

A conceptual framework to model social determinants of COVID-19 vaccination uptake among underserved homeless populations

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A B S T R A C T

Background: Homeless people have a higher risk of COVID-19 infection, linked to several social, economic and environmental determinants, frequent comorbidities, obstacles to exercising their constitutional social and health rights, poor medical cover, and insufficient use of the healthcare system. Data on COVID-19 vaccine uptake and its main determinants are lacking for this underserved population.

Objectives: To construct and test a conceptual framework to model structural social determinants of COVID-19 vaccine uptake among underserved homeless populations, and to test this model to identify the determinants of COVID-19 vaccine uptake on the homeless population living in two metropolitan areas in France.

Methods: We implemented a multicenter cross-sectional survey from 15/11/2021 to 22/12/2021 in homeless adults in the city of Marseille and in the greater Paris area. Persons sheltered in migrant worker hostels or in emergency social shelters, members of the COVID HOMELESS cohort study in Marseille, and Travelers living in traditional housing were all eligible. A standardized face-to-face questionnaire was administered to the participants where they lived in various languages by trained interviewers. We used structural equation modeling to analyze the structural social determinants of COVID-19 vaccine uptake, the latter defined as receiving at least one dose.

Results: The participation rate was 64 %, accounting for 3811 participants. There were three main factors associated with greater vaccine uptake: i) **opportunity**, which included having a personal general practitioner ($\beta = 0.05$, $p < 0.05$), healthcare cover ($\beta = 0.05$, $p < 0.05$), and somebody to accompany the participant for medical appointments ($\beta = -0.04$, $p < 0.05$); ii) **motivation**, which included attitudes towards vaccination ($\beta = 0.55$, $p < 0.05$), press- and poster-based information ($\beta = 0.03$, $p < 0.05$), and vaccination history ($\beta = 0.03$, $p < 0.05$); iii) **type of housing** ($\beta = 0.13$, $p < 0.05$) and **housing stability** ($\beta = 0.04$, $p < 0.05$).

Conclusion: Our results highlight that housing exclusion is a structural social determinant of COVID-19 vaccine uptake in homeless people in France. They also underline the role which opportunity and motivation play in improving uptake in this underserved homeless population.

Background.

Homelessness is defined as a lack of access to suitable housing (1). In France, people experiencing homelessness (PEH) include individuals living on the street, persons sheltered in temporary emergency accommodation (1) or in collective accommodation, as well as Travellers who live in traditional housing (e.g., caravans). The term Travellers refers to French citizens who live and move around in mobile dwellings for all or part of the year, they have a particular way of life characterized by regular nomadism, community support and occasional or seasonal employment. PEH vaccination uptake and vaccine hesitancy rates in

France are often lower and higher, respectively, compared to the general population (2).

Vaccine hesitancy has influenced COVID-19 immunization programs worldwide since the 2020–2022 pandemic (3,4). There are several determinants involved in vaccine hesitancy. Behavioral theories are used to understand the determinants behind vaccine-related decision-making, by assessing the motivations and inhibitions involved in terms of adopting health-related behaviors. According to the health belief model (HBM), beliefs, perceived severity and susceptibility of a disease, perceived risks and benefits of a vaccine, as well as perceived barriers to

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vaccination, are all related to health behaviors, and therefore to vaccine uptake and vaccine hesitancy (5). Determinants of health, however, influence health outcomes. They are defined as the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life. They also explain how differences in health status and healthcare use within a population are not the result of biology and individual choices in health behavior alone, but also of the conditions under which those choices are exercised.

The World Health Organization identified vaccine hesitancy as one of the major global health challenges in 2019, ranking it among the top 10 threats to public health worldwide (6). France is one of the most vaccine-hesitant countries in the world, including COVID-19 vaccine hesitancy. In the late spring of 2020, vaccine hesitancy was estimated at 25 % of the general French population (7), rising to 60 % in December 2020 (8). Potential strategies to increase COVID-19 vaccination in the country have been investigated in previous studies (9,10). According to Cambon, perceived vaccine efficacy, attitudes and beliefs including perceived severity and risk, subjective norms, the vaccine manufacturer, and the risk of serious side effects, are all major determinants of vaccine acceptability in France (9).

France's official COVID-19 vaccination strategy had no social-based criterion. It followed a five-stage coverage plan. The first three stages prioritized individuals based on their age and high-risk comorbidities. People living in social precariousness, including PEH, were only included in the fourth stage (11) (Appendix 1).

PEH have a higher risk of COVID-19 infection, which is linked to several determinants of health such as unhealthy housing, poor medical cover, and overall insufficient use of healthcare system (including insufficient vaccination coverage), which make them even more susceptible to worse COVID-19 outcomes such as incidence, hospitalization, and mortality (12). Overcrowding in collective accommodations leads to a higher risk of contamination by COVID-19 and other diseases (13). Healthcare accessibility, a fundamental human right, which also includes vaccine access, is defined by the ability to access health services. Healthcare accessibility also includes geographic accessibility (nearby health services), financial or economic accessibility (affordability, which varies according to the health system in the country), temporal and organizational accessibility (availability of physicians and the length of time they wait for appointments).

PEH face barriers to vaccination, including a lack of dedicated services and negative experiences in the past with healthcare services. They are also more likely to have loss trust in the state. All these factors add to create substantial vaccine hesitancy in PEH and lead them to give low priority to their health (14). Migrant PEH face additional difficulties, such as a liminality, language barriers, and obstacles to exercising their constitutional rights (15).

