


Predictors of COVID-19 vaccine hesitancy in Germany: a cross-sectional, population-based study

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ABSTRACT

Purpose of the study Achieving high COVID-19 vaccination rates is a key public health challenge. The study aims to investigate factors determining COVID-19 vaccine hesitancy and adherence to prevention measures, in German adults.

Study design This cross-sectional study was conducted in Germany, from 21 February 2021 to 3 April 2021, during the strict lockdown period of the third COVID-19 wave. A total of 2029 adults (75.3% women and median age 38 years) participated in an online survey. Participants completed a questionnaire assessing sociodemographic and anthropometric characteristics, adherence to COVID-19 prevention measures and willingness to vaccinate. Health literacy (HL), perceived stress, life satisfaction and adherence to Mediterranean diet (MD) were also assessed. Multiple linear and logistic regression analysis were employed.

Results The median score of COVID-19 adherence to the prevention measures tool, was 23.08 (3.83) (range 1–35). A total of 57.5% of the participants were willing to vaccinate against COVID-19, 12.1% were unwilling and 30.4% were undecided. Linear regression analysis revealed that women, obese participants, those with a chronic disease and those willing to vaccinate, reported higher adherence to prevention measures. Older age, higher levels of HL, life satisfaction and adherence to MD were also positively associated with higher adherence. Logistic regression revealed that being a woman decreases the odds of having the willingness whereas, older age, higher education and adherence to measures, increase the odds of willingness to vaccinate.

Conclusion The results of the study could be used by practitioners, researchers and policy-makers working in the field of prevention and management of COVID-19.

INTRODUCTION

COVID-19 is a major threat to public health. Adherence to the prevention measures of COVID-19 and adequate vaccination levels of the population are undoubtedly the main means for managing the disease, till today.^{1 2} In addition, the recurrent mutations of the virus renders the management of the disease, both in terms of prevention and treatment, more and more challenging. SARS-CoV-2 is a highly transmissible virus, and in order for the chain of transmission to be broken, the vast majority of the population needs to be vaccinated.^{3–5} There is, however, a growing body of evidence that vaccination rates are low in many parts of the world and vaccine hesitancy is emerging as a major barrier to tackling the recurrent waves of the pandemic.^{2 5–7} In a recent study, almost half of the adult population

in Germany reported that they were hesitant to vaccinate against the SARS-CoV-2.⁸ It is important to note that in 2019, vaccine hesitancy, in general, has been identified by WHO as one of the top 10 threats to global health.⁹

Low levels of health literacy (HL) are often linked with ill-health and they constitute an emerging field for health research, policy and practice, worldwide. More specifically, studies suggest that HL is a stronger predictor of health than age, income, employment, education and race, can lead to premature death and it is also a modifiable risk factor.^{10–12} HL is defined as the set of cognitive and social skills that determine the motivation and ability of individuals to access, understand and use information in a way that promotes and maintains good health.¹³ Sørensen *et al*, report that HL is a multidimensional concept that includes motivations, skills and knowledge required to access, understand, evaluate and implement health-related information for individuals, be able to make decisions about prevention, care and health promotion, to achieve optimal quality of life throughout their lives.¹⁴ HL is a key factor in good health and is also associated with inadequate use of public health and primary healthcare services, low participation in preventive screening and vaccination programmes, high rates of hospitalisation.^{15–18}

Throughout the course of the COVID-19 pandemic, HL has proven to be, as expected, an essential, potentially life-saving determinant of health and of health-related behaviours.^{19 20} It was also reported in the past that higher levels of HL aids in the identification of fake news, which is especially relevant, since during the COVID-19 pandemic, fake news are negatively impacting on the general population's willingness to vaccinate against the disease.^{21–24} A recent study conducted in a representative sample of the population of Germany, has shown that 57.8% of the participants had low and problematic levels of HL.²⁵

With respect to psychological stress, it is very prevalent in the general population and a lot more prevalent in vulnerable groups.²⁶ Perceived stress is defined as 'the feelings or thoughts that an individual has about how much stress they are under at a given point in time or over a given time period'. Perceived stress is characterised by feelings about the uncontrollability and unpredictability of one's life, how often one has to deal with irritating hassles, how much change is occurring in one's life, and confidence in one's ability to deal with problems or difficulties.²⁷

It is well documented that life satisfaction is positively associated with health.²⁸ The COVID-19



