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► **To cite this version:**

Pierre Verger, Christian Dualé, Nezha Lenzi, Dimitri Scronias, Céline Pulcini, et al.. Vaccine hesitancy among hospital staff physicians: A cross-sectional survey in France in 2019. *Vaccine*, 2021, 39 (32), pp.4481-4488. 10.1016/j.vaccine.2021.06.053 . hal-03557454

HAL Id: hal-03557454

<https://hal.univ-lorraine.fr/hal-03557454v1>

Submitted on 2 Aug 2023

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1 Title. Vaccine hesitancy among hospital staff physicians: a cross-
2 sectional survey in France in 2019

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1 Introduction

2 Vaccine hesitancy (VH), defined as the refusal, delay, or acceptance of vaccines with doubts about
3 their usefulness and safety [1], is recognized as one of the 10 most important health threats in the
4 world today; while it varies between countries, it concerns up to 50% of the French public [2].

5 Because of their role in motivating their patients to be vaccinated and answering questions and
6 concerns about vaccines and because their patients trust them strongly, healthcare professionals
7 (HCPs) are the cornerstone of vaccination. Nonetheless, a growing number of publications from
8 various countries show that VH also exists among them [3]. Because most are not really experts in
9 vaccination, they sometimes share with laypeople uncertainties about vaccines' benefits and safety
10 [4]. They may hesitate to accept some vaccines that health authorities recommend, such as seasonal
11 influenza vaccines [5,6], or to recommend and/or prescribe some vaccines to their patients [7,8].

12 Nonetheless, studies quantifying the prevalence of VH among HCPs for various vaccines and target
13 populations are infrequent. In France in 2014, we found moderate to high levels of VH in 1 in 8
14 general practitioners (GPs), defined by uncertainty about vaccine utility and safety [9]. Moreover, VH
15 was strongly associated with a reduced propensity to recommend vaccines on the official schedule to
16 their patients [8]. Studies suggest that level of initial medical training and confidence in health
17 authorities are important determinants of HCPs' VH [10–12].

18 Hospital staff physicians (HSPs) treat people with chronic and severe conditions, who account for a
19 substantial portion of the general population often targeted for specific vaccine recommendations.
20 Despite studies suggesting VH among HSPs, we have not found publications addressing
21 simultaneously all specialties and various vaccine situations encountered in hospitalized patients. We
22 organized a national survey of HSPs aimed at studying: 1) their prevalence of VH, by specialty 2) their
23 characteristics associated with VH, and 3) the impact of their VH on their behaviors and attitudes

Abbreviations: HCP, healthcare professionals; HSP, hospital staff physicians; VH, vaccine hesitancy; dTP, diphtheria-tetanus-poliomyelitis; HBV, hepatitis B; MCA, multiple correspondence analysis; AHCA, agglomerative hierarchical cluster analysis; VIF, variance inflation factor

24 toward their patients (recommendation frequency and communication attitudes) and themselves
25 (self-vaccination acceptance).

26 Methodology

27 Population

28 We conducted a cross-sectional in-person questionnaire survey [13] (fewer than 5% of the
29 questionnaires were self-administered) of HSPs in 14 French public hospitals (Figure S1,
30 supplementary material). They represent 15.0% of the hospitals of their size in mainland France and
31 21.5 % of their HSPs. We excluded hard-to-reach HSPs (physicians working in emergency
32 departments, who rotate frequently) and specialties that do not address vaccination with patients
33 (e.g., clinical biologists and radiologists). HSPs were stratified into specialties likely to deal with
34 vaccination in their daily practice (e.g. pediatricians) or not (e.g. surgeons), referred to hereafter as
35 “vaccinators” and “non-vaccinators”.

36 Procedure and questionnaire

37 Clinical research associates established the list of eligible HSPs in each hospital, contacted them by e-
38 mail or telephone, and, if they agreed to participate, used computer-assisted personal interview
39 software to interview them from September 2018 to October 2019.

40 The standardized questionnaire was adapted from a previous questionnaire developed and used to
41 study vaccination practices and perceptions among French GPs [9]. After qualitative interviews with
42 18 HSPs of various specialties in several hospitals in Marseille (France), the questionnaire was
43 adapted by a multidisciplinary panel of experts including epidemiologists, HSPs, and infectious
44 disease specialists. We pilot-tested it for clarity, length, and face validity among 50 HSPs in 3
45 hospitals.