Although Longchamps et al. highlighted a significant association between low vaccination intention against COVID-19 and low health literacy, female sex, and being a legal resident in France (16), few studies to date have focused on the social determinants on COVID-19 vaccination uptake in vulnerable populations in the French context. Despite these few studies to date, no conceptual framework to model social determinants of health was created particularly for underserved homeless populations, which could help us understand the association between determinants of health and vaccine uptake.

The present study aimed to construct a conceptual framework to model social determinants of COVID-19 vaccine uptake among underserved homeless populations, and to test this model by identifying the main determinants of COVID-19 vaccine uptake in PEH in two metropolitan areas in France.

Methods

Survey design and study population

We implemented a multi-center cross-sectional survey in two

metropolitan areas, specifically the city of Marseille and the greater Paris area. Participants from Marseille were included from the COVID HOMELESS cohort which is a cohort study that followed up for two years approximately 1,200 homeless persons, migrants and other persons living in very precarious condition in the city of Marseille (Appendix 2). The survey was conducted from 15/11/2021 to 22/12/2021.

The sampled populations were stratified according to the European Typology of Homelessness and housing exclusion (ETHOS) (17) (Appendix 3). Inclusions were performed at the place where participants had slept the previous night. Survey participation criteria were as follows: living on the street, sheltered in a hostel for migrant workers, sheltered in an emergency social shelter, living in traditional Traveler housing, or participating in the COVID HOMELESS cohort. Participants had to be 18 years old or older and be able to provide free and informed consent. Exclusion criteria were refusal to participate, language barriers with no translation capabilities available (whether in-person or telephone-based), and not being able to give free and informed consent.

A complex two-stage random sample design was constructed. In each stratum, recruitment sites were randomly selected (first stage). Participants were then drawn at random depending on the site type (second stage). The sample size per site (Appendix 2) was calculated in proportion to the expected site population depending on the type of site. In emergency social shelters and in Migrant Worker Hostels, individuals were randomly selected using simple random sampling when resident lists or room plans/lists were available; otherwise systematic random sampling was performed. If a person randomly selected to participate was absent, he/she was replaced by another adult sharing the same room or living in the next adjacent room. Eligible adults living on the street (including those living in squats and slums) were randomly selected and were systematically invited to participate (exhaustive sampling) until the stratum sample size was reached. In the case of refusal, the next person in sight was invited (13).

We categorized participating PEH from both metropolitan areas into five groups based on the most frequent living place over the previous three months as follows: temporarily hosted in accommodation centers ($n = 994$), emergency social shelters ($n = 1185$), individuals who rented or owned a place of their own (including Travelers) ($n = 149$), migrant worker hostels ($n = 851$) and people living on the street including those living in squats and slums ($n = 632$) (Fig. 1).

Data collection

A standardized face-to-face questionnaire was administered to participants by trained interviewers. Interviews were either conducted or interpreted in French, English, Arabic, Farsi, Pashto, Dari, Spanish, Turkish, Wolof, and Pulaar. The questionnaire collected demographic and socioeconomic data, details of the participant's housing and immigration situation, and information on health literacy (18), discrimination history (19), social support (20), food security, healthcare access, self-perceived health. Stable housing (*versus* unstable) was defined as having moved house fewer than 4 times in the previous three months.

A COVID-19 module in the questionnaire collected data on healthcare utilization, history of vaccination, COVID-19 vaccination, opinions about vaccination (COVID-19 and in general), whether the participant had attitudes towards COVID-19 prevention measures or not, and his/her perception of the COVID-19 information provided by different sources, such as the press, posters, social workers and health workers.

Conceptual model

We constructed and tested a model that characterized COVID-19 vaccine uptake, which was defined as receiving at least one dose of the vaccine (Appendix 4). We named this model RVAX-COM-B (Fig. 2). To construct it, we used Andersen et al's. Behavior Model of Health Service Use (BMHSU) (21) adapted for people in vulnerable situations,