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outbreak has posed considerable challenges for people's health and life satisfaction. In a survey conducted in 2015, a significantly positive correlation between self-reported health and life satisfaction, was reported in 32 European countries, including Germany.²⁹ In addition, recent data suggest a reduction of life satisfaction due to the COVID-19 pandemic, which is more pronounced for vulnerable groups.^{30 31}

Finally, a healthy and balanced diet accompanied by healthy lifestyles, is also vital, because they impact on general well-being, levels of psychosomatic health and risk of disease.^{32 33}

Low HL, mental stress, poor life satisfaction and an unhealthy diet are significantly associated with serious negative health outcomes.^{34 35} Based on the global health indices, the best-performing countries in combatting the ongoing COVID-19 pandemic have been those with smaller population, higher government funding allocation towards healthcare and those having robust public governance.³⁶ The current study aims to investigate adherence to COVID-19 prevention measures and willingness to vaccinate against COVID-19, in relation to HL, perceived stress, life satisfaction and other participant's sociodemographic and lifestyle characteristics, among the adult German population.

MATERIAL AND METHODS

Study design and participants

A cross-sectional, population-based study was conducted in Germany. The sample collected in a period of 6 weeks, between 21 February 2021 and 3 April 2021, during the lockdown and the third wave of COVID-19.

Inclusion criteria included: men and women, ≥ 18 years of age and the ability to read and write in German. There were no other exclusion criteria. Individuals were invited to participate in an online survey with the snowball sampling method. This method was used in order to succeed large distribution and recruitment of participants. A total of 2029 participants (75.3% women) participated in the study.

An online form of the questionnaire was created and it was distributed by email and Facebook (Cambridge, Massachusetts, USA). In the first section of the online questionnaire, participants were informed about the aim of the study and their ability to withdraw at any time. Also, the anonymity and the confidentiality in their response were ensured. Consenting participants proceeded to complete and submit their responses. Participants' data were collected with no identification.

Survey questionnaire

A self-administrated online survey was designed using Google document forms in German. The questionnaire included questions about: sociodemographic (such as sex, age, etc) and anthropometric characteristics (self-reported), adherence to COVID-19 prevention measures, willingness to vaccinate against COVID-19, HL, perceived stress, satisfaction with life and adherence to Mediterranean diet (MD). The mean time of completion of the questionnaire was about 7–8 min.

Assessment of adherence to COVID-19 prevention measures and willingness to vaccinate against COVID-19

A specifically designed questionnaire of seven items with a 5-point Likert type scale, about participants' implementation of COVID-19 prevention measures was created. The answers to these questions ranged from 1=never to 5=always (score range from 5 to 35). The questions dealt with issues relevant to physical distance, crowding, masks, wash cleaning, coughing/

sneezing, face touching and objects' disinfection. In order to assess reliability of this tool, Cronbach's a coefficient was calculated and it was 0.796. Also, a question relevant to participants' willingness to vaccinate against COVID-19 was used and the possible answers were: 'yes', 'no' and 'I have not decided yet'.

European Health Literacy Survey Questionnaire

The European Health Literacy Survey Questionnaire (HLS_EU_Q16) is a short version of the HLS_EU_Q47 which was created to evaluate HL levels of eight European countries which participated in the HLS_EU project. HLS_EU_Q16 includes 16 items and the answers range from 0=very difficult to 4=very easy. Difficult categories are coded with 0 and easy categories are coded with 1. Total HL score is a sum score and ranges from 0 to 16. A score between 0 and 8 indicates inadequate HL levels, between 9 and 12 problematic HL levels and between 13 and 16 sufficient HL levels.³⁵

Perceived Stress Scale-14

The Perceived Stress Scale-14 (PSS-14) is a self-reported 14-item questionnaire with a 5-point Likert type scale (0=never, 1=almost never, 2=sometimes, 3=fairly often, 4=very often) (Cohen *et al*, 1983). This measure assesses whether situations experienced by a person during the last month are stressful. It concludes seven positive and seven negative items and the highest possible score is 56. A higher score indicates higher levels of perceived stress during the past month. The scale has been validated into German.^{37 38}

Satisfaction with Life Scale

The Satisfaction with Life Scale (SWLS) was developed by Diener *et al*.³⁹ This tool assesses the cognitive component of subjective well-being. The scale assesses a global level of life satisfaction and does not focus on specific domains of an individual's life. The scale includes five items and the answers range from 1 (strongly disagree) to 7 (strongly agree), in a 7-point Likert scale. Total score of life satisfaction is the sum of the five answers. The possible range of scores is ranges from 5 to 35, with greater scores indicating higher satisfaction with life. The scale has been validated into German.⁴⁰