46 The questionnaire asked about participants' professional characteristics (e.g., specialty, continuing
47 medical education on the topics of infectious diseases and/or vaccination over the past three years),
48 their own vaccinations against HBV, diphtheria-tetanus-poliomyelitis (dTP) (both mandatory for HCPs
49 at the time of the study), and seasonal influenza (only recommended) and the frequency at which
50 they recommend vaccines to at-risk patients in three vaccine situations frequently observed in their
51 specialty (these situations thus differed between specialties; see Table S1, supplementary material).
52 It also asked about HSPs' perception of their role towards patients related to vaccination, experience
53 with severe side effects potentially related to vaccination (leading to hospital admission) among their
54 vaccinated patients, and whether any of their patients in the past five years had had any of the
55 following vaccine-preventable diseases: measles, acute or recently diagnosed chronic hepatitis B
56 (HBV), bacterial meningitis, cervical cancer, or complicated seasonal influenza requiring
57 hospitalization. Finally, the questionnaire asked about their perception of the utility and safety of
58 vaccines, trust in different sources of information about vaccine risks and benefits (French Ministry of
59 Health, scientific sources, and medical colleagues), knowledge about vaccine components (if the
60 influenza vaccine contains aluminum), and perceived self-efficacy in explaining the role of vaccine
61 adjuvants.

62 The participants gave their written consent and did not receive any incentive. The Ethics Committee
63 of Aix-Marseille University approved this study (2017-14-12-006).

64 Statistical analysis

65 We weighted data for age and sex, according to the Ministry of Health's Shared Directory of Health
66 Professionals to match the HSP population in France. In a sensitivity analysis, we separately weighted
67 data on regional HSP numbers and hospital size (in addition to age and sex) and found no significant
68 differences in the distribution of HSPs' responses compared to that after age- and sex-weighting. The
69 following results are thus presented with the latter weighting only.

70 To estimate vaccine hesitancy prevalence among HSPs, we constructed a typology of vaccine-related
71 attitudes, based on items on trust in sources of information about vaccines, perceived usefulness and
72 risks of vaccines, and self-efficacy (Table A2, Appendix), adapting a previously published approach
73 used for GPs [9]. In addition to the self-efficacy dimension, our measure of vaccine hesitancy also
74 covers the two dimensions of the Vaccine Hesitancy Scale developed by the WHO SAGE group: lack
75 of confidence in vaccine benefits and information, and fear of vaccine risk [14]. We performed a
76 weighted multiple correspondence analysis (MCA) combined with an agglomerative hierarchical
77 cluster analysis (AHCA) of the different dimensions of HSPs' VH [15]. MCA is an exploratory technique
78 used to understand the interrelations between multiple categorical variables [16]; it allows
79 correlated variables to be combined into continuous factors [17]. These factors are then introduced
80 in the AHCA, which classifies individuals with similar characteristics into clusters. To identify the
81 optimal number of clusters, we used a method based on minimum inertia lost [17,18], corresponding
82 to the lowest total within-cluster variance (individuals with maximum similarity in each cluster) and
83 highest between-cluster variance.

84 We then used this typology as a dependent variable in univariate and multiple modified Poisson
85 regressions to analyze factors potentially associated with it [19]. We tested the following explanatory
86 variables: demographic and professional characteristics, perceived role in the field of vaccination,
87 experience of serious adverse effects with vaccines (Yes/No), experience of vaccine-preventable
88 diseases among patients (count variable ranging from 0 to 5), knowledge about vaccine components,
89 self-vaccination behaviors, and a score of the HSPs' frequency of patient vaccine recommendations.
90 We calculated the latter by adding their responses on a Likert scale (range [0–6]; Cronbach's alpha =
91 0.66). Because we observed multicollinearity between specialty and the vaccine recommendation
92 frequency score, we constructed two models each including one of these two variables.

93 We used the variance inflation factor (VIF) to test for multicollinearity and interpreted VIF values of
94 <5 as not presenting any multicollinearity issues. All analyses were based on two-sided *P* values, with

95 statistical significance defined as $P \leq 0.05$; they were performed with Stata 14 (StataCorp, College
96 Station, TX, USA) and R 3.6.3 (R Foundation, Vienna, Austria).