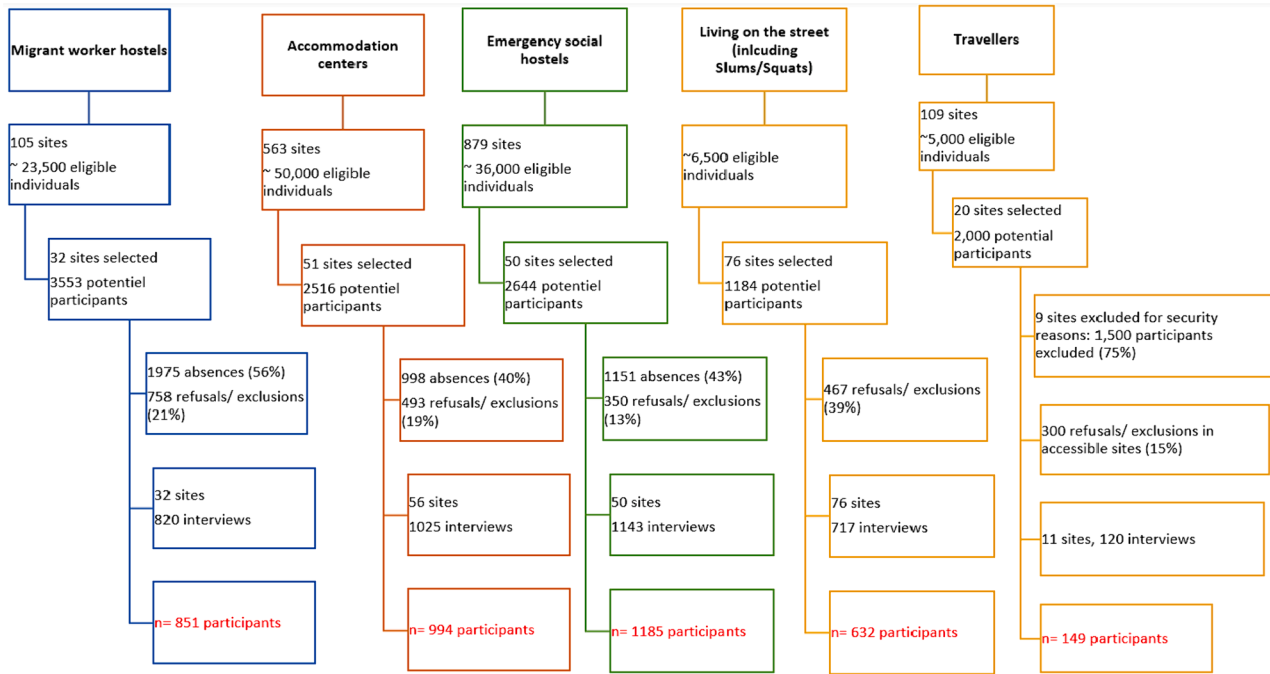


Fig. 1. Flow chart of the survey design and study population.

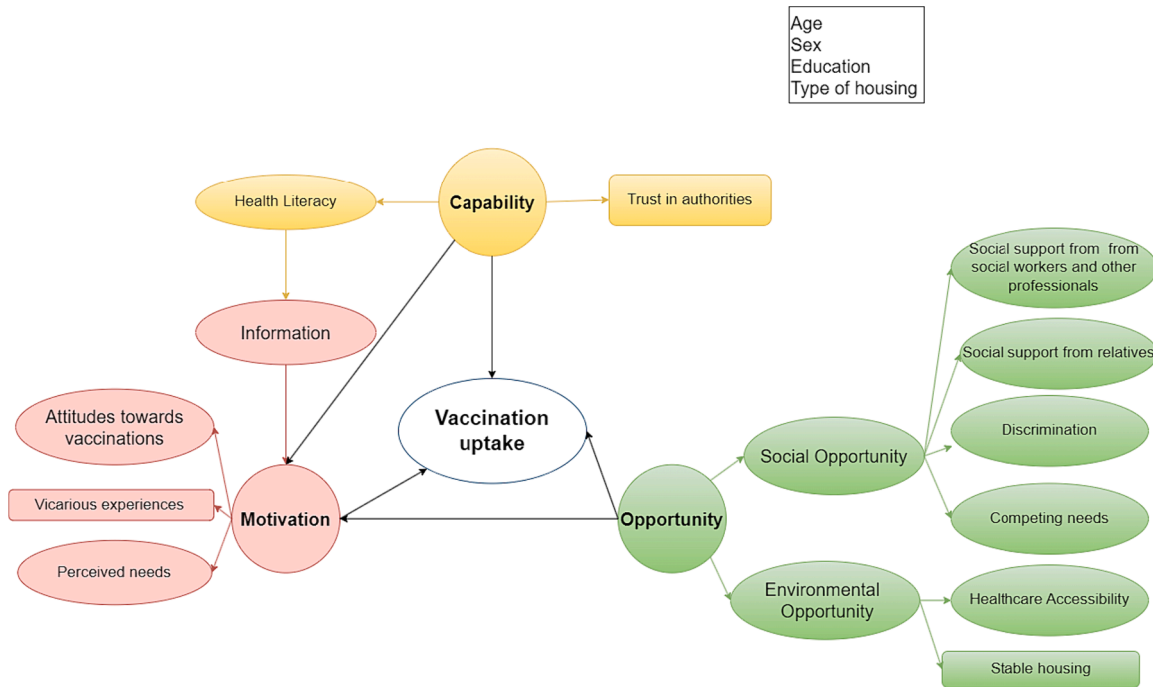


Fig. 2. Conceptual model (RVAX-COM-B) of the determinants of COVID-19 vaccine uptake.

as proposed by Gelberg et al. (22). This adaptation involves dividing each component of the BMHSU into two parts: one grouping the ‘classic’ factors common to different populations (e.g., age, gender, education, employment), and the other grouping factors more specific to populations exposed to vulnerability (e.g., living conditions, mobility, information sources). We then sorted the factors identified following Michie’s COM-B model (23). The latter model (where COM stands for capability, opportunity, and motivation) enables researchers to take equally into account individual mechanisms (capability and motivation), and social and environmental factors (opportunity), which

facilitate or inhibit behavioral change (in our case, change concerning COVID-19 vaccine uptake). More specifically, capability represents an individual’s physical and psychological capacities to perform a health-related behavior. Motivation represents a person’s reflective and automatic mechanisms that activate or inhibit a behavior, as well as the perception of risks (24). Finally, opportunity represents the physical or social environment that enables the behavior (23). It is used to explore perceived barriers and facilitators in order to identify potential levers for change in order that adoption of the behavior can occur.

To test our model on the five groups of PEH described above, that is

to say, to study the factors associated with COVID-19 vaccine uptake in these sub-populations, we used Structural Equation Modelling (SEM). This diverse group of methods is used to represent, estimate and test relationships between a set of variables according to a conceptual model. These variables can be observed (i.e., measured in a questionnaire) or unobserved (also called “latent variables” (LV)) (25).

Construction of the conceptual model

We identified nine latent variables (Table 1) which included a total of 42 indicators (i.e., 42 observed variables from the questionnaire); two other observed variables were not indicative of any of these nine latent variables.