Mediterranean Diet Adherence Screener

Mediterranean Diet Adherence Screener (MEDAS) is a 14-item screener, which consists of 12 questions on food consumption frequency and 2 questions on food intake habits characteristic of the MD. Each question was scored with a 0 or 1. The MEDAS score (sum of above items) ranged from 0 to 14 points. MEDAS ranges from 0 (minimum) to 14 (maximum) points and a total score ≥ 10 points was considered for high adherence to MedDiet. Low-fat diet questionnaire ranges from 0 (minimum) to 9 (maximum) points and a total score ≥ 6 points was considered for high adherence to a diet restricted in fat.^{41 42} The scale has been validated into German.⁴³

Statistical analysis

Data are presented as N (%) for categorical variables (ie, sex, education etc) and as median (IQR) and mean (SD) for continuous variables (ie, age, body mass index (BMI), etc). Due to the skewed distribution of the continuous variables the Mann-Whitney U test, non-parametric test was used to evaluate differences between sexes. Also, χ^2 test was used to evaluate differences between sexes and the categorical variables. Then, multiple linear regression analysis was employed to evaluate whether

adherence to the COVID-19 prevention measures (dependent variable) was associated with various participants' characteristics (independent variables). The inclusion of the independent variables was based on literature review made and the tested research hypothesis of this study. Multicollinearity was evaluated using the variance inflation factor (variables with value >4 were not included at the same time in the model). Finally, logistic regression models were used to evaluate various participants' characteristics (independent variables) as determinants of the willingness to vaccinate against COVID-19 (yes vs no/I have not decided yet) (dependent variable). The STATA software, version 14 was used for all statistical analyses.

RESULTS

Sample's descriptive and anthropometric characteristics and measurements scores

Table 1 describes sample's descriptive and anthropometric characteristics and measurements scores. The total sample consists of 2029 participants (75.3% women) and the median age (IQR) was 38 (16). Most of the participants had tertiary education (56.3%), were ex or non-smokers (63.3%), did not mention the existence of a chronic disease (79.4%), had sufficient levels of HL (80.4%) and moderate adherence to MD (68.1%). The median BMI (IQR) was 24.89 (6.32) and 48.6% were classified as overweight or obese. Finally, 57.5% mentioned that they have the willingness to vaccinate against COVID-19 contrary to those who did not want to or have not decided yet (12.1% and 30.4%, respectively).

According to sex, women in contrast to men, were younger ($p<0.0001$), smoked more ($p<0.0001$), were thinner and in normal weight ($p<0.0001$) and those that they want to vaccinate against COVID-19 were less ($p<0.0001$). Also, women implement COVID-19 prevention measures more ($p<0.0001$), were classified in the sufficient HL category in a higher percent ($p=0.001$), had higher perceived stress levels ($p<0.0001$) and higher adherence to MD ($p=0.037$).

Table 2 shows sample's answers for each question relevant to their adherence to the COVID-19 prevention measures and their beliefs about the disease. Total sample applies the measure 'I cover my mouth and nose when I cough or sneeze' more than the other measures. The measures 'I wash my hands or use hand sanitiser regularly' and 'I wear face masks when I go out' are the next according to their application frequency. As for sex, women seem to be more attached to every prevention measure against COVID-19, contrary to men ($p<0.0001$).

Also, participants had to express their agreement or not, in two statements about how COVID-19 will affect their lives. In the 'I believe that the COVID-19 pandemic will not have a long-term effect on our 'normal' life' statement almost 44% of the sample disagreed and 'I believe that the COVID-19 pandemic will affect our lives in the long run and we will not return to the 'normal' life as we knew it' statement almost 48% of the participant expressed their agreement. In both statements men seemed to be more optimistic about COVID-19 long-term effect ($p<0.0001$).