97 Results

98 Of the 4,327 eligible HSPs, 2,154 (50%) could be contacted: 1,851 (86%) participated in the survey; 45
99 (2.4%) of them were excluded because their specialty was outside the scope of the study (biologists,
100 radiologists, etc.), and 11 (0.6%) who did not provide their age or sex. This left 1,795 (83%) HSPs for
101 the analyses. Female HSPs accounted for 53.6% of the participants, and 49.1% of HSPs were younger
102 than 45 years; the specialties included most often (i.e., >6% of the sample) were cardiology, geriatrics,
103 hepato-gastroenterology, oncohematology, pediatrics, and pulmonology; specialties least
104 represented were general practice, ophthalmology-otolaryngology, psychiatrics, psychiatry, public
105 health-social medicine-occupational medicine (Table 1).

106 Almost all HSPs (99%) were favorable to vaccination (93.7% strongly; Table 2). Among those
107 accustomed to discussing vaccination with their patients, 54% reported that they try to convince
108 vaccine-reluctant patients to be vaccinated while 45% reported that they would simply inform them
109 of the benefits and risks of vaccines, but do not try to convince patients about the need for
110 vaccination.

111 Most HSPs reported that they had been vaccinated against seasonal influenza (82%) in 2017/18, that
112 they had their last dTP booster within the past 20 years (91%), and at least 3 doses of the HBV
113 vaccine (86%). Only 20%, however, had taken at least one continuing medical education program on
114 infectious diseases and/or vaccination in the past three years.

115 Among the participants, 52.5% trusted the Ministry of Health as a source of information about the
116 benefits and risks of vaccines (Table 3). Only 3% agreed with the proposition that some vaccines
117 recommended by health authorities are useless, and only 40.7% felt comfortable giving their patients
118 explanations about the role of adjuvants. Regarding the potential risks of vaccines, 10.3% found a

119 causal link between hepatitis B vaccine and multiple sclerosis to be likely or did not express an
120 opinion about this purported link, while the corresponding percentages were 26.3% for a link
121 between seasonal influenza vaccine and Guillain-Barré syndrome, and 21.3% for one between
122 aluminum adjuvants and neurological complications (Table 4).

123 The analysis of cross-tabulated proportions of HSPs attributing to a particular vaccine a specific
124 severe adverse effect (or other severe adverse effects or unsure about it, Table S1) shows that these
125 responses were all very significantly associated. For example, of the HSPs who considered a causal
126 link between seasonal influenza vaccination and Guillain-Barré syndrome to be likely (or who were
127 unsure), 22% attributed multiple sclerosis to hepatitis B vaccine (or were unsure), compared with
128 4.6% of other HSPs ($P<0.001$). The percentages of participants attributing one, two, or three or more
129 severe adverse effects to vaccines were respectively 22.0%, 9.6%, and 3.1%.

130 We identified three clusters according to VH level (Figure 1). HSPs in cluster 1 (58%) were
131 characterized by low or almost no VH (Table 3): they had the greatest trust in official sources of
132 information about vaccine risks and benefits and reported the fewest doubts regarding vaccine utility
133 and safety. Most considered links between all of the proposed vaccines and potential severe adverse
134 effects unlikely.

135 Given the very small size of cluster 3 (High VH; $n=14$; 0.8%), we merged it with cluster 2 (41%, Table
136 3). HSPs in the resulting cluster (“moderate” VH; they will be referred hereafter as to hesitant HSPs)
137 were relatively less trustful of official sources of information on vaccination (higher frequency of
138 “trust somewhat” answers); in particular, 37% of them believed that French health authorities are
139 influenced by the pharmaceutical industry. Hesitant HSPs did not perceive vaccines to be as useful or
140 as safe as those in cluster 1 and showed lower perceived self-efficacy in their responses in general
141 (Tables 3 & 4). Prevalence of hesitancy was lowest in infectious disease specialists (12.3%) and
142 pediatricians (27.7%) and highest in ophthalmologists or otolaryngologists (61.9%) (Table S2).

143 The two-model strategy presented above showed no multicollinearity issue. In both the univariable
144 and multivariable regressions, the least vaccine-hesitant among all "vaccinators" were the specialists
145 in infectious diseases and the pediatricians (Table 7). Apart from these two specialties, VH prevalence
146 did not differ significantly between "vaccinators" and "non-vaccinators". Vaccine-hesitant HSPs
147 reported they were less frequently vaccinated against seasonal influenza and were less often up-to-
148 date for their vaccination against HBV, less likely to try to convince reluctant patients to accept
149 vaccines and to discuss vaccination with their patients and more likely to rely on their own judgment
150 over national vaccine recommendations (Table 5). HSPs' VH was associated with a significantly lower
151 patient vaccine recommendation frequency score. It was less prevalent among HSPs who had had
152 training on infectious diseases and vaccination over the past three years.

