Social conformism and confidence in the system as antecedents of vaccine hesitancy: A questionnaire to explain intention for COVID-19 vaccination among healthcare workers in France

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Abstract

Background

Healthcare workers (HCW) are a priority group for COVID-19 vaccination. The start of the COVID-19 campaign among French HCW offered an opportunity to explore the psychological antecedents of vaccine hesitancy (VH), in particular their extension from the 5C model (complacency, confidence, convenience, calculation, collective benefit) to a 7C model including social conformism and confidence in the system.

Methods

We developed a knowledge and attitude (KA) questionnaire with 30 items relating to the 7 components of psychological antecedents. The questionnaire was administered online among a snowballing sample of French HCW, recruited December 2020 through January 2021 via professional organizations. We used multivariate logistic regression to explore the association of 7C components and individual KA items with COVID-19 vaccine intention.

Results

Among the 5234 participants, the vaccine intention model fits (pseudo R-squared values (R2)) of individual components ranged from R2=0.48 for Calculation to R2=0.07 for Convenience, with R2=0.29 for Confidence in System and R2=0.26 for Social Conformism. In nested models including the initial 5C components, adding Confidence in System or Social Conformism increased the model fit significantly. In a multivariate model including a shortlist of items, the strongest associations with vaccine intention

were observed for a positive attitude on the vaccine's benefit-risk balance (strongly agree vs. strongly disagree: odds ratio 16.81, 95%-confidence interval 9.66-29.25).

Discussion

The results suggest that social conformism and confidence in the system are essential independent antecedents of VH. This questionnaire can be used to explore COVID-19 VH accompanying the transition into a long-term vaccination strategy.

Keywords

COVID-19 vaccination; healthcare workers; vaccine hesitancy

Conflict of Interest

The authors declare that they have no conflicts of interest in relation to the content of the article.

Funding

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INTRODUCTION

Vaccination is a main tool to respond to the current pandemic of COVID-19. Healthcare workers (HCW) are among the priority groups in most countries, to provide them protection given their continuous exposure, protect the health care system from absenteeism and prevent nosocomial transmission of SARS-CoV-2 [1]. In France, COVID-19 vaccination of HCW has been recommended from January 2021, initially based on age and risk factors, and without any conditions thereafter.

At the end of May 2021, the COVID-19 vaccine coverage for at least one dose among HCW in France was estimated at 95.2% [2], but this figure is likely an overestimate due to imputation of retired HCW and non-HCW and may in fact be below 70%, likely with large differences between professional categories [3]. To improve uptake and since re-vaccination might be required (booster doses or update of strain coverage), it will be important to understand and follow-up vaccine hesitancy (VH) against COVID-19 vaccination.

The term VH was coined to describe the attitude of delay in acceptance or refusal towards vaccination despite availability [4]. To better understand the source of VH, it is important to consider the psychological aspects of human behavior and choice. Thus, the 3C psychological antecedents model [4] was developed as a tool to describe sources of VH and to evaluate interventions to mitigate it. The original three components were confidence (in the system that delivers the vaccine, including the reliability and competence of the health services and health professionals), complacency (need of the vaccine given its effectiveness and severity of the disease), and

convenience (accessibility) [4]. Betsch et al., proposed an expanded 5C model including two additional C antecedents: calculation (deliberation on risks and benefits), and collective responsibility (sense of altruism towards vaccinating) [5]. Both the 3C and 5C model related to vaccination in general, while we here propose an application specifically for COVID-19 vaccination.

We also propose to add social conformism as a sixth C antecedent. Taking decisions by imitating peers is known as an important heuristic that helps reduce mental load in daily life [6]. For example, in religious environments, even if there is no theologically based objection for vaccination, VH is described among social networks of people, having personal beliefs or concerns about vaccine safety [5]. Even beyond extreme group opinions, social conformism may play a role as studied in several discrete choice experiments which described higher theoretical acceptance in scenarios presenting higher coverage in the community [7,8,9].

Furthermore, we here examine whether the confidence component should be split – specifically during the current epidemic vaccine response situation – into confidence in the vaccine itself and confidence in the overall public or governmental system [10]. In a recent study looking at French-speaking general practitioners (GPs), the distrust in the ministry of health and in vaccine safety appeared to lead to lower COVID-19 vaccine acceptance [11].

The roll-out of COVID-19 vaccination among HCW in France provided an opportunity to study how psychological antecedents of VH influence intention for COVID-19 vaccination, to evaluate the role of the two additional components: social

conformism and confidence in the system, and to distinguish between the role of knowledge and attitudes.

Methods

Participant inclusion

Between December 18, 2020 and February 1, 2021, the Research Group for the Prevention of Occupational Infections in Healthcare Workers (GERES) published an online questionnaire through the Sphinx online survey platform, which was disseminated throughout France by different healthcare worker networks. All French regions were comprised, including the overseas departments, albeit the latter contributed to a small representation. Through the "snowball sampling" effect, the questionnaire reached a total of 9580 participants of diverse health-related careers and sectors. Since participants forwarded the questionnaire across their own networks, response rate could not be estimated.