Models of linear regression analysis that evaluated various participants' characteristics as determinants of adherence to the COVID-19 prevention measures

Table 3 presents the results of linear regression analysis for adherence to the COVID-19 prevention measures in relation to various participants' characteristics. In the seventh model, where all study variables were added, sex and age were still

Table 1 Sample's descriptive and anthropometric characteristics and measurements scores (n=2029)

	Men	Women	P value	Total
Sex N (%)	501 (24.7)	1528 (75.3)	–	2029 (100)
Age in years median (IQR)	40 (18)	38 (15)		38 (16)
Mean (SD)	40.97 (12.52)	38.22 (10.80)	<0.0001	38.90 (11.31)
Education N (%)				
Up to lyceum	91 (18.2)	216 (14.1)		307 (15.1)
Tertiary education	269 (53.7)	874 (57.2)		1143 (56.3)
MSc/PhD	141 (28.1)	438 (28.7)	0.086	579 (28.5)
Smoking status N (%)				
Yes	142 (28.3)	603 (39.5)		745 (36.7)
Non/ex-smokers	359 (71.7)	925 (60.5)	<0.0001	1284 (63.3)
BMI median (IQR)	26.78 (4.84)	24.22 (6.27)		24.89 (6.32)
Mean (SD)	27.50 (4.60)	25.26 (5.43)	<0.0001	25.81 (5.32)
Weight status category N (%)				
Thin*	2 (0.4)	49 (3.2)		51 (2.5)
Normal weight*	154 (30.7)	834 (54.8)	<0.0001	988 (48.8)
Overweight*	239 (47.7)	403 (26.5)		642 (31.7)
Obese*	106 (21.2)	237 (15.6)		343 (16.9)
Chronic disease N (%)				
Yes	91 (18.2)	326 (21.3)	0.144	417 (20.6)
No	410 (81.8)	1202 (78.7)		1612 (79.4)
Willingness of vaccination against COVID-19 N (%)				
Yes*	329 (65.7)	837 (54.8)		1166 (57.5)
No	55 (11)	191 (12.5)	<0.0001	246 (12.1)
I haven't decided yet*	117 (23.4)	500 (32.7)		617 (30.4)
Adherence to the COVID-19 prevention measures median (IQR)	23 (6)	24 (4)		24 (5)
Mean (SD)	21.77 (4.24)	23.51 (3.58)	<0.0001	23.08 (3.83)
HLS_EU_Q16 score median (IQR)	15 (3)	15 (3)		15 (3)
Mean (SD)	13.96 (2.76)	14.19 (2.19)	0.781	14.13 (2.34)
HLS_EU_Q16 categories N (%)				
Inadequate HL*	31 (6.2)	39 (2.6)		70 (3.4)
Problematic HL	78 (15.6)	250 (16.4)	0.001	328 (16.2)
Sufficient HL	392 (78.2)	1239 (81.1)		1631 (80.4)
PSS score median (IQR)	22 (10.5)	25 (11)		24 (11)
Mean (SD)	22.19 (8.02)	25.04 (7.93)	<0.0001	24.32 (8.05)
SWLS score median (IQR)	22 (9)	23 (10)		22 (10)
Mean (SD)	21.46 (6.36)	21.92 (6.54)	0.12	21.80 (6.50)

Continued

Table 1 Continued

	Men	Women	P value	Total
MEDAS score median (IQR)	7 (3)	7 (3)		7 (3)
Mean (SD)	7.12 (2.28)	7.38 (1.93)	0.037	7.31 (2.03)
MEDAS categories N (%)				
Low adherence to MD*	118 (23.6)	240 (15.7)		358 (17.6)
Moderate adherence to MD*	306 (61.1)	1076 (70.4)	<0.0001	1382 (68.1)
High adherence to MD	77 (15.4)	212 (13.9)		289 (14.2)

P<0.05, χ^2 , Mann-Whitney U test.

*Shows between which categories exists the significant differences.

BMI, body mass index; HL, health literacy; HLS_EU_Q16, Health Literacy Survey European Questionnaire 16; MD, mediterranean diet; MEDAS, Mediterranean Diet Adherence Screener; PSS, Perceived Stress Scale; SWLS, Satisfaction with life scale.

significantly positively associated with higher levels of adherence to the COVID-19 prevention measures with 1.968 points ($p<0.0001$) and 0.049 points ($p<0.0001$) respectively, but education was not. Obese participants and those with a chronic disease were also significantly positively associated with higher levels of adherence to the COVID-19 prevention measures with 0.537 points ($p=0.019$) and 0.407 points ($p=0.040$) in contrast to normal weight participants and to those without a chronic disease respectively. Those who had the willingness to vaccinate against COVID-19 were still significantly positively associated with higher levels of adherence to the COVID-19 prevention measures with 1.980 points ($p<0.0001$) in contrast to those who did not want to or haven't decided yet. Finally, higher levels of HL, satisfaction with life and adherence to MD were significantly positively associated with higher levels of adherence to the COVID-19 prevention measures with 0.101 points ($p=0.004$), 0.064 points ($p<0.0001$) and 0.166 points ($p<0.0001$) respectively, but perceived stress levels were not.