153

154 Discussion

155 While almost all the HSPs in our study reported that they were strongly favorable to vaccination, 40%
156 of them reported moderate VH.

157 Among hesitant HSPs, VH remained moderate, however, with only 14 HSPs showing high VH: the
158 very low percentage of HSPs considering that some vaccines recommended by health authorities are
159 useless (Table 3) contrasts with the corresponding percentage found among French GPs in 2014
160 (25%) [9]. Less than one in five HSPs found a causal link between hepatitis B vaccine and multiple
161 sclerosis to be likely or preferred not to express an opinion about this purported link, compared with
162 30% among French hesitant GPs in 2014 [9] and 74% among French nurses in 2018 [20]. As we had
163 noticed for GPs previously, HSPs' answers about the potential links between vaccines and severe
164 adverse effects reflect their risk perceptions more than their knowledge of epidemiological results in
165 this field. This finding is supported by the strong association in the cross-analyses (Table S1) of HSPs'
166 responses between the corresponding six items, whether these side effects were rumored or
167 documented. Moreover, the high frequency of "don't know" answers (Table 4) suggests that
168 significant proportions of them feel uncertain about vaccine safety, an important subject of concern
169 for hesitant patients. However, the results also suggest that HSPs' knowledge was somewhat better
170 with regard to the links between seasonal influenza vaccination and Guillain-Barré syndrome, and
171 Pandemrix and narcolepsy for which there is some evidence [21–23] (Table 4). These percentages
172 differed less markedly between non-hesitant and hesitant HSPs than for alleged neurological effects
173 of adjuvants, which have been an important subject of controversy in France over the past two
174 decades [8].

175 Another feature of hesitant HSPs is their moderate or relative trust of health and safety agencies and
176 the Ministry of Health (Table 3). Comparisons of our results with previous ones among other French
177 HCPs using an item proposing that the Ministry of Health is influenced by the pharmaceutical
178 industry show a rising gradient of distrust towards the Ministry of Health from HSPs (35%, whole

179 sample) to GPs (53%) [8] and nurses (80%) [20]. Trust in public health institutions plays a substantial
180 role in shaping GPs' perceptions of vaccine utility and safety [10]. The results of this study illustrate
181 that trust in the healthcare system and, more generally, in government bodies affects vaccine
182 acceptance not only by the public but also by HCPs, even those who have had more extensive
183 medical training about vaccination. These results might be explained by multiple factors that deserve
184 further research. The numerous health crises – at the time of this survey, the most recent was that of
185 Mediator® (benfluorox), a drug marketed as an antidiabetic with harmful cardiac effects claimed to
186 have resulted over the years in the deaths of as many as 2000 patients without being withdrawn by
187 its manufacturer or removed by French health authorities) – as well as the decades-long social
188 conflicts and underfunding of public hospitals, could well have significantly impaired HSPs'
189 confidence in the Ministry of Health [24].

190 Our results are consistent with previous results suggesting that VH in physicians and other HCPs is
191 associated with their lower uptake of some vaccines, especially against the seasonal flu [25,26], even
192 though self-reported vaccine coverage against this disease is high in our study [27]. A questionnaire
193 survey of more than 1200 physicians in 2018-19 in France found a self-reported vaccine coverage
194 rate of 67% for seasonal flu: the inclusion in their sample of some hospitals in the French overseas
195 territories (about 15% of the sample), where seasonal flu vaccine uptake was very low, may explain
196 in part the difference with our results.

197 They also suggest that hesitant HSPs have different behaviors and attitudes towards their patients
198 than non-hesitant doctors do (Table 5). First, they suggests that hesitant HSPs might be less prone
199 than their non-hesitant counterparts to recommend to their patients vaccines officially
200 recommended for them because of their chronic or severe conditions [8]. This is a matter of concern
201 because the recommendation of vaccines to patients by their doctors is one of the most important
202 drivers of their acceptance [28]. VH also encompasses the greater tendency by hesitant than non-
203 hesitant HSPs to give more weight to their own judgment than to official vaccine recommendations,

204 as we previously found in a qualitative study of hesitant GPs [12]. In that study, some GPs criticized
205 official vaccine recommendations that they found too complex to apply; others considered that their
206 frequent revision creates doubt about their validity; finally, many were willing to adapt the
207 vaccination schedule for acute conditions.