Data collection

The questionnaire itself consisted of three parts, where the first and third parts of the survey collected sociodemographic, professional and health-related characteristics of the participants and intention to accept and recommend the COVID-19 vaccination. The second part of the survey directed participants, by choosing a shape (square or triangle), to either a discrete choice experiment or the present KA-7C questionnaire. Effective survey completion time was approximately 8 minutes.

Questionnaire development

The knowledge and attitude (KA) questionnaire was based on the 3C and 5C psychological antecedents presented by MacDonald et al. and Betsch et al. respectively. Based on recent evidence, two additional dimensions of antecedents were added: Social Conformism [7,8,9] and Confidence in Systems as a dimension separate from Confidence in Vaccines [14]. Each antecedent consisted of at least one attitude and knowledge question. In total, the KA-7C questionnaire had 30 questions; nine questions were associated with the attitude towards the vaccine and the systems delivering them**,** 19 were associated with the knowledge about the vaccines, their development and COVID-19, and two general attitude questions on confidence in epidemic management and worry about the COVID-19 epidemic (Supplementary Table S1). Attitude items were evaluated using 5-point Likert-scales. Where needed, attitude items were reduced to a 3-point scale (not agree / do not know / agree) for simplicity of presentation. However, regression models included the 5-point Likert scale for precision. Knowledge items were evaluated using either a statement with "right/ do not know / wrong" appreciation or a single choice from several options with *do not know* (Supplementary Table S1). For analysis, knowledge variables were coded as an *incorrect answer*, a *does not know response*, and a *correct answer*. The general attitude questions were evaluated on an 11-point scale and transformed for analysis in three categories (low 0-3, medium 4-6, high 7-10).

Data Analysis

We used bivariate logistic regression models to explore the association of participant characteristics and individual KA-7C items with vaccine intention. Initial analyses explored vaccine intention as the original a three-level variable (yes vs. do not know vs no), but the final analyses carried on the two-level variable (yes vs no/do not know). We created a variable for period of survey participation: period 1 from December 18, 2020 through January 4, 2021, early phase of the campaign targeting nursing home residents; period 2 from January 5 through 14, 2021, when vaccination was expanded to HCW aged 50 years or older; period 3 from January 15 through February 1, 2021, when the vaccination campaign was expanded in the general population to persons aged 75 years and older or having specific high-risk comorbidities (such as rare immune disorders).

To identify socio-demographic and health-related determinants of vaccine intention, we included variables with *P*-value <0.20 in bivariate regression into a multivariate logistic regression model using a stepwise forward procedure (basic model). We evaluated collinearity between the KA-7C items using the *collin* command in STATA. For variables with variance inflation factor (VIF) >2, we conducted pairwise Spearman correlation testing and considered any correlation with rho <0.70 as not critical. We examined the contribution of each 7C component to vaccine intention (fit) based on pseudo R-squared values. We first defined the fit of each 7C component item group individually. We then included 7C components stepwise into a full model, in descending order according to their individual pseudo R-squared values. Significant

contribution of each component was assessed based on the nested log likelihood ratio test.

We constructed a knowledge score based on the knowledge items with significant contribution to the overall model. Knowledge variables were summed up (correct = 2 points, do not know = 1 point, incorrect = 0 points) to create the variable "knowledge score".

We defined a shortlist of 15 KA-7C items, selecting two items per 7C component (one attitude and one knowledge item) based on R-squared values. We analyzed a final, full multivariate logistic regression model based on the shortlist items in 5-point Likert format.

We used STATA/IC 16.1 software for data analysis.

Ethics

The planning, conduct and reporting of the study was in line with the Declaration of Helsinki, as revised in 2013. The study protocol was approved by the Institutional Review Board "Terre d'Ethique" of CHU St Etienne (N° IRBN1092021/CHUSTE) and the database was registered by EHESP French School of Public Health according to the GRDP regulation. Because the data collection was observational, collected no sensitive and only self-declared biomedical information, no informed consent was required. Participants visiting the study website saw the complete study information and agreed to study participation before starting the questionnaire. Study participation was anonymous without any risk of indirect identification. The funding source did not have any role in the conduct of the study or decision to submit this article.