Statistical analysis

A descriptive analysis of all participant characteristics was performed. Multiple imputations were carried out for missing values as a pre-requisite to SEM. Imputations were mostly performed for the ‘health literacy’ (23–26 %), ‘social support from social workers and other professionals’ (13–15 %), and ‘social support from relatives’ (5–10 %) latent variables. To study factors associated with vaccine uptake, we first analyzed each latent variable’s weighted covariance matrix of indicators with the Pearson correlation coefficient. We excluded all variables with a correlation coefficient lower than 0.30 (26). Second, we ensured the mono-dimensionality of each latent variable (27). Third, we carried out a confirmatory factor analysis to estimate relationships between indicators for each latent variable (27). Finally, the model was assessed using the Weighted Least Squares with Mean and Variance adjustment (WLSMV) estimator (28). The significance level was set at 5 %. The model’s goodness-of-fit was evaluated using the comparative fit index (CFI > 0.90) and the root mean square error of approximation (RMSEA < 0.08). Analyses were performed using R software version 4.1.0. Significant interaction was defined by a positive factor loading β . The higher the β was, the stronger the correlation. *Sensitivity analysis.*

We also conducted a sensitivity analysis only for housed participants (in accommodation centers, emergency social shelters, migrant worker hostels), in order to find the specific factors associated with COVID-19 vaccination uptake by them, with a view to adapting current vaccination strategies and interventions in these structures..

Ethical considerations

The study received ethical approval from the French Ministry of Health on 17 July 2021, specifically through the National Priority for Research certification. The study protocol was approved by the Committee for the Protection of Persons (CPP) (20050–62628) in Paris on 13 August 2021.

Results

Characteristics of the study population

Socio-demographic characteristics

The participation rate (number of people who participated over the number of people who were asked) was 64 %, accounting for 3811 participants: 3440 in the greater Paris area and 371 in the city of Marseille (Appendix 5). Just over half the participants were men (53.8 %), and median age was 38 years (Table 2). One-fifth (21.4 %) had never attended school or were illiterate. With respect to the five different PEH groups investigated, 36.9 % were living in accommodation centers, 21.4 % in hostels for migrant workers, 30.3 % in emergency social shelters, 9.3 % were living on the street, and 2.1 % had personal housing (including Travelers).

COVID-19 Vaccine Uptake: COVID-19 vaccine uptake overall was 74.5 % in the study sample. Individuals living in emergency social

Table 1
Latent variable construction.

Latent Variable	N°	Indicator	
Information about COVID-19		Internet was a source of information	Yes/No
		Social and Health workers were a source of information	Yes/No
		Press and Posters were a source of information	Yes/No
		Family and friends were a source of information	Yes/No
		Perception that information was sufficient	Yes/No
		Fear of illness	Yes/No
Attitudes to vaccination		Fear of vaccine	Yes/No
		Had a history of vaccination	Yes/No
		Personal opinion of COVID vaccine	Favorable/Opposed
		Personal opinion of vaccination in general	Favorable/Opposed/Neither
		Social norms (i.e., opinion of family and friends about the COVID-19 vaccine)	Favorable/Opposed/Neither
		Vicarious experiences (i.e., Covid and entourage)	Yes/No
Perceived needs		Perceived COVID-19 vaccine to be useful	Yes/No
		Perceived health status	Score from 0 to 10
Competing needs		Perceived financial situation	Difficult/ Comfortable
		Sufficient food	Yes/No
Discrimination		Administrative status	Having French nationality or a valid residence permit/ Not having French nationality or expired/ no permit
		Being a victim of racism	Yes/No
		Being threatened with eviction	Yes/No
		Being discriminated against in healthcare settings	Yes/No
		Being discriminated against in the COVID-19 vaccination process	Yes/No
		Listening support	Yes/No
Social support from social workers and other professionals		Material support	Yes/No
		Advice	Yes/No
		Encouragement	Yes/No
		Being accompanied by someone for medical appointments	Yes/No
Social support from relatives		Listening support	Yes/No
		Material support	Yes/No
Healthcare accessibility		Advice	Yes/No
		Encouragement	Yes/No
		Feeling alone	Yes/No
		Distance to a doctor (<15 min walk)	Yes/No
		Distance to a pharmacy (<15 min walk)	Yes/No
		Distance to a hospital (<15 min walk)	Yes/No
		Distance to a vaccination center (<15 min walk)	Yes/No
			Yes/No

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Table 1 (continued)

Latent Variable	N°	Indicator
Health literacy		Having healthcare cover Yes/No
		Having a personal general practitioner Yes/No
		Understanding written posters Yes/No
		Understanding written prescriptions Yes/No
		Understanding oral prescriptions Yes/No
		Know how to book appointments Yes/No
		Know how to Fill out medical forms Yes/No

shelters and those living on the street were less likely to be vaccinated (70.4 % and 41.5 %, respectively) than participants in migrant worker hostels and those in in accommodation centers (85.9 % and 80 %, respectively).

With respect to Michie’s three COM-B model components, we divided opportunity into two sub-components, social and environmental. Below are the COM-B results:

Social opportunity: 18.6 % of participants declared that they had been a victim of racism (Table 2); 5.5 % declared that they experienced discrimination in a healthcare setting. A higher percentage of participants had received advice and encouragement from relatives than from social workers and other professionals (67.3 % and 70.5 %, respectively, versus 43.8 % and 45.7 %).

Environmental opportunity: Over half of the participants had their own general practitioner, and most had healthcare cover (86.7 %).

Motivation: 72.4 % were opposed to the COVID-19 vaccine, and 51.9 % found the information on COVID-19 to be insufficient.