208 Second, hesitant HSPs were less proactive in motivating their hesitant patients to be vaccinated than
209 non-hesitant HSPs (Table 5), perhaps because they might share some concerns with their hesitant
210 patients about some vaccines and/or may not feel adequately prepared to address these concerns
211 appropriately. In the current context of scientific debate about the most effective communication
212 approaches in the field of vaccination [1], it is difficult to draw firm conclusions about the
213 consequences of such attitudes: they are not necessarily a sign that HSPs are disengaging from their
214 role in patient vaccination.

215 As expected, VH frequency was lowest among infectious disease specialists and pediatricians,
216 specialties (Table S2) in which vaccination has a more important place in training and practice than in
217 other specialties. A recent study in Finland among various HCPs (doctors and nurses) found that their
218 vaccine confidence followed a gradient that increased with their educational level [11,12]. In our
219 results, however, this gradient was limited to the comparison of infectious disease specialists and
220 pediatricians to other doctors, thereby suggesting that, except for these specialties, moderate VH
221 prevalence was present in all other specialties, vaccinators or non-vaccinators, with prevalence rates
222 of the same order of magnitude. In other words, most hospital physician specialties may be affected
223 by VH.

224 These results should be interpreted while bearing the study's strengths and limitations in mind. The
225 participation rate was high (86%). The main reasons for refusing participation were lack of time or
226 lack of interest in the topic. Selection bias cannot be ruled out, however, as not all eligible HSPs could
227 be contacted by the clinical research associates, and participation was voluntary: physicians who
228 agreed to participate could have been more aware of vaccination issues than non-participants, and

229 this could have led to an underestimation of VH prevalence. The questionnaire used in this study was
230 adapted from a previous one prepared for a survey among GPs in 2014 [8] and thus enabled some
231 “qualitative” comparisons of HSPs' answers with those of GPs several years earlier. After adaptation
232 of the questionnaire, its face validity was very good, with few non-responses.

233 The 14 participating hospitals (among 93 in mainland France) were not randomly selected: the
234 resulting sample may not be representative of all HSPs in France. However, weighting the data
235 according to hospital region and size did not produce changes in the observed distributions of
236 responses to questionnaire items. Moreover, most HSPs' specialties (and all of those participating in
237 vaccination tasks) were represented in the sample and were affected by VH at similar frequencies
238 and to similar extents (with the exception of specialists in infectious diseases and pediatricians; see
239 the supplementary analysis detailing the specialty variable (Table A3, Appendix).

240 The cross-sectional design prevents us from drawing any conclusions about causality for the relations
241 between VH and its potential determinants, as is the case for most studies in this field. Finally, all
242 data were self-reported and a social desirability bias cannot be ruled out. The field survey
243 nonetheless took place during a period not marked by intense vaccine controversies. Memory bias
244 might have affected the reliability of responses to self-reported vaccination: authors consider that it
245 could slightly overestimate actual uptake [29]; it should not, however, have influenced the relation
246 between self-declared uptake and VH.

247 In conclusion, the results of this study contribute to a more complete assessment and understanding
248 of VH among HCPs. Concerns or uncertainties about the safety of specific vaccines were observed in
249 most specialties in hospitals, with the exception of infectious disease specialists and pediatricians.
250 Our results, combined with those of previous studies of HCPs, suggest that hesitant HSPs may have
251 less proactive practices than non-hesitant HSPs.

252 Qualitative studies are needed to better understand the various determinants underlying HSPs' VH,
253 as hospitals are an important specific setting as mentioned above. Taken together our results

254 underscore once again the urgent need to address VH in physicians and to allocate to vaccination the
255 place it deserves in their initial training curriculum [30] and in continuing medical education.
256 Interventions are needed to help them discern falsities from truth about vaccine controversies and
257 better prepare them to cope with their patients' hesitancy.

258 Funding

259 This study was supported by a grant from the French Ministry of Health, Direction Générale de l'Offre
260 de Soins (PREPS, DGOS/PF4/2015/368).