Results

Participants

Among the 5234 participants assigned to the KA-7C questionnaire (54.6%), all completed the questionnaire with similar distribution across the periods defined by roll-out of the vaccination campaign: 38.7%, 30.9% and 30.4%. Women represented 78.4% of participants and 23.2%, 40.0% and 36.8%, respectively were aged 18-34 years, 35-49 years and ≥50 years (Table 1). Nurses represented 22.9%, nurse assistants 9.4%, biomedical professionals (including midwives, pharmacists and biologists) 27.7%, paramedical 15.7%, and administration 24.4% (Table 1) . Working at least part-time in a nursing home was reported by 15.4% (Table 1) and 58.1% of all HCW indicated intending to get vaccinated against COVID-19, while 19.8% did not know yet (not shown). Among participants, 53.1% reported vaccination against flu during the 2019-20 winter season (not shown). The variable on receiving the previous flu vaccine in 2019–20 was highly associated with COVID-19 vaccine intention but not included in models to avoid overfitting.

Table 1. Characteristics and shortlist of KA-7C items on a 5-point Likert scale by intention to get vaccinated (yes vs. no / do not know). Healthcare workers in France during December 18, 2020 through February 1, 2021 (N=5234) at the start of the COVID-19 vaccination campaign.

KA-7C item				Intention COVID-19 No/do not know		Intention COVID-19 Yes		Full multivariate model (Yes vs DNK/No)
		N	%	N	%	N	%	OR (95% CI)
Sociodemographic Characteristics								
Age (years)	18 - 34	1215	23.2	681	56.1	534	44.0	ref
	35 - 49	2092	40.0	932	44.6	1160	55.5	1.04 (0.80 - 1.35)
	50+	1927	36.8	578	30.0	1349	70.0	1.47 (1.11 - 1.96)[b]
Gender	Female	4103	78.4	1889	46.0	2214	54.0	ref
	Male	1131	21.6	302	26.7	829	73.3	1.22 (0.94 - 1.60)
Profession	Nurses	1197	22.9	603	50.4	594	49.6	ref
	Nurse Assistants	491	9.4	341	69.5	150	30.6	0.78 (0.51 - 1.19)
	Other paramedical	819	15.7	407	49.7	412	50.3	0.73 (0.53 - 1.01)
	Bio-medical professionals	1449	27.7	287	19.8	1162	80.2	1.25 (0.92 - 1.70)
	Admin/technical	1278	24.4	553	43.3	725	56.7	1.03 (0.77 - 1.37)
Nursing Home	No	4429	84.6	1766	39.9	2663	60.1	ref
	Yes	805	15.4	425	52.8	380	47.2	0.97 (0.72 - 1.31)
Study Period	1	2026	38.7	1113	54.9	913	45.1	ref
	2	1618	30.9	574	35.5	1044	64.5	1.73 (1.34 - 2.23)[b]
	3	1590	30.4	504	31.7	1086	68.3	2.20 (1.68 - 2.88)[b]
Confidence in Vaccine								
I am afraid of having a severe side effect of vaccination.	Strongly disagree	1203	23.0	127	10.6	1076	89.4	12.36 (7.76 - 19.70)[c]
	Disagree	1341	25.6	245	18.3	1096	81.7	10.52 (7.02 - 15.79)[c]
	Undecided	959	18.3	418	43.6	541	56.4	4.87 (3.30 6 7.17)[c]
	Agree	891	17.0	652	73.2	239	26.8	2.19 (1.48 - 3.24)[c]
	Strongly agree	840	16.1	749	89.2	91	10.8	ref
The security of vaccines is monitored not only at the national level, but also in collaboration between other European countries.	False (i)	92	1.76	79	85.9	13	14.1	ref
	DNK	855	16.3	596	69.7	259	30.3	1.43 (0.42 - 4.84)
	True (c)	4287	81.9	1516	35.4	2771	64.6	2.20 (0.66 - 7.29)
Confidence in Systems								
If my employer incites me to get vaccinated, this …	Dissuades me	274	5.2	247	90.2	27	9.9	ref
	Has no effect	3409	65.1	1695	49.7	1714	50.3	2.71 (1.45 – 5.06)
	Motivates me	1551	29.6	249	16.1	1302	84.0	6.41 (3.36 – 12.22)