Models of logistic regression analysis that evaluated various participants' characteristics as determinants of the willingness to vaccinate against COVID-19 (yes vs no/I have not decided yet)

Table 4 presents the results of logistic regression analysis models that various participants' characteristics as determinants of the willingness to vaccinate against COVID-19 (yes vs no/I have not decided yet). In the seventh model, were all study variables were added, being a woman decreases the odds of having the willingness to vaccinate against COVID-19 ($OR=0.450$, $p<0.0001$). Also, higher age in years, increases the odds of having the willingness to vaccinate against COVID-19 ($OR=1.025$, $p<0.0001$). As for education, having tertiary education or MSc/Phd increase the odds of having the willingness to vaccinate against COVID-19 in contrast to those who had up to Lyceum education ($OR=1.574$, $p=0.001$ and $OR=2.970$, $p<0.0001$, respectively). Finally, higher adherence to the COVID-19 prevention measures increases the odds of having the willingness to vaccinate against COVID-19 ($OR=1.182$, $p<0.0001$).

Table 2 Sample's answers for each question relevant to the adherence to the COVID-19 prevention measures and their beliefs about COVID-19 (N=2029)

	Men median (IQR) Mean (SD)	Women median (IQR) Mean (SD)	P value	Total median (IQR) Mean (SD)
Question relevant to the adherence to the COVID-19 prevention measures				
I try to keep the physical distance of 1.5–2 metres from the rest when I go out.	3 (1) 3.03 (0.96)	3 (1) 3.22 (0.86)	<0.0001	3 (1) 3.17 (0.89)
I avoid going to places where a lot of people gather.	3 (1) 3.08 (0.95)	4 (4) 3.33 (0.87)	<0.0001	3 (1) 3.27 (0.90)
I wear face masks when I go out.	4 (0) 3.64 (0.75)	4 (0) 3.80 (0.57)	<0.0001	4 (0) 3.76 (0.62)
I wash my hands or use hand sanitiser regularly.	3 (1) 3.35 (0.77)	4 (0) 3.59 (0.66)	<0.0001	4 (0) 3.53 (0.70)
When I cough or sneeze, I cover my mouth and nose.	4 (0) 3.80 (0.53)	4 (0) 3.91 (0.33)	<0.0001	4 (0) 3.88 (0.39)
I avoid touching my face (eyes, nose, and mouth).	3 (1) 2.66 (0.99)	3 (2) 2.90 (0.92)	<0.0001	3 (2) 2.85 (0.95)
I regularly disinfect objects and surfaces that I use often.	2 (2) 2.21 (1.13)	3 (1) 2.76 (1.01)	<0.0001	3 (1) 2.62 (1.07)

Beliefs about how COVID-19 will affect everyone's life

	Men N (%)	Women N (%)	P value	Total N (%)
I believe that the COVID-19 pandemic will not have a long-term effect on our 'normal' life.				
I absolutely disagree*	91 (18.2)	372 (24.3)		463 (22.8)
Disagree	203 (40.5)	692 (45.3)		895 (44.1)
Neither disagree nor agree	93 (18.6)	247 (16.2)		340 (16.8)
Agree*	99 (19.8)	171 (11.2)		270 (13.3)
Strongly agree	15 (3)	46 (3)	<0.0001	61 (3)
I believe that the COVID-19 pandemic will affect our lives in the long run and we will not return to the "normal" life as we knew it.				
I absolutely disagree*	27 (5.4)	29 (1.9)		56 (2.8)
Disagree*	116 (23.2)	189 (12.4)		305 (15)
Neither disagree nor agree	105 (21)	351 (23)		456 (22.5)
Agree*	202 (40.3)	765 (50.1)		967 (47.7)
Strongly agree	51 (10.2)	194 (12.7)	<0.0001	245 (12.1)

Agree*: I believe that the COVID-19 pandemic will affect our lives in the long run and we will not return to the "normal" life as we knew it. Disagree*: I believe that the COVID-19 pandemic will not have a long-term effect on our "normal life".