261 Acknowledgments

262 We warmly thank all of the physicians who participated in this survey, the I-Reivac coordination team
263 at the Clinical Research Centre of the hôpital Cochin, Paris (Mylène HODEBOURG, Meriam JERBI
264 MANSRI), Assistance Publique - Hôpitaux de Paris (Paris public hospital system); the Clinical Research
265 Centre of the Centre Hospitalier Annecy Genevois; Xavier JARRIGE, Laetitia HENAFF and Claire DE
266 BASTIANI (Hospices Civils de Lyon); Clinical Research Centre (of the Hôpitaux Universitaires de
267 Strasbourg; the Clinical Research Unit of the CHU de RENNES; Pr Lionel PIROTH, Infectious Diseases
268 Department, Centre Hospitalier Universitaire de Dijon Bourgogne; Nicole Allard and Marie Alexandra
269 Paquot IDRC, DRCl of the CHRU de Nancy; the survey platform of the Observatoire régional de la
270 santé Paca (Gwenaëlle Maradan, Cyril Bérenger, Michael Huart) and Jo Ann Cahn for the revision of
271 this article.

272 All authors attest they meet the ICMJE criteria for authorship.

273

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363 Tables

364 Table 1: Characteristics of hospital staff physicians (n = 1,795)^a

	No. (N = 1,795)	%
Characteristics		
Sex		
Women	962	53.58
Men	833	46.42
Age (years)		
< 35	407	22.67
35-44	475	26.47
45-54	357	19.87
55-64	488	27.18
> 64	68	3.81
Specialty		
Anesthesiology-critical care	62	3.46
Cardiology	119	6.61
Dermatology	68	3.78
Endocrinology-diabetes	88	4.91
General practice	32	1.81
Geriatrics	118	6.56
Gynecology-obstetrics	95	5.32
Hepato-gastroenterology	122	6.81
Infectious diseases	102	5.70
Internal medicine	100	5.56
Nephrology	93	5.20
Neurology	104	5.78

Oncohematology	115	6.42
Ophthalmology, otolaryngology	30	1.65
Pediatrics	186	10.35
Physiatrics	12	0.70
Psychiatry	32	1.77
Public health, social medicine and occupational health	52	2.89
Pulmonology	117	6.52
Rheumatology	60	3.33
Surgery	87	4.87

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^a weighted data, France, September 2018 to October 2019

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367 Table 2: Experience, practices, knowledge and opinions of hospital staff physicians towards vaccines and
 368 vaccination (n = 1,795)^a

	No. (N = 1,795)	%
Opinions on vaccination in general & perceived role		
Favorable to vaccination in general		
Strongly favorable	1682	93.70
Somewhat favorable	99	5.50
Not favorable/NR (N = 11) ^b	14	0.80
Perceived role towards vaccine-hesitant patients (N=1,659) ^c		
Try to convince reluctant patients to get vaccinated	898	54.13
Inform patients on vaccines benefits & risks, without trying to convince them	753	45.41
Will not agree to care for patients refusing vaccination	8	0.46
Experience with vaccination		
Has had at least one patient hospitalized with at least one vaccine-preventable disease in the past 5 years ^d		
Yes	1,603	89.30
No/DK (3) ^e /NR (3)	192	10.70
Has had any patients with a serious health problem potentially related to vaccination		
Yes	141	7.84
No/DK (11)/NR (6)	1,654	92.16
Personal vaccinations		
Against 2017/18 seasonal influenza		
Yes	1,468	81.76
No/DK (3)/NR (1)	327	18.24

Last diphtheria-tetanus-polio (DTPolio) booster		
< 20 years ago	1,627	90.62
> 20 years ago	111	6.16
Does not remember/NR (2)	58	3.22
Against hepatitis B		
Yes, 3 or more doses	1,547	86.18
Yes, fewer than 3 doses	150	8.34
No/DK (48)/NR (2)	98	5.49
Knowledge about vaccination		
Has taken at least one continued medical education program on infectious diseases and/or vaccination in the last three years		
Yes	371	20.68
No, but teaches classes about vaccination	101	5.64
No/DK (3)	1,323	73.68

^a Weighted data

^b NR: no response

^c Question asked only to HSs who are accustomed to discuss vaccination with their patients; 5 NRs