Some stages of vaccine development (control) have been skipped due to the epidemic emergency.	False (c)	2252	43.0	399	17.7	1853	82.3	2.36 (1.73 - 3.22)[b]
	DNK	2023	38.7	1071	52.9	952	47.1	2.02 (1.50 - 2.71)[b]
	True (i)	959	18.3	721	75.2	238	24.8	ref
Complacency								
I am afraid of getting a severe form of COVID-19.	Strongly disagree	1109	21.2	528	47.6	581	52.4	ref
	Disagree	1524	29.1	673	44.2	851	55.8	1.28 (0.94 - 1.73)
	Undecided	1222	23.4	488	39.9	734	60.1	1.38 (0.96 - 1.93)
	Agree	796	15.2	284	35.7	512	64.3	1.88 (1.30 - 2.71)[b]
	Strongly agree	583	11.1	218	37.4	365	62.6	2.76 (1.76 - 4.33)[b]
The gravity of the epidemic requires making vaccines quickly available.	False (i)	411	7.9	331	80.5	80	19.5	ref
	DNK	513	9.8	387	75.4	126	24.6	1.73 (0.97 - 3.12)
	True (c)	4310	82.4	1473	34.2	2837	65.8	1.72 (1.05 - 2.82)[a]
Convenience								
In practice, it will be difficult for me to get vaccinated.	Strongly disagree	2429	46.4	772	31.8	1657	68.2	ref
	Disagree	1386	26.5	610	44.0	776	56.0	0.93 (0.72 - 1.20)
	Undecided	765	14.6	436	57.0	329	43.0	0.60 (0.44 - 0.81)[b]
	Agree	361	6.9	182	50.4	179	49.6	1.08 (0.71 - 1.65)
	Strongly agree	293	5.6	191	65.2	102	34.8	0.71 (0.41 - 1.22)
It is necessary to have 2 injections to be immunized. [e]	False (i)	159	3.0	98	61.6	61	38.4	ref
	DNK	524	10.0	372	71.0	152	29.0	0.76 (0.38 - 1.51)
	True (c)	4551	87.0	1721	37.8	2830	62.2	1.14 (0.62 - 2.09)
Calculation								
I think that vaccination against COVID-19 will have more benefits than risks for me.	Strongly disagree	496	9.5	437	88.1	59	11.9	ref
	Disagree	670	12.8	603	99.0	67	10.0	0.74 (0.42 - 1.31)
	Undecided	1136	21.7	841	74.0	295	26.0	1.33 (0.80 - 2.20)
	Agree	1205	23.0	242	20.1	963	79.9	6.39 (3.82 - 10.67)[b]
	Strongly agree	1727	33.0	68	3.9	1659	96.1	16.97 (9.78 - 29.47)[b]
For a person with risk factors, these vaccines have more benefits than risks in the current epidemic situation. [e]	False (i)	148	2.8	124	83.8	24	16.2	ref
	DNK	875	16.7	700	80.0	175	20.0	0.76 (0.32 - 1.81)
	True (c)	4211	80.5	1367	32.5	2844	67.5	0.87 (0.37 - 2.00)
Collective Responsibility								
Getting vaccinated will also be a collective action to stop the crisis due to the epidemic.	Strongly disagree	253	4.8	231	91.3	22	8.7	ref
	Disagree	318	6.1	297	93.4	21	6.6	0.70 (0.28 - 1.73)
	Undecided	686	13.1	620	90.4	66	9.6	0.71 (0.33 - 1.55)
	Agree	1222	23.4	612	50.1	610	49.9	2.35 (1.12 - 4.93)[a]

	Strongly agree	2755	52.6	431	15.6	2324	84.4	5.04 (2.44 - 10.43)[b]
The vaccine blocks transmission of the virus to those around you in case of infection. [e]	False (c)	781	14.9	1095	41.7	1531	58.3	0.91 (0.67 - 1.22)
	DNK	1827	34.9	820	44.9	1007	55.1	0.95 (0.69 - 1.30)
	True (i)	2626	50.2	276	35.3	505	64.7	ref
Social Conformism								
Among your family and friends, how would you describe the majority opinion towards COVID-19 vaccination?	Very favorable	390	7.5	8	2.1	382	98.0	11.57 (4.51 - 29.67)[b]
	Favorable	1418	27.1	199	14.0	1219	86.0	4.42 (2.70 - 7.22)[b]
	Both skeptical and favorable	1653	31.6	701	42.4	952	57.6	2.28 (1.43 - 3.63)[b]
	Skeptical	1319	25.2	897	68.0	422	32.0	1.59 (0.99 - 2.56)
	Very skeptical	454	8.7	386	85.0	68	15.0	ref
Do you know the approximate percentage of healthcare workers who intend to get the vaccine?	30% (i)	1743	33.3	906	52.0	837	48.0	ref
	DNK	2064	39.4	937	45.4	1127	54.6	1.14 (0.89 - 1.46)
	60% & 90% (c)	1427	27.3	348	24.4	1079	75.6	1.41 (1.07 - 1.86)[a]

Confidence: Confidence in the authorities to manage the health and economic crisis due to COVID-19; (c): correct knowledge item response; DNK: Does not know; (i): incorrect knowledge item response; OR: odds ratio; Worry about epidemic: Worry about Covid-19 epidemic in France

[a] p-value <0.05

[b] p-value < 0.01

[c] p-value < 0.001

[d] Full multivariate model adjusting for sociodemographic and professional determinants.

