR = –0.764, CI (0.589, 0.991), $p = <0.043$).

Regression model exploring the association between properties of the health beliefs model and face mask use behaviour

Multiple linear regression was computed to examine the impacts of HBM properties on the likelihood of participants' face mask usage as a protective measure against COVID-19 infection. The result showed that the regression model is a good fit for the data, F (13, 650) = 17.093, $p < .001$, and adjusted $R^2 = .240$, where 13 and 650 are the degrees of freedom (df) for the models' regression and residual, respectively.

As shown in Table 4 above, age, gender and education returned no significant association with face mask usage. Among the properties of HBM, self-efficacy (95% CI (–0.344, 0.640), $p = 0.554$) did not add statistical significance to face mask usage. Whereas perceived susceptibility, perceived severity, perceived threat, cues to action, perceived barrier and perceived benefit showed significant association with face mask usage. The result showed that for each 1-score increase in perceived susceptibility and perceived severity, there is an increase in adherence to face mask use of 0.126 times (95% CI (0.099, 0.441), $p = 0.002$) and 0.244 times (95% CI (0.325, 0.622), $p = <0.001$), respectively. Correspondingly, each 1-score increase in cues to action and perceived benefit suggested the increase in the likelihood of wearing a face mask by 0.176 times (95% CI (0.229, 0.582), $p = <.001$) and 0.125 times (95% CI (0.064, 0.341), $p = 0.004$), respectively. The perceived threat (–0.221, 95% CI (–1.483, –0.696), $p = <.001$) and perceived barrier (–0.087, 95% CI (–0.388, –0.016), $p = 0.033$), on the other hand, were noted to have a significant negative association with mask-wearing.

Discussion

The current analysis examined the properties of HBM constructs on vaccination uptake and face mask use among adults in Hamburg. The employed models exhibited a good fit with the data and adequately elucidated the shift in adults' COVID-19 preventive behaviour in Hamburg. The findings showed that the key factors influencing vaccine uptake against the pandemic were cues to action and perceived benefits. Perceived severity and cues to action were the strongest determinants of mask-wearing, followed by perceived susceptibility and perceived benefit. Low engagement in vaccination practices and use of face masks were associated with high perceptions of barriers.

The properties of HBM exhibited a distinct strength of association with vaccine practice and mask-wearing. A technical explanation for this could be the predictive power of the model factor, which varies with the target behaviour (Karl et al. 2022). The study findings revealed a significant negative association between perceived susceptibility and vaccination against SARS-CoV-2. This may suggest that despite decreased vulnerability, the study population had taken recommended interventions against the pandemic. This finding was corroborated by several other studies (Fathian-Dastgerdi et al. 2021; Kim and Kim 2020). A possible explanation for the negative influence of perceived vulnerability on vaccine practice could

Table 4 Multiple linear regression analysis for the assessment of health beliefs and face mask use behaviour

Variables	Unstandardised Coefficients		β	t	95% C. I for B		P value
	B	S. E			L.B	U. B	
Age	–.019	.020	–.037	–.948	–.058	.020	.343
Gender (male)	–.714	.391	–.064	–1.828	–1.482	.053	.068
Education (bachelor)	.204	.224	.034	.911	–.236	.644	.362
Master's or higher	.039	.180	.009	.218	–.314	.392	.827
Perceived susceptibility	.270	.087	.126	3.104	.099	.441	**.002**
Perceived severity	.474	.076	.244	6.267	.325	.622	**<.001**
Perceived threat	–1.090	.200	–.221	–5.441	–1.483	–.696	**<.001**
Cues to action	.405	.090	.176	4.512	.229	.582	**<.001**
Perceived barriers	–.202	.095	–.087	–2.131	–.388	–.016	**.033**
Perceived benefit	.202	.071	.125	2.869	.064	.341	**.004**
Self–efficacy	.148	.250	.023	.592	–.344	.640	.554

be the social campaign promoting the advantages of vaccination and its role in pandemic mitigation, including other efforts such as addressing the public's misconceptions regarding the COVID-19 vaccine taken by the government and other organisations. Solidarity and fear for older family members, who are more likely to contract the disease, may have also influenced vaccine adoption among Hamburg adults (Patzina and Dietrich 2022). Contrarily, perceived susceptibility was a third strong determinant of mask-wearing. The finding aligns with the results from previous studies, which concluded that the greater the perception of the possibility of infection, the greater the likelihood that individuals will engage in preventive behaviour (Baek et al. 2022; Barakat and Kasemy 2020).

Furthermore, the results showed that perception of COVID-19 severity was the most important factor that significantly influenced the adoption of face mask use among adults residing in Hamburg. Several existing studies provide evidence of this strong relationship between perceived seriousness and preventive measures (Jadil and Ouzir 2021; Kim and Kim 2020; Shmueli 2021). However, the construct had no significant impact on vaccine practice. This finding concurs with earlier studies based on HBM, which indicated that perception of seriousness does not affect preventive behaviour (Mahindarathne 2021; Tesema et al. 2021). The discrepancy between vaccine practice and masking behaviour explained by perceived sensitivity suggests that it is not a driving force behind vaccine practice among Hamburg adults but strongly influences face mask use.