DISCUSSION

Effectively tackling poor compliance to COVID-19 prevention measures and vaccine hesitancy, are of paramount importance in the battle against the urgent management of the pandemic. The current study was conducted during the lockdown period of the third wave of the pandemic of COVID-19, in Germany and it was set out to assess adherence to the prevention measures and willingness

Table 3 Results (b, SE) from regression analysis models that evaluated various participants' characteristics as determinants of adherence to the COVID-19 prevention measures

	First model		Second model		Third model		Fourth model		Fifth model		Sixth model		Seventh model	
	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value	b±SE, p value
Sex (women/men)	1.739±0.193, <0.0001	1.955±0.189, <0.0001	1.948±0.189, <0.0001	1.969±0.194, <0.0001	1.942±0.194, <0.0001	2.137±0.188, <0.0001	1.968±0.190, <0.0001	NA	0.079±0.007, <0.0001	0.074±0.008, <0.0001	0.059±0.007, <0.0001	0.049±0.008, <0.0001	0.049±0.008, <0.0001	0.049±0.008, <0.0001
Age in years	NA	0.079±0.007, <0.0001	0.078±0.007, <0.0001	0.076±0.007, <0.0001	0.074±0.008, <0.0001	0.059±0.007, <0.0001	0.049±0.008, <0.0001	0.079±0.007, <0.0001	0.074±0.008, <0.0001	0.059±0.007, <0.0001	0.049±0.008, <0.0001	0.049±0.008, <0.0001	0.049±0.008, <0.0001	
Education (Ref: up to lyceum)														
Tertiary education	NA	NA	0.100±0.235, 0.672	0.112±0.235, 0.634	0.128±0.235, 0.587	-0.081±0.228, 0.721	-0.101±0.225, 0.653	NA	0.100±0.235, 0.672	0.128±0.235, 0.587	-0.081±0.228, 0.721	-0.101±0.225, 0.653	0.101±0.235, 0.672	0.128±0.235, 0.587
MSc/PhD	NA	NA	0.573±0.258, 0.026	0.592±0.258, 0.022	0.605±0.258, 0.019	0.095±0.252, 0.706	-0.073±0.250, 0.771	NA	0.573±0.258, 0.026	0.605±0.258, 0.019	0.095±0.252, 0.706	-0.073±0.250, 0.771	0.573±0.258, 0.026	0.605±0.258, 0.019
Weight status category (Ref: normal weight)														
Thin	NA	NA	0.093±0.524, 0.859	0.021±0.193, 0.914	0.000±0.193, 0.999	-0.129±0.506, 0.799	-0.032±0.501, 0.950	NA	0.093±0.524, 0.859	0.043±0.525, 0.935	-0.129±0.506, 0.799	-0.032±0.501, 0.950	0.093±0.524, 0.859	0.043±0.525, 0.935
Overweight	NA	NA	0.021±0.193, 0.914	0.021±0.193, 0.914	0.000±0.193, 0.999	0.021±0.186, 0.911	0.055±0.184, 0.764	NA	0.021±0.193, 0.914	0.000±0.193, 0.999	0.021±0.186, 0.911	0.055±0.184, 0.764	0.021±0.193, 0.914	0.000±0.193, 0.999
Obese	NA	NA	NA	NA	0.448±0.235, 0.057	0.343±0.229, 0.136	0.537±0.229, 0.019	NA	NA	0.375±0.238, 0.115	0.343±0.229, 0.136	0.537±0.229, 0.019	NA	0.375±0.238, 0.115
Existence of chronic disease (yes/no)	NA	NA	NA	NA	0.401±0.207, 0.053	0.358±0.200, 0.074	0.407±0.198, 0.040	NA	NA	0.401±0.207, 0.053	0.358±0.200, 0.074	0.407±0.198, 0.040	NA	0.401±0.207, 0.053
Willingness of vaccination against COVID-19 (yes/no-I have not decided yet)	NA	NA	NA	NA	NA	2.011±0.164, <0.0001	1.980±0.162, <0.0001	NA	NA	NA	2.011±0.164, <0.0001	1.980±0.162, <0.0001	NA	NA
HLS_EU_Q16 score	NA	NA	NA	NA	NA	NA	0.101±0.035, 0.004	NA	NA	NA	NA	0.101±0.035, 0.004	NA	NA
PSS score	NA	NA	NA	NA	NA	NA	0.021±0.013, 0.094	NA	NA	NA	NA	0.021±0.013, 0.094	NA	NA
SWLS score	NA	NA	NA	NA	NA	NA	0.064±0.015, <0.0001	NA	NA	NA	NA	0.064±0.015, <0.0001	NA	NA
MEDAS score	NA	NA	NA	NA	NA	NA	0.166±0.040, <0.0001	NA	NA	NA	NA	0.166±0.040, <0.0001	NA	NA

P<0.05.

b, unstandardised; HLS_EU_Q16, European Health Literacy Survey Questionnaire; MEDAS, Mediterranean Diet Adherence Screener; NA, not applied; PSS, Perceived Stress Scale; SWLS, Satisfaction with Life Scale.