[e] These questions were introduced as follows: "For the most advanced COVID-19 vaccines (close to licensure), the scientific data show that …"

Items' association with vaccine intention

In individual analyses adjusting for socio-demographic and professional characteristics, all KA-7C items were significantly associated with COVID-19 vaccine intention, except for knowledge items Severe side effects beyond 6 months after vaccination, Report side effects, Obesity risk, and Worry about the epidemic (Supplementary Table S2). No critical collinearity between KA-7C variables was identified. The maximum VIF observed was 2.42 for the attitude towards the benefit risk ratio in getting the COVID-19 vaccine and 2.24 for vaccination as a collective action to stop the epidemic, with a correlation of rho=0.67.

In a full model including the shortlist KA-7C items and adjusting for sociodemographic and professional characteristics, the strongest associations were observed for a positive attitude on the vaccine's benefit-risk balance (strongly agree vs. strongly disagree, odds ratio (OR)=16.81, 95%-confidence interval (CI): 9.66-29.25), fear of a severe side effect (strongly agree vs. strongly disagree, OR=12.47 (95% CI: 7.80-19.92) and a very favorable majority opinion among family and friends (vs. very skeptical, OR=11.02 (95% CI: 4.19-29.01) (Table 1, Figure 1).

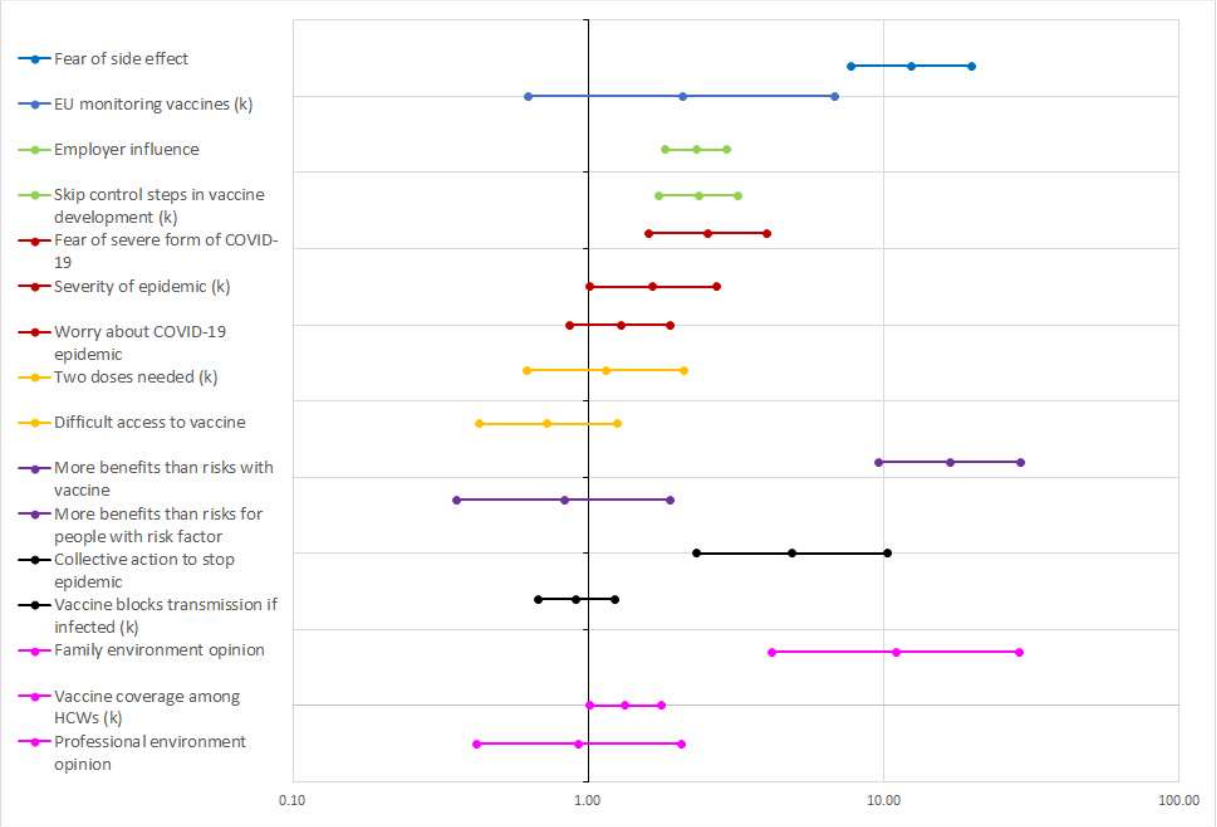

Figure 1. Forest plot of associations with COVID-19 vaccine intention of the shortlist of KA-7C items on a 5-point Likert scales. Healthcare workers in France during December 18, 2020 through February 1, 2021 (N=5234) at the start of the COVID-19 vaccination campaign.

K: knowledge variable; OR: odds ratio
[a] Points and bars represent odds ratios and confidence intervals estimated in a multivariate model adjusting for social demographic variables and including all items of the short diagnostic tool.
[b] Only highest vs reference categories are shown.

