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Self-reported immunity and opinions on vaccination of hospital personnel among paediatric healthcare workers in Denmark



Marie-Louise von Linstow^{a,*}, Thilde Nordmann Winther^b, Anna Eltvedt^c, Allan Bybeck Nielsen^{a,b}, Alex Yde Nielsen^d, Anja Poulsen^a

^a Department of Paediatrics and Adolescent Medicine, The Juliane Marie Centre, Copenhagen University Hospital Rigshospitalet, Copenhagen, Denmark

^b Department of Paediatrics and Adolescent Medicine, Copenhagen University Hospital Hvidovre, Copenhagen, Denmark

^c Department of Paediatrics and Adolescent Medicine, Nordsjællands Hospital, Hillerød, Denmark

^d Department of Clinical Microbiology, Copenhagen University Hospital Rigshospitalet, Copenhagen, Denmark

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ABSTRACT

Background: Denmark has no general recommendations for vaccination of healthcare workers (HCWs). We explored the self-reported immunity to varicella, measles, mumps, and rubella, reasons for receiving the influenza vaccine or not, and opinions on vaccination of HCWs against varicella, MMR, pertussis, diphtheria, and influenza among staff from departments with a high risk of exposure to infectious agents. **Methods:** From May 2019 to August 2019, a structured questionnaire was distributed to clinical and non-clinical HCWs at a tertiary and a general paediatric department in Denmark. Self-reported immunity was defined as either previous infection or vaccination against the disease.

Results: Of 619 employed HCWs, 555 (90%) were included. A large proportion were unsure of or denied previous vaccination or infection with measles (20.1%), mumps (30.2%), rubella (21.4%), varicella (12.1%), pertussis (44.1%), and diphtheria (32.1%). Non-clinical personnel and employees born in 1974–1983 had the lowest level of self-reported immunity. Mandatory vaccination of non-immune HCWs was approved by 54–68.9% of participants, and any kind of vaccination (mandatory or as an offer at hospitals) was approved of up to 95.3% of all participants depending on the disease. During the season 2018/19, 214 (38.6%) HCWs received the influenza vaccine, including 20.3% of non-clinical staff, 34.8% of nurses and 56.5% of doctors ($P < 0.001$). Reasons for lack of vaccine uptake were mainly employees considering themselves rarely sick, the vaccine was not regarded as necessary, forgetfulness or lack of time. Only 37.8% was in favour of mandatory influenza vaccination.

Conclusions: A large proportion of paediatric HCWs were not aware of their immune status against important vaccine-preventable diseases. >90% supported vaccination of HCWs, with two out of three supporting mandatory MMR, pertussis and diphtheria vaccination. Better information and an official immunisation policy of non-immune HCWs in Denmark is warranted.

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1. Introduction

Healthcare workers (HCWs) in paediatric settings are often exposed to communicable diseases and represent a source of infection for susceptible patients, parents, and colleagues. Measles, mumps, rubella, varicella, influenza and pertussis are highly conta-

rious infectious diseases that can cause serious complications, particularly in immunocompromised patients, infants and pregnant women.

The child vaccination programme in Denmark includes two doses of measles, mumps, rubella (MMR) vaccine and a 2 + 1 regimen of diphtheria, tetanus, acellular pertussis, polio, and Haemophilus influenzae type b (DTaP-IPV-Hib) vaccine with a booster dose of DTaP-IPV at five years. Varicella vaccination and further booster doses of DTaP are not implemented in the program and influenza vaccination is only given to certain risk groups. Despite high vaccination coverage (>90% for most vaccines), and a measles elimination status since 2017, 15 cases of measles occurred in Denmark in 2019, six of them as imported cases [1].

* Corresponding author at: Department of Paediatrics and Adolescent Medicine, The Juliane Marie Centre, Copenhagen University Hospital Rigshospitalet, Blegdamsvej 9, 2100 Copenhagen, Denmark.

E-mail addresses: Marie-Louise.von.Linstow.01@regionh.dk (M.-L. von Linstow), thildewinther@gmail.com (T. Nordmann Winther), anna.eltvedt@gmail.com (A. Eltvedt), Allan.Bybeck.Nielsen@regionh.dk (A. Bybeck Nielsen), alex.christian.yde.nielsen@regionh.dk (A. Yde Nielsen), anja.poulsen.01@regionh.dk (A. Poulsen).

Many vaccine-preventable diseases (VPDs) spread rapidly in closed settings even before onset of symptoms or when symptoms are mild and nonspecific. Vaccination is the best way to protect susceptible individuals and prevent transmission of infections, but vaccination status and immunity of Danish HCWs have only attracted little attention. It is estimated that HCWs have a 13–19 fold increased risk of acquiring measles compared to the general population [2] and numerous outbreaks of measles, rubella, pertussis, varicella, and influenza have been traced to HCWs [3–8]. In a recent Italian study, five of 20 HCWs involved in a nosocomial measles outbreak had no direct contact to patients [9].

Denmark experienced a national pertussis epidemic from June 2019 until lockdown of the country due to COVID-19 in mid-March 2020 with up to 300 cases/100,000 per year in some areas [10]. To date, no outbreaks in hospital settings were recorded. A national initiative was taken to vaccinate pregnant women for pertussis until the end of 2020. No booster vaccination programme of front-line HCWs was undertaken and no booster vaccinations in teenagers and adults were implemented.

During each season, 20% of HCWs are estimated to contract influenza [11], and a large group of HCWs continue to go to work despite of symptoms [12,13]. A recent study showed that nearly half of HCWs with laboratory-confirmed influenza were afebrile, posing a risk of influenza transmission to patients and co-workers [14]. Influenza vaccination of HCWs is an inexpensive and safe way to reduce transmission [15].

As opposed to many other European countries [16], Denmark has no national recommendations for vaccination of HCWs except for hepatitis B to specific groups, and there is no requirement of up-to-date vaccinations for new employees. Vaccination of HCWs is highly debated globally and mandatory vaccination against e.g. influenza, pertussis, MMR and diphtheria has been implemented as a requirement to be employed at some institutions in the United States and Europe [16,17]. Refusal of mandatory vaccination may result in transfer to a post with no patient contact, a fine or employment termination. However, not all countries have a regulatory policy or penalty in case of mandatory vaccine refusal [16].

Before considering implementing recommendations for vaccination of HCWs it is important to know the magnitude of the need and understand staff attitudes and perceptions of such an initiative.

We explored the self-reported immunity to varicella and the MMR diseases, reasons for receiving the influenza vaccine or not, and opinions on vaccination of HCWs against varicella, MMR, pertussis, diphtheria, and influenza among staff from two departments with a high risk of exposure to infectious agents.

2. Methods

2.1. Study design and population

Denmark has 15 general paediatric departments and 3 tertiary referral paediatric departments employing approximately 3500 HCWs. In this cross-sectional survey, all HCWs employed at the Department of Paediatrics and Adolescent Medicine, Rigshospitalet, a tertiary care centre including oncology, cardiology and bone marrow transplant units, and the Department of Paediatrics and Adolescent Medicine, Hillerød Hospital, a general hospital including a neonatal ward were invited to participate in the study in the period from May 2019 to August 2019. Both centres have a paediatric emergency ward and outpatient clinics. HCWs included nurses, physicians, medical and nursing students, secretaries, dieticians, cleaning staff, clowns and others with direct or indirect con-

tact to patients or access to patient rooms. HCWs were full-time employed or only temporarily associated to the departments.

2.2. Data collection

Initially, HCWs were informed about the project by flyers distributed to all units followed by short information meetings. During the study period, all HCWs