^d Five vaccine-preventable diseases were mentioned in the questionnaire: measles, acute or recently diagnosed chronic hepatitis B, bacterial meningitis, cervical cancer, and complicated seasonal influenza requiring hospitalization

^e Does not know

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372 Table 3: Typology of hospital physicians according to their level of vaccine hesitancy, cross-tabulated with their
 373 trust in sources of information about vaccines, and their perceptions of usefulness vaccines (n = 1,795)^a

	Vaccine hesitancy		
	Almost none or low (N = 1,038) 57.83% [55.38-60.25] ^b	Moderate ^c (N = 757) 42.17% [39.75-44.62]	Total (N = 1,795) %
Trust in sources of information about the benefits and risks of vaccines			
French Ministry of Health***			
Distrust/DK (N = 18)/NR (7) ^d	5.24	9.60	7.08
Somewhat trust	28.14	57.22	40.40
Strongly trust	66.61	33.18	52.52
French Health and Safety agencies***			
Distrust/DK (34)/NR (6)	2.90	7.79	4.96
Somewhat trust	22.99	51.94	35.20
Strongly trust	74.11	40.27	59.84
Scientific sources***			
Distrust/DK (3)/NR (3)	0.52	1.59	0.97
Somewhat trust	13.48	35.21	22.64
Strongly trust	86.00	63.20	76.39
Physician colleagues***			
Distrust/DK (3)/NR (1)	0.74	1.64	1.12
Somewhat trust	10.05	23.40	15.68
Strongly trust	89.21	74.96	83.20
French health authorities are influenced by the pharmaceutical industry***			
Disagree/DK (66)/NR (18)	78.05	63.19	71.78

Agree	21.95	36.81	28.22
You trust the group of experts who establishes vaccine recommendations in France*			
Disagree/DK (4)/NR (2)	1.51	3.56	2.37
Agree	98.49	96.44	97.63
Perception of the usefulness of vaccines			
Some vaccines recommended by health authorities are useless			
Disagree/DK (18)/NR (39)	97.43	96.38	96.77
Agree	2.57	3.62	3.23
Children are vaccinated against too many diseases***			
Disagree/DK (14)/NR (3)	99.03	93.66	96.77
Agree	0.97	6.34	3.23
Self-efficacy			
Generally, do you feel comfortable giving your patients explanations about the:			
Usefulness of vaccines***			
No/DK (1)/NR (7)	3.10	10.69	6.30
Yes	96.90	89.31	93.70
Role of adjuvants***			
No/DK (18)/NR (12)	51.10	70.59	59.32
Yes	48.90	29.41	40.68

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$ (Chi-squared test (with Rao-Scott correction))

^a Agglomerative hierarchical cluster analysis, weighted data

^b 95% confidence interval

^c 14 HSs with high VH were included with the low to moderate VH group

^d DK/NR: Does not Know/No Response

375 Table 4: Typology of hospital physicians according to their level of vaccine hesitancy, cross-tabulated with their
 376 perceived risks of vaccines (n = 1,795)^a

	Vaccine hesitancy		
	Almost none or low	Moderate ^b	Total
	(N = 1,038)	(N = 757)	(N = 1,795)
	%	%	%
Perceived likelihood of risks between specific vaccines			
and potential severe adverse effects			
Seasonal influenza vaccine and Guillain-Barré syndrome***			
Unlikely	81.69	62.67	73.67
Likely	16.39	27.28	20.98
Does not know (N = 88)/NR (8) ^c	1.92	10.05	5.35
Hepatitis B vaccine and multiple sclerosis***			
Unlikely	97.02	82.33	90.82
Likely	2.86	11.83	6.64
Does not know (36)/NR (9)	0.13	5.84	2.54
Aluminium adjuvants and neurological complications***			
Unlikely	89.58	63.89	78.75
Likely	4.32	19.86	10.88
Does not know (178)/NR (8)	6.09	16.25	10.37
AS03-adjuvanted influenza A(H1N1)pdm09 vaccine			
Pandemrix® and narcolepsy***			
Unlikely	76.46	56.65	68.11
Likely	11.80	10.90	11.42
Does not know (360)/NR (8)	11.74	32.45	20.47
Human papilloma virus vaccine and multiple			

sclerosis***

Unlikely	96.14	76.97	88.06
Likely	0.15	3.19	1.43
Do not know (182)/NR (6)	3.71	19.84	10.51