Contribution of 7C components to model fit

In individual models, all 7C components contributed significantly (log likelihood tests all $P<0.05$), but at various levels, to the explanation of COVID-19 vaccine intention (Figure 2). Model fits (pseudo R-squared values (R2)), corresponding to the percentage of variation in vaccine intention that can be explained by a group of variables, ranged from R2=0.48 for Calculation items and R2=0.36 for Confidence in Vaccines items to R2=0.07 for Convenience items. The additional components contributed significantly with a fit of R2=0.29 for Confidence in System and R2=0.26 for Social Conformism. In nested models including the initial 5C components, adding Confidence in System increased the model fit significantly from R2=0.60 to 0.61 ($p<0.001$), and Social Conformism from R2=0.60 to 0.62 ($p<0.001$) (Table 2, Figure 3).

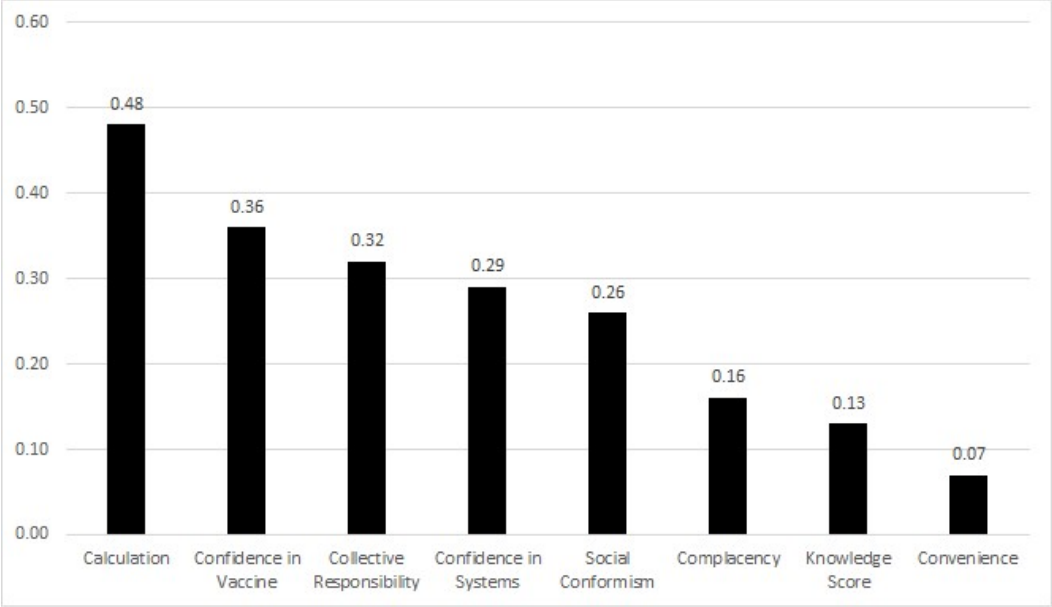

Figure 2. Fit of regression models explaining COVID-19 vaccine intention: Individual contribution from 7C components. Healthcare workers in France during December 18, 2020 through February 1, 2021 (N=5234) at the start of the COVID-19 vaccination campaign.

[a] Pseudo R-squared values obtained from multivariate regression models including vaccine intention and items from a given C component (including knowledge items).

Table 2. Fit of full multivariate models on intention to get vaccinated against COVID-19 Healthcare workers in France during December 18, 2020 through February 1, 2021 (N=5234) at the start of the COVID-19 vaccination campaign.

Model	R2
7C Long version with 5-Point Likert Scale	0.65
7C Long version 5-Point Likert Scale with knowledge items separated into a knowledge score	0.64
7C Long version with 3-Point Likert Scale	0.63
7C Shortlist version with 5-Point Likert Scale [a]	0.64
7C Shortlist version with 3-Point Likert Scale	0.62
5C Shortlist version 5P without Social Conformism and Confidence in System	0.60
5C Shortlist version 5-Point Likert Scale with Social Conformism	0.62
5C Shortlist version 5-Point Likert Scale with Confidence in System	0.61

[a] questionnaire retained for further analysis

[b] Comparison of the full and shortlist questionnaire versions, the 5- and 3-point Likert scale and addition of Social conformism and Confidence in system.

[c] Pseudo R2 obtained from multivariate regression models.