Capability: Data on the health literacy latent variable was unavailable for 20 % of respondents (Table 2). With regard to the indicators in this variable, 32.2 % of the study population could not complete medical forms correctly.

Factors associated with vaccine uptake

Validation of latent variables

The weighted correlations between the indicators (i.e., observed variables) of each latent variable ranged from -0.01 to 0.80 (details given in Supplementary data).

Fig. 3 presents the final structural equation model. The factor loading β represents the unique strength of the relationship between the identified factors and greater vaccine uptake. The main variables associated with vaccine uptake in terms of Michie’s COM-B model components were as follows: for **motivation**, the variables were attitudes towards vaccination ($\beta = 0.55, p < 0.05$), press and posters as sources of information ($\beta = 0.03, p < 0.05$), and having a history of vaccination ($\beta = 0.03, p < 0.05$). For **opportunity**, the variables were having a personal general practitioner ($\beta = 0.05, p < 0.05$), having healthcare cover ($\beta = 0.05, p < 0.05$), and being accompanied by someone for medical appointments ($\beta = 0.04, p < 0.05$). No **capability** variable including health literacy was significantly associated with COVID-19 vaccine uptake.

In addition, being temporarily hosted in an accommodation center, staying in an emergency social shelter, and renting or owning one’s housing in the three previous months ($\beta = 0.13, p < 0.05$) were all associated with better vaccine uptake, as was stable housing ($\beta = 0.04, p < 0.05$).

With regard to indirect associations, the latent variable ‘social support from social workers and other professionals’ exerted a positive impact on two other latent variables: ‘attitudes towards vaccination’ (β

Table 2

Characteristics of the participants.

Characteristics	N	%*	CI 95 %**
Age (years)	3802	99.8	
- 18–35	1532	39.9	(37.1; 42.6)
- 35–55	1558	40.9	(38.7; 43.6)
- 55–75	623	16.6	(14.6; 18.6)
- >75	89	2.6	(1.8; 3.5)
Mean: 41 years			
Median: 38yearsStandard deviation: 0.79			
Sex	3807	99.9	
- Male	2218	53.1	(49.9; 56.4)
- Female	1589	46.9	(43.6; 50.1)
Education	3811	100.0	
- Never attended school / illiterate	846	21.4	(19.4; 23.5)
- Primary school	757	19.1	(17.4; 20.8)
- Middle /High school	1635	43.3	(40.9; 45.6)
- Tertiary education	573	16.2	(14.6; 17.7)
Country of birth	3791	99.5	
- France	450	11.7	(10.1; 13.4)
- European Union	230	4.1	(3.1; 5.0)
- Outside the European Union	3111	84.2	(82.3; 86.1)
Type of housing during the previous 3 months	3811	100.0	
- Accommodation centers (CFA/ES)	994	36.9	(33.6; 40.3)
- Migrant worker hostels	851	21.4	(19.2; 23.5)
- Emergency social shelters	1185	30.3	(27.3; 33.3)
- Living on the street (including Slums/Squats)	632	9.3	(8.2; 10.3)
- Personal housing	149	2.1	(1.1; 3.1)
Number of times participant changed housing in previous 3 months	3757	95.6	
- 0 times	447	12.1	(8.6; 15.6)
- 1 times	2805	77.5	(74.0; 81.1)
- 2 to 3 times	414	9.1	(7.7; 10.4)
- More than 4 times	91	1.3	(0.9; 1.8)
Social opportunity			
Discrimination			
Being a victim of racism	3389	88.9	
- No	2713	81.4	(79.0; 83.9)
- Yes	676	18.6	(16.1; 21.0)
Being threatened with eviction	3811	100.0	
- No	3507	92.4	(91.0; 93.8)
- Yes	304	7.6	(6.2; 9.0)
Being discriminated against in healthcare settings	3749	98.4	
- No	3507	94.5	(93.5; 95.5)
- Yes	242	5.5	(4.5; 6.5)

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Table 2 (continued)

Characteristics	N	%*	CI 95 % **
Being discriminated against in the COVID-19 vaccination process	3649	95.7	
- No	3632	99.6	(99.4; 9.8)
- Yes	17	0.4	(0.2; 0.6)
Social support			
- Having social support from social workers and other professionals			
Listening support	3327	87.3	
- No	1700	49.4	(46.3; 52.5)
- Yes	1627	50.6	(47.5; 53.6)
Having a material support	3323	87.2	
- No	1674	50.1	(46.6; 53.7)
- Yes	1649	50.1	(46.3; 53.4)
Having someone to advise you	3329	49.9	
- No	1641	47.2	(44.0; 50.5)
- Yes	1688	52.8	(49.5; 56.0)
Having someone to encourage you	3244	85.1	
- No	1885	56.2	(52.8; 59.6)
- Yes	1359	43.8	(40.4; 47.2)
Being accompanied by someone for medical appointments	2603	68.0	
- No	1396	54.3	(50.5; 58.1)
- Yes	1207	45.7	(41.9; 49.5)
- Social support from relatives			
Listening support from relatives	3648	95.7	
- No	996	25.3	(23.1; 27.4)
- Yes	2652	74.7	(72.5; 76.9)
Material support from relatives	3538	92.8	
- No	1855	53.5	(50.8; 56.2)
- Yes	1683	46.5	(43.8; 49.2)
Advice from relatives	3581	93.9	
- No	1260	32.7	(30.2; 35.2)
- Yes	2321	67.3	(64.7; 69.8)
Encouragement from relatives	3515	92.2	
- No	1136	29.5	(26.9; 31.9)
- Yes	2379	70.5	(68.0; 73.0)
Feeling alone	3715	97.5	
- No	1877	52.4	(49.8; 55.0)
- Yes	1838	47.6	(44.9; 50.2)
Competing needs			
- Having sufficient food	3763	98.7	
- No	1786	45.3	(42.1; 48.5)
- Yes	1977	54.7	(51.5; 57.9)
Administrative status (Having the French nationality/ or a valid residence permit)	3798	99.7	
- No	1194	30.9	(28.3; 33.6)
- Yes	2604	69.1	(66.4; 71.7)