Table 4 Results (OR, 95% CI) from logistic regression analysis models that evaluated various participants' characteristics as determinants of the willingness to vaccinate against COVID-19 (yes vs no/ have not decided yet)

	First model		Second model		Third model		Fourth model		Fifth model		Sixth model	
	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	OR (95% CI), p value	
Sex (women/men)	0.633 (0.513 to 0.791), <0.0001	0.679 (0.548 to 0.841), <0.0001	0.657 (0.528 to 0.817), <0.0001	0.647 (0.517 to 0.809), <0.0001	0.642 (0.513 to 0.804), <0.0001	0.450 (0.350 to 0.577), <0.0001						
Age in years	NA	1.033 (1.025 to 1.042), <0.0001	1.034 (1.026 to 1.043), <0.0001	1.035 (1.026 to 1.044), <0.0001	1.034 (1.025 to 1.043), <0.0001	1.025 (1.015 to 1.035), <0.0001						
Education (Ref: up to lyceum)												
Tertiary education			1.549 (1.192 to 2.012), 0.001	1.562 (1.202 to 2.029), 0.001	1.568 (1.206 to 2.038), 0.001	1.574 (1.200 to 2.067), 0.001						
MSc/PhD	NA	NA	2.987 (2.226 to 4.009), <0.0001	3.005 (2.238 to 4.035), <0.0001	3.015 (2.245 to 4.049), <0.0001	2.970 (2.185 to 4.036), <0.0001						
Weight status category (Ref: normal weight)												
Thin				1.344 (0.719 to 2.515), 0.355	1.351 (0.723 to 2.528), 0.346	1.525 (0.793 to 2.933), 0.206						
Overweight				0.915 (0.701 to 1.196), 0.382	0.933 (0.711 to 1.222), 0.613	1.019 (0.768 to 1.351), 0.897						
Obese	NA	NA	NA	0.873 (0.660 to 1.154), 0.340	0.885 (0.668 to 1.172), 0.393	0.949 (0.709 to 1.272), 0.728						
Existence of chronic disease (yes/no)	NA	NA	NA	NA	1.109 (0.875 to 1.405), 0.393	1.041 (0.813 to 1.331), 0.752						
Adherence to the COVID-19 prevention measures	NA	NA	NA	NA	NA	1.182 (1.148 to 1.217), <0.0001						
HLS_EU_Q16 score	NA	NA	NA	NA	NA	0.994 (0.951 to 1.039), 0.798						
PSS score	NA	NA	NA	NA	NA	0.997 (0.982 to 1.013), 0.733						
SWLS score	NA	NA	NA	NA	NA	0.999 (0.981 to 1.018), 0.951						
MEDAS score	NA	NA	NA	NA	NA	0.966 (0.920 to 1.015), 0.175						

HLS_EU_Q16, European Health Literacy Survey Questionnaire; MEDAS, Mediterranean Diet-Adherence Screener; NA, not available; PSS, Perceived Stress Scale; SWLS, Satisfaction with Life Scale.

to vaccinate, while concurrently investigating their determining factors.

The results of the current study indicate that a total of only 57.5% of the participants reported that they are willing to vaccinate against COVID-19, 12.1% reported that they did not want to vaccinate and 30.4% were undecided. Women were less willing to vaccinate but their reported adherence to the prevention measures, was statistically significantly higher, in comparison to men. The results are similar to another earlier study conducted in Germany, in 2020, where almost half of the adult population, reported that they were hesitant to vaccinate against the SARS-CoV-2.⁸ It is interesting to note that the above two studies, were conducted a year apart, and in spite of the obvious increasing seriousness of the pandemic, both worldwide and in Germany, a great proportion of the population reported that they were still reluctant to vaccinate. Similar trends are seen in Europe and worldwide. This was recently reported that over a quarter of people living in Europe indicate a hesitancy toward the COVID-19 vaccine.⁴⁴ The reasons behind this reported hesitancy are complex, may differ from country to country and require further thorough investigation. In the current study, HL was not associated with willingness to vaccinate, however, in a very recent study conducted in France, a significant association between vaccine hesitancy and low levels of HL was reported.⁴⁵ Higher education levels, older age and better adherence to the prevention measures, in the current study, increase the odds of willingness to vaccinate, which is plausible given the fact that the seriousness of the disease increases with age.