MMR vaccine and autism***

Unlikely	97.36	81.92	90.85
Likely	0.06	1.50	0.67
Does not know (143)/NR (9)	2.57	16.58	8.48

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$ (Chi-squared test (with Rao-Scott correction))

^a Agglomerative hierarchical cluster analysis, weighted data, France, September 2018 to October 2019

^b 14 HSs with high VH were included with the low to moderate VH group

^c NR: No response

378 Table 5: Factors associated with higher vaccine hesitancy among hospital physicians, modified Poisson
 379 regression (n = 1,795)

Moderate vaccine hesitancy					
(ref. Almost none or low)					
N = 1,795					
	Simple	Multiple – Model 1		Multiple – Model 2	
	RR†	aRR†	CI 95%	aRR†	CI 95%
Characteristics					
Specialty (ref. Likely vaccinators ^a)					
Infectious disease specialists	0.25***			0.31***	[0.17,0.55]
Pediatricians	0.58***			0.63***	[0.49,0.81]
Likely non-vaccinators ^b	1.04			0.95	[0.81,1.13]
Other ^c	1.12			1.11	[0.88,1.39]
Perceived role					
Perceived role towards vaccine-hesitant patients (ref. Motivate them to vaccinate, even when they are reluctant)					
Inform them of the benefits and risks of vaccines, but let them decide	1.23***	1.18**	[1.05,1.32]	1.20**	[1.07,1.34]
Not concerned (does not discuss vaccination with patients)	1.61***	1.34**	[1.08,1.66]	1.34**	[1.11,1.61]
Experience related to vaccination					
Number of different vaccine-preventable diseases among the HSPs' patients [0–5]	0.94***	1.00	[0.96,1.04]	1.01	[0.97,1.06]
Knowledge on vaccines and vaccination					
Has had at least one continuing medical education in infectious diseases and/or vaccination in the last three years (ref. No/Do					

not Know)

No, but trains others in the field of vaccination	0.59**	0.71*	[0.50,0.99]	0.83	[0.60,1.17]
Yes	0.66***	0.76***	[0.64,0.90]	0.81*	[0.69,0.95]
According to you, does the flu vaccine contain aluminum? (ref. No)					
Yes	1.05	1.01	[0.82,1.24]	0.98	[0.80,1.21]
Does not know	1.30***	1.15	[1.00,1.31]	1.13	[0.99,1.29]

Personal vaccinations

Against 2017–2018 seasonal influenza (ref. Yes)

No/Does not know	1.46***	1.23***	[1.09,1.39]	1.26***	[1.12,1.43]
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Last diphtheria-tetanus-polio (dTPolio) booster (ref. <20 years ago)

>20 years ago	1.18	1.06	[0.86,1.32]	1.03	[0.83,1.28]
Does not remember	1.40**	1.21	[0.95,1.54]	1.21	[0.96,1.52]

Against hepatitis B (ref. Yes, 3 or more doses)

Yes, fewer than 3 doses	1.29**	1.19*	[1.01,1.41]	1.15	[0.97,1.35]
No/Does not know	1.39**	1.26*	[1.03,1.55]	1.25*	[1.02,1.54]

Vaccination towards patients

Score of vaccine recommendation (ref. Low, first tertile [0–3])

Moderate, second tertile [4–5]	0.79**	0.87	[0.75,1.00]		
High, third tertile [6]	0.64***	0.75***	[0.64,0.88]		
Not concerned (does not vaccinate patients)	0.97	0.91	[0.76,1.08]		

You rely on your own judgment over official vaccine recommendations (ref. No)

Yes	1.22*	1.22*	[1.02,1.46]	1.23*	[1.03,1.47]
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RR: relative risks; aRR: adjusted relative risks; CI: confidence interval; ***: p <= 0.001, **: p < 0.01, *: p < 0.05

Variables not shown (not significant): age, sex, has had patients with a serious health problem potentially related to vaccination. All VIF < 5: no proof of multicollinearity.

^aLikely vaccinators: cardiologists, dermatologists, endocrinologist-diabetologists, geriatricians, gynecologist-obstetricians, internists, nephrologists, neurologists, oncohematologists, pulmonologists, rheumatologists; ^bLikely non-vaccinators: anesthetist/intensivists, ophthalmologists, otolaryngologists, psychiatrists, surgeons; ^cOthers: general practitioners, physiatrists, doctors working in public health, social medicine and occupational health