Table 2 (continued)

Characteristics	N	%*	CI 95 % **
Environmental opportunity			
Healthcare accessibility			
Distance to a doctor (<15 min walk)	3811	100.0	
- No	486	14.22	(10.3; 18.2)
- Yes	3325	85.78	(81.8; 89.7)
Distance to a pharmacy (<15 min walk)	3811	100.0	
- No	141	4.88	(2.5; 7.3)
- Yes	3670	95.12	(92.7; 97.5)
Distance to a vaccination center (<15 min walk)	3811	100.0	
- No	996	26.76	(21.9; 31.6)
- Yes	2815	73.24	(68.4; 78.1)
Distance to a hospital (<15 min walk)	3811	100.0	
- No	1407	33.99	(28.7; 39.3)
- Yes	2404	66.01	(60.7; 71.3)
Having a personal general practitioner	3767	98.8	
- No	1359	31.2	(29.0; 33.5)
- Yes	2408	68.8	(66.5; 71.0)
Having healthcare cover	3771	98.9	
- No	689	13.3	(11.8; 14.7)
- Yes	3082	86.7	(85.2; 88.2)
Motivation	3804	99.8	
COVID vaccination			
- No	1077	25.5	(23.5; 27.5)
- Yes, at least 1 dose	2727	74.5	(72.5; 76.5)
Information about COVID-19			
Internet was a source of information	3788	99.4	
- No	2419	63.8	(61.2; 66.4)
- Yes	1369	36.2	(33.6; 38.8)
Press and Posters were a source of information	3788	99.4	
- No	1187	29.2	(26.9; 31.6)
- Yes	2601	70.8	(68.4; 73.1)
Social and Health workers were a source of information	3788	99.4	
- No	2953	77.7	(75.1; 80.3)
- Yes	835	22.3	(19.7; 24.8)
Family and Friends were a source of information	3788	99.4	
- No	2478	68.5	(66.1; 70.9)
- Yes	1310	31.5	(29.1; 33.9)
Perception that information was sufficient	3785	99.3	
- No	1963	51.96	(49.3; 54.6)
- Yes	1822	48.04	(45.3; 50.7)
Had a history of vaccination	3711	97.4	
- Yes	3433	92.6	(91.4; 93.7)
- No	278	7.4	(6.3; 8.6)
Personal opinion of the COVID vaccine	3503	91.9	

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Table 2 (continued)

Characteristics	N	%*	CI 95 % **
- Favorable	1013	27.6	(25.4; 29.9)
- Opposed	2490	72.4	(70.1; 74.6)
Personal opinion of vaccination in general	3797	99.6	
- Favorable	3323	89.4	
- Opposed	227	4.9	(88.0; 91.8)
- No opinion	247	5.8	(4.8; 6.7)
Having a fear of vaccine	3775	99.0	
- No	2007	52.8	(50.4; 55.2)
- Yes	1768	47.2	(44.8; 49.6)
Fear of illness	3086	80.9	
- No	1346	42.4	(39.9; 45.0)
- Yes	1740	57.6	(55.0; 60.1)
Perceive COVID-19 vaccine to be useful	3373	88.5	
- No	1046	30.2	(27.8; 32.7)
- Yes	2327	69.8	(67.3; 72.2)
Social norms (i.e., opinion of family and friends about the COVID-19 vaccine)	3328	87.3	
- Favorable	1533	46.9	(44.1; 49.6)
- Neither favorable nor opposed	963	29.1	(26.7; 31.5)
- Opposed	832	24.0	(21.7; 26.3)
Vicarious experiences (i.e., loved one's experiences with COVID-19)	3797	99.6	
- No COVID-19 or hospitalization	1997	50.8	(48.5; 53.2)
- COVID-19 without hospitalization	915	26.9	(24.6; 29.1)
- COVID-19 with hospitalization	828	22.3	(20.3; 24.2)
Perceived needs	3745	98.3	
Perceived financial situation			
- Getting by/ Comfortable	1641	48.3	(45.1; 51.1)
- Difficult/ in debt	2104	51.7	(48.5; 54.9)
Perceived health status (from 0 to 10, 10 being excellent health)	3735	98.0	
- ≤4	312	8.5	(7.3; 9.7)
- 5	513	12.6	(10.9; 14.4)
- ≥6	2910	78.9	(76.7; 81.1)
Capability			
Health literacy			
Understanding written posters	2907	76.3	
- No	1004	30.9	(28.1; 33.7)
- Yes	1903	69.1	(66.3; 71.9)
Understanding written prescriptions	2890	75.8	
- No	925	28.5	(25.4; 31.6)
- Yes	1965	71.5	(68.4; 74.6)
Understanding Oral prescriptions	2883	75.6	
- No	541	16.4	(13.9; 18.9)
- Yes	2342	83.6	(81.1; 86.1)
Know how to book appointments	2853	74.9	

Table 2 (continued)

Characteristics	N	%*	CI 95 % **
- No	632	19.1	(16.2; 21.9)
- Yes	2221	80.9	(78.1; 83.8)
Know how to fill out medical forms	2814	73.8	
- No	993	32.2	(29.1; 35.4)
- Yes	1821	67.8	(64.6; 70.9)
Having trust in health authorities (from 1 to 11, 11 being having full trust)	3350	87.9	
- 0-4	841	23.5	(21.5; 25.6)
- 5	330	10.1	(8.7; 11.4)
- 6-10	2179	66.4	(64.1; 68.8)

*weighted and post-stratified proportion by gender.