Another interesting finding from the current analysis was the significant negative association between perceived threat and mask-wearing. This may suggest that mask-wearing has reduced the pandemic threat among adults in Hamburg. The outcome is reasonable because most participants in this study claimed that they feel protected from COVID-19 infection when wearing a mask. A study by Zickfeld et al. (2020) also identified that participants perceived a lesser threat when they were more engaged in health measures, corroborating the present study's findings. However, recent studies have noted an ambivalent relationship between fear and preventive behaviour (Kojan et al. 2022). They have also suggested that the relationships between these two variables change over time. In some research, the relationship between perceived threat and preventive measures is weak or very weak, whereas, in others, it is significant or moderate.

In the study, the perceived barrier had a significant negative relationship with COVID-19 vaccination and face mask use, indicating that Hamburg adults were more likely to follow preventive measures if they were able to overcome their perceived obstacles, such as limited access to affordable health-promoting activities related to COVID-19 infection and concerns about side effects of the COVID-19 vaccination. This finding confirms the conclusion of several other studies, which showed that perceived difficulty in implementing recommended behaviours impedes public participation in health-promoting activities (Mahindarathne 2021; Shitu et al. 2022; Wang et al. 2022). Therefore, identifying the common barriers that hinder the public from adopting health measures and facilitating overcoming such obstacles is essential to persuade the public to continue participating in the required health measures to control the pandemic.

The study further revealed the strong association between cues to action and an individual's engagement in vaccination. This corroborates findings from previous studies conducted in Israel, China and Hong Kong (Shmueli 2021; Wang et al. 2022; Wong et al. 2021). The studies suggested that a high level of cues to action enhances the individual willingness to receive the COVID-19 vaccine. Therefore, it can be concluded from the present study that participants who often receive pandemic-related information and have people around them involved in preventive behaviours are more likely to adhere to the precautionary measures. Likewise, the construct showed a significant association with face masking. The outcome goes along with the study done by Karimy et al. (2021) and Li et al. (2021), which noted the positive impact of higher cues on adherence to FMU. However, the result sharply contrasts with a study by White et al. (2022), which identified an insignificant association between the construct and mask-wearing.

Similarly, the second most potent factor influencing COVID-19 vaccine acceptance was perceived benefit. This outcome is plausible because when the advantages of preventive measures outweigh the barriers, people tend to adopt the recommended interventions to prevent infection. Researchers have reported similar results in their studies of acceptance of the COVID-19 vaccine based on the health belief model (Shmueli 2021; Wong et al. 2021). The construct also showed a positive impact on mask-wearing, in line with Li et al.'s (2021) study, which demonstrated that increased perceived advantages induce public adherence to face masking. This signifies that adults in Hamburg believe in the efficacy of the suggested countermeasures.

Surprisingly, self-efficacy, a substantial model component, had an insignificant impact on two variants of the preventive measures in the regression analysis, despite having a positive correlation in the correlation analysis. This was an unexpected outcome from the present study because a person should have sufficient confidence to perform healthy behaviours. Numerous studies have shown a strong correlation between self-efficacy and precautionary measures (Baek et al. 2022; Barakat and Kasemy 2020; González-Castro et al. 2021; Karl et al. 2022; Shitu et al. 2022). Additionally, a systematic review conducted by Zewdie et al. (2022) found that high self-efficacy is the second most frequent significant determinant of COVID-19-related preventive measures after perceived benefit. Hence, more research is needed to examine factors causing its insignificant association with COVID-19 preventive behaviour.

Limitations

This paper has several limitations that can be addressed in future research. Firstly, the study's cross-sectional design limits the generalisability of the results. A longitudinal study would provide the necessary data to monitor the trend over time, considering the variation in the public's reaction to the pandemic.

Secondly, participant self-reports served as the foundation for the data collection. As a result, there is a possibility that the responses provided are different from the information obtained through observation. Furthermore, the study findings showed that 4.9% of the participants were not vaccinated, and 8% never worn a face mask. Owing to the use of snowball sampling, this percentage may not accurately represent the true figures. The sampling technique adapted could be biased, impacting the results' adaptability.

Conclusion

This study used the health belief model to investigate the psychological factors impacting adults' participation in vaccination and face mask use in Hamburg. The findings indicated that vaccination uptake against the pandemic among Hamburg adults is positively influenced by cues to action and perceived benefit. In contrast, perceived barriers and susceptibility negatively affected vaccine adoption. Concerning face masks, increased perceived susceptibility, perceived seriousness, cues to action and perceived benefit increased adherence to face masking. However, perceived threat and perceived barrier showed a negative association with face masking. This study's findings provide robust evidence to recommend that the concerned public health professionals consider individuals' health beliefs when designing an effective COVID-19 preventive programme. Public health messaging should consider highlighting the benefits of precautionary actions and the potential lethality of COVID-19 to evoke an individual's appropriate concern. Additionally, cues to action towards COVID-19 should be provided through various reminders on social platforms to boost public commitment towards adopting preventive measures. The authorities should also focus on eliminating barriers perceived by the public.

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Author contributions S.S.: Project conceptualisation, data collection, data analysis, and contributed to writing the main manuscript text.

W.L.: Project supervision and contributed to and reviewed the main manuscript text.

A.A.: Project supervision, support with data analysis, and contributed to and reviewed the main manuscript text.

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Data availability statement The data supporting this study's findings are available on request from the first author, SS.

Declarations

Ethical approval and consent to participate All procedures were by the ethical standards of the institutional and national research committee and comparable ethical standards. Furthermore, informed consent was obtained from all participants included in the study.

Consent for publication Not applicable.

Conflict of interest The authors have no conflicts of interest to disclose

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