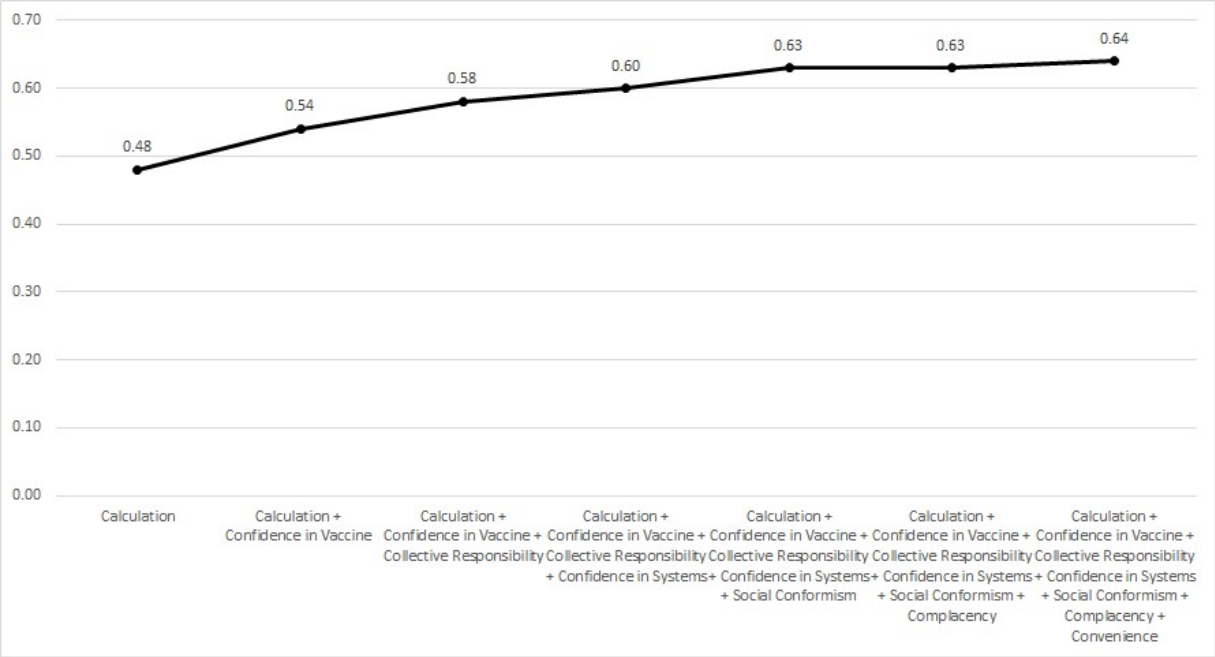

Figure 3. Nested models explaining COVID-19 vaccine intention. Cumulative contribution from 5-C components and Social Conformism. Healthcare workers in France during December 18, 2020 through February 1, 2021 (N=5234) at the start of the COVID-19 vaccination campaign.

[a] Pseudo R-squared values obtained from multivariate regression models including vaccine intention and items from each C component**.**

[b] All components contribute with $P < 0.001$ in log-likelihood ratio test.

[c] Short version 5-point Likert scale used.

The knowledge scores ranged from 0 to 36 with a median of 28 and slight skew to the right (Supplementary Figure S1)**.** Compared to a 7C model without knowledge items, adding the knowledge score did not increase the model fit substantially (both R2=0.64) (Table 2)**.** Furthermore, different formats of the questionnaire (short vs long, 3-point Likert vs 5-point) only slightly modified the model fit (range R2=0.62-0.65) (Table 2).

Discussion

In this cross-sectional study of a snow-ball sample of French HCW exploring the antecedents of COVID-19 vaccine intention and hesitancy, we found that Social Conformity was an essential sixth component to vaccine intention, in addition to the 5C model previously presented [5]. Additional precision in explaining vaccine intention could be gained by adding Confidence in Systems as a separate component, beyond Confidence in Vaccines. The comprehensive KA-7C questionnaire explained 65% of the variation in vaccine intention, while across the seven components, most explanatory power came from attitude items with limited contribution from knowledge items. Furthermore, the analysis could be done at a 3-point level instead of a 5-point level which explained the variation in vaccine intention by 63%.

In Social Conformism, the description of the majority opinion on COVID-19 vaccination among colleagues or family and friends was strongly associated with vaccine intention of the individual HCW. Even GPs, seen as reliable sources regarding vaccines, may hesitate to recommend vaccination [13]. The perception of the social norm in vaccine intention among HCW is influential as it affects their colleagues and the

circle in which each professional treats their patients [15]. Vaccination is a socially influenced process, and through *homophily* (self-selected association to similar people) [15] those who intend to vaccinate will likely be in a social network with those who share the same sentiments and vice versa [17]. Our results are in concordance with previous reports of discrete choice experiments, where the presentation of higher community level vaccine coverage was associated with more frequent theoretical acceptance among HCW (seasonal flu and pertussis) [8], parents and adolescents (Human Papilloma Virus (HPV)) and university students [7]. This interaction with the social environment may be even more important among HCW, as they are the bridge between public health decisions and patients; thereby, influencing vaccine uptake in the population. The heuristic concept of *imitating-your-peers* [6] should be further explored in vaccine promotion towards HCW. Taking into account local cultures and group norms, creating chain effects within social networks should help normalize vaccination. Research on VH should therefore increasingly target specific milieus, professional categories and social networks.