Self-reported adherence to COVID-19 prevention measures in the current study, is considered inadequate, with a median score of 23.08 (3.83) (range 1=low-35=high), based on the specially created questionnaire. Due to the seriousness of the disease, the easy transmissibility of the virus and the fact that the study was conducted during the third wave in Germany and during a lock down period, a more satisfactory adherence to the prevention measures, was expected. In the current study, women reported statistically significantly higher adherence to the prevention measures, in comparison to men. The reasons behind the above difference need to be further and more thoroughly investigated. One plausible explanation for the reported better adherence to the prevention measures of COVID-19, could be attributed to the traditional role of females, in most societies, in caring for sick family members and children.^{46 47} Females, in general, tend to have higher levels of HL and have more interactions with the healthcare system, in comparison to men.^{25 48}

It is important to underline in this study HL levels, older age, existence of chronic disease, obesity, higher life satisfaction levels and low adherence to the MD, were positively associated with higher adherence to the prevention measures of COVID-19. With respect to HL levels and its positive association with better adherence to the prevention measures, the results are plausible. A health literate population is more likely to better adhere to the protective measures related to the prevention of COVID-19 spread, to better manage the disease if they are infected and to successfully cope with navigating health services and be less influenced by fake news. It is well documented that the risk for severe illness with COVID-19 and the risk of dying from the disease, increases with age, chronic disease and excess body weight, hence, it was anticipated that older people, people with chronic disease and obese participants, would adhere better to the prevention measure and would be more willing to vaccinate. The results of the

current study are also supported by another similar study conducted in Germany in early 2020.⁸ Another interesting finding of the current study is the positive association between adherence to the prevention measures of COVID-19 and life satisfaction levels. Life satisfaction is a concept related to how positively a person evaluates the overall quality of their life and it is well documented that people with higher own life satisfaction, will be better equipped to engage in a more reflective and rational behaviours in difficult situations, such as a global, life-threatening pandemic.⁴⁹⁻⁵³

It is also interesting to note that better diet quality, as assessed by the levels of adherence to the MD, was significantly associated with better adherence to the prevention measures of COVID-19. It is highly likely that people who have healthier eating habits, have in general better health behaviours, which could partly explain the above association.⁵⁴ A recent study conducted in Spain has concluded that better adherence to the MD may be associated with a lower risk of COVID-19.³⁴

The findings of this study should also be considered in the light of a few methodological limitations including the self-reported nature of the data and the snowball sampling method of the participants, which resulted in a large, but not representative sample of the German adult population, with respect to sex.

CONCLUSION

Higher HL levels, higher education levels, older age and being a woman are some of the factors positively associated with higher adherence to the prevention measures of COVID-19. Older age, higher education level, adherence to prevention measures and being a man, increase the odds of willingness to vaccinate. The current study provides an urgently needed, better insight with respect to the factors affecting adherence to the prevention of COVID-19 and willingness to vaccinate against the disease. The results could be used by practitioners, researchers and policy-makers working in the field of prevention and management of COVID-19 – 19, in the community.

Main messages

- ▶ The study aims to investigate factors determining COVID-19 vaccine hesitancy and adherence to prevention measures, in German adults.
- ▶ Higher health literacy levels, higher education levels, older age and being a woman are some of the factors positively associated with higher adherence to the prevention measures of COVID-19.
- ▶ The current study provides an urgently needed, better insight with respect to the factors affecting adherence to the prevention of COVID-19 and willingness to vaccinate against the disease.

Current research questions

- ▶ What are the major predictors for COVID-19 vaccine hesitancy in a high-risk population?
- ▶ Mention the role of literacy, diet and socioeconomic to combat COVID-19 vaccine hesitancy.
- ▶ What is the role of government health policy in the field of prevention and management of COVID-19 in the community?

What is already known on the subject

- ▶ Age, socioeconomic status, education and health literacy are the known major predictors for COVID-19 vaccine hesitancy.
- ▶ The geographic considerations of the population are proven to cause theoretical disparities in vaccination coverage programme.
- ▶ A diet characterized by healthy plant-based foods are associated with lower risk and severity of COVID-19.

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