** 95% confidence interval.

N: number of respondents.

= 0.12, $p < 0.05$) and 'social support from relatives' ($\beta = 0.05$, $p < 0.05$). We also noticed a positive indirect association between 'health literacy' and 'social support from social workers and other professionals' ($\beta = 0.12$, $p < 0.05$), and between 'health literacy' and 'social support from relatives' ($\beta = 0.06$, $p < 0.05$).

Factors associated with vaccine uptake for sheltered participants¹

In terms of the **motivation** component of Michie's three COM-B model, the indicator 'Social and Health workers were a source of information' (i.e., latent variable 'Information about COVID-19') was associated with vaccine uptake in sheltered participants (i.e., those living in accommodation centers, hostels for migrant workers, and emergency social shelters) (Supplementary data). In contrast, in terms of **opportunity**, the indicators 'being accompanied by someone for medical appointments' (latent variable 'Social support from social workers and other professionals'), 'having a history of vaccination (latent variable 'attitudes towards vaccination)'), and stable housing were not significantly associated with COVID-19 vaccine uptake.

Discussion

In the present study, COVID-19 vaccine uptake (i.e., at least one dose) was lower in our study sample of PEH than in the general French population (74.5 % versus 81 %, respectively) (29). Our conceptual framework was based on Andersen's Behavior Model of Health Service Use (BMHSU) and Michie's COM-B model. Two components of the latter were associated with COVID-19 vaccine uptake in the study sample. The first was **opportunity**; specifically, having a personal general practitioner, having healthcare cover and being accompanied by someone for medical appointments, were all associated with greater vaccine uptake.

¹ Although all goodness-of-fit indices were acceptable, five latent variables were not represented by their indicators; accordingly, they were not maintained in the final model (Supplementary data). These variables were as follows: i) information about COVID-19, ii) perceived needs, iii) accessibility to care, iv) competing needs, and v) discrimination. Several observed variables (i.e., indicators) of the 9 listed latent variables were not significant and were therefore excluded from the model. These were i) being accompanied by someone for medical appointments, ii) social support from social workers and other professionals, iii) fear of the vaccine, iv) personal opinion about vaccination in general, v) vicarious experiences, vi) having a history of vaccination, and vii) attitudes towards vaccination. They were therefore added into the model as observed variables not indicative of latent variables.

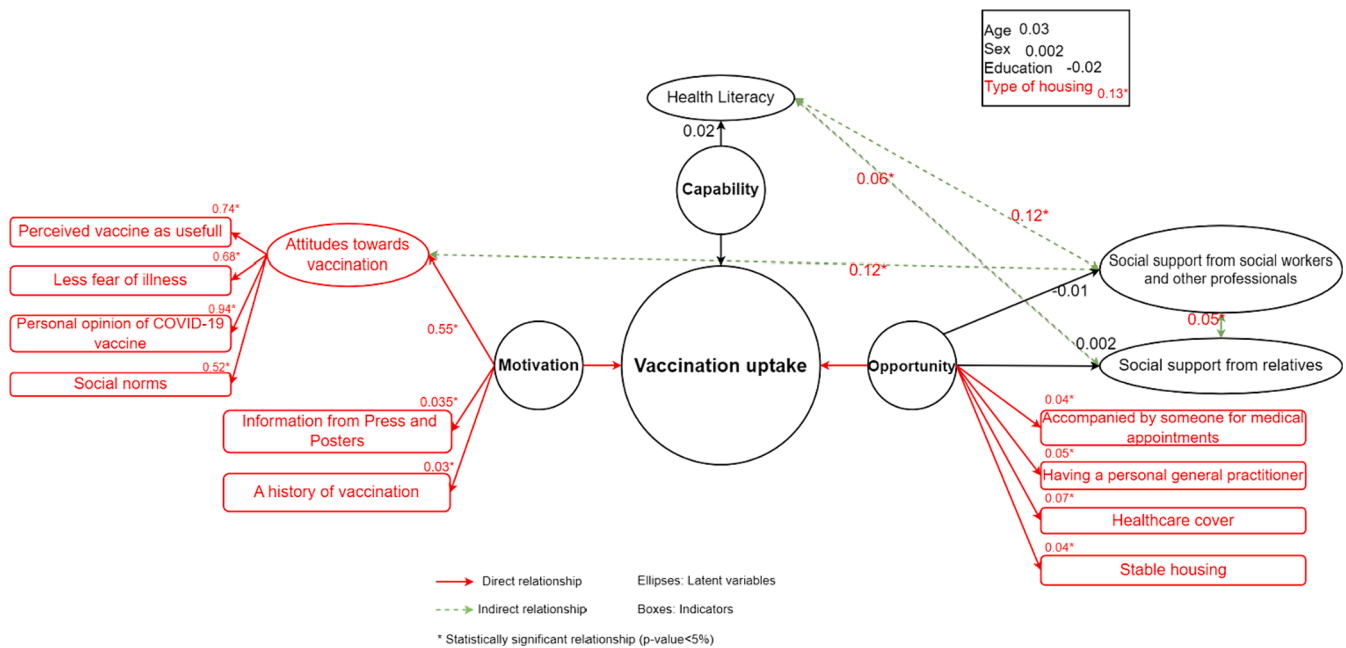


Fig. 3. SEM model of the determinants of vaccine uptake among underserved homeless populations in Paris and Marseille (N = 3811).