During this COVID-19 epidemic, confidence in national authorities in general has become an important characteristic dividing the population [10] and impacting adherence to epidemic control measures and vaccine intention. We addressed this aspect in two ways: confidence in authorities with regard to COVID-19 crisis management and perception of a vaccine recommendation from the employer. In France, far-wing voting was found negatively associated with early COVID-19 vaccine intention in spring 2020 [16]; and a negative perception of healthcare working

conditions has been found inversely related to flu vaccine uptake [18]. HCW play a crucial role between public health officials and the general population. However, many HCW are not vaccinology experts and are aware of how little they know of the vaccine and their inability to answer some of the patients' questions [13]. As put by Ward et al., the relationship between public health authorities and HCW have degraded over the last 30 years along with depleting funding for public hospitals and restructuration of the health system in France. Both have not helped at inducing a positive perception of the systems providing the vaccines [19]. Ongoing discussions on vaccine mandates for HCW – often supported by hospital managers and doctors - can be seen either as the solution or as an aggravating factor for the problem of suboptimal vaccine coverage among HCW. Further research is needed to evaluate how far such general, not vaccine-related societal trust, should be taken into account as a separate antecedent of hesitancy on other recommended vaccines and for the general population.

Knowledge items played a small role in explaining COVID-19 vaccine intention. HCW in our sample were a heterogeneous group with education ranging from below the French high school level to over 6 years of medical training. The frequently observed gradient in flu vaccine uptake between professional categories has led to the conclusion that categories with shorter educational duration need more or better information on vaccines adapted to their respective population. Previous vaccine promotion among French HCW therefore has focused on campaigns by organizing meetings to deliver scientific messages and answer any questions [20]. In addition, governmental decision makers tend to think that lack of knowledge might be conducive to VH among French

HCW [19], while attitudes may be more important- albeit more challenging - to influence. In a previous study looking at the general population, better knowledge about the vaccine and less acceptance of conspiracy theories were associated with higher COVID-19 vaccine acceptance [21], while education level was not consistently associated with believing vaccine misinformation across countries [22]. However, social psychology research has been insisting on the fact that better knowledge alone does not lead to greater motivation for behavior change, but that attitude may be a stronger guide for behavior [23,24]. Social marketing research has suggested that using nudges could allow presenting information in a way that helps influencing attitudes.

There is a considerable body of evidence on factors that influence COVID-19 vaccine acceptance and uptake among HCW [25]. However, evidence for HCW in Europe and the period since authorisation of first vaccinees and start of vaccine campaigns are available only from two studies, both underpinning the importance of trust and confidence [26,27]. We found a high overall capacity (65%) of this KA-7C questionnaire to explain COVID-19 vaccine intention among HCW. In comparison, socio-demographic and professional differences explained a much smaller proportion of variation (14%), which is surprising given the observation that vaccine coverage against flu and currently COVID-19 consistently differs to large amounts between socio-professional groups [14]. A separate analysis will address the capacity of the KA-7C questionnaire to explain these variations between professional categories. We identified a shortlist of KA-7C items and suggest that it could be used as a diagnostic tool for COVID-19 VH among HCW, after adaptation to current scientific evidence about the

vaccines. For studies with smaller sample sizes and lower statistical power, the questionnaire can also be simplified into a 3-point Likert scale instead of a 5-point Likert scale without substantially losing diagnostic precision.

Our study has some limitations. Firstly, the study evaluates COVID-19 vaccine intention, but not eventual uptake. A considerable gap between vaccine intention and uptake exists [28], but looking at the factors that influence intention can at least contribute to explaining the thought process towards health decision making as suggested in the Health Belief Model [12], the COM-B model [29] and the Theory of Planned Behavior [30]. Secondly, the results apply to HCW in France and the relative importance of 7C components may be different in other population groups or countries. Thirdly, the data collection took place at the start of the vaccine campaign in France, during a period of constant publication of new information regarding vaccine efficacy and safety both at national and international levels. While vaccine intention increased during the study period, this aspect is likely of limited impact on our results, as our final model adjusted for the phases of survey participation and no controversy or safety concern emerged during the study period.

Despite these limitations, our study provides evidence that including Social Conformity and Confidence in Systems adds more precision in explaining vaccine intention by VH antecedent and that knowledge items are not strong predictors. These findings can help improve diagnostics of COVID-19 VH among French HCW, but possibly also in other population groups, countries and for other vaccines.

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Conflict of Interest

The authors declare that they have no conflicts of interest in relation to the content of the article.

Authors' Contribution

Study design: CO, AGB, GP, DA, IB, ER, EBN, JEM

Funding acquisition: IB, GP, ER

Data collection: CO, AGB, GP, DA, IB, ER, EBN

Data analysis: SM, JEM

Manuscript drafting: SM, AGN, JEM

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