We should also note that in France, there is no cost for neither having a personal general practitioner nor taking the covid-19 vaccine. The second component was **motivation**; specifically, attitudes towards vaccination, having a history of vaccination, and source of information. These motivational variables are also found in the general population. In addition, vaccination in this underserved homeless population was also associated with their type of housing and housing stability.

COVID-19 vaccine uptake in our study was higher than that in Danish people under 65 years old experiencing homelessness listed in the Danish Homeless Register (54.6 %) (30), but similar to individuals in emergency housing settings with a recent history of homelessness in Canada (63.6 %) (31). Similar to our study, these two studies also identified important factors of vaccine uptake such as trust in the national health authorities (30), healthcare accessibility (30) and housing condition (31).

The originality of our study is that it highlights several factors specific to the PEH community. First, even within this greatly underserved homeless population, there is a gradient in COVID-19 vaccine uptake which depends on the level of precariousness and of social integration mediated by housing exclusion; people living on the street (i.e., including squats and slums) were less likely to be vaccinated than sheltered participants. The COVID-19 crisis and the measures taken to contain it highlight and exacerbate pre-existing social inequalities. By recognizing the importance of global collaboration and multidisciplinary research approaches, governmental policy should be developed to promote health equity while relying on social determinants of health and including concrete multi-sectoral actions to address barriers to access to healthcare services., especially by prioritizing vaccination for individuals in socially vulnerable situations. Second, having a personal general practitioner and receiving state-provided medical health cover designed to provide access to healthcare for people who are in an irregular permit situation (called *Aide Médicale de l'État*) were two important factors in vaccine uptake. Third, the specific competing needs of PEH (e.g., where to sleep, food), which are much more difficult than those of the general population, exacerbate social disparity in the perception of risks (32). PEH don't prioritize healthcare in comparison to other basic needs like housing and food. Their risk perception is altered by their competing needs. Inaccuracy in risk perception is also associated to health literacy inadequacy. This may explain, at least in part, why vaccine hesitancy is higher in this population than in the

general public (16).

Third, receiving vaccination information from the press and official Posters was associated with greater uptake (33). This reflects findings in PEH in a study in Los Angeles, U.S.A, and in previous work in France. In both of those studies, PEH who trusted official sources and professional workers were less hesitant about vaccination than those the COVID-19 information provided by the media and loved ones for COVID-19 information (2,34). This finding emphasizes the important role of social workers in the field. These stakeholders can promote health mediation interventions mobilizing 'outreach' actions, with a view to facilitating access to prevention and care for socially disadvantaged populations. These interventions could also help to reveal unmet social needs and highlight the failings in a healthcare system (35). In a study on migrants in Europe, a lack of trust in healthcare systems, and struggling to communicate with healthcare professionals was highlighted; furthermore, not understanding or accessing information led to avoid care and delay vaccination (36). Experiences of marginalization or discrimination in host countries may lead immigrant communities to distrust the health system and health providers (37).

Strengths and limitations

This study has several strengths. First, the questionnaire was administered to participants in various languages by trained interviewers which minimized language barriers. Second, by using SEM to test our conceptual model using real-world data, we were able to take into account many complex relationships between vaccine uptake and personal and contextual factors. These factors should be addressed and included when preparing vaccination campaigns.

The study also has limitations. First, the absence or refusal of persons initially selected at random may have been associated with a negative opinion about vaccination; consequently, this may have led to an overestimation of vaccine uptake in homeless people in general. Second, some participants did not complete the entire questionnaire (20 % for the health literacy section). We noticed that the health literacy questionnaire (HLQ) was not adapted for individuals in socially vulnerable situations, it was not comprehended by everyone. Third, the information collected was self-reported, which may be unreliable due to memory bias and social desirability bias; the tendency to underreport socially undesirable attitudes and behaviors and to over report more desirable

attributes. (38).

Conclusion

The results from our study suggest the need for actors in the field of underserved homeless population to implement on site interventions which focus on improving the information communicated by trusted professionals. Based on our findings regarding the importance of information on COVID-19 (latent variable) and specifically information sources (indicators related to this latent variable), especially by social workers and mediators, *Santé publique France* (the French National public health agency) recently created a communication system to specifically address vaccine uptake in the various sub-populations of PEH. This involves strategies which are culturally sensitive, population-adapted and evidence-based. One example is knowledge mobilization by field professionals in contact with people in precarious situations to promote access to vaccination against COVID-19 (39). For the present study, we worked with other research teams, and various stakeholders and decision-makers. This multi-element collaboration could help to implement actions inspired by research which target the needs of PEH. Finally, the French public healthcare system needs to include socially vulnerable populations from the very start in decision-making regarding national vaccination strategies. This could be done by strengthening outreach actions and by taking into consideration health cover in this underserved homeless population.

CRedit authorship contribution statement

Sahar Haidar: Data curation, Formal analysis, Validation, Writing – original draft, Writing – review & editing. **Thomas Roederer:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. **Cécile Allaire:** Methodology, Validation. **Bastien Mollo:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration. **Charline Vincent:** Investigation, Writing – review & editing. **Isabelle Bonmarin:** Conceptualization, Methodology. **Marine Mosnier:** Investigation, Methodology. **Elodie Richard:** Conceptualization, Investigation, Methodology. **Stéphanie Vandentorren:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jvaxc.2024.100472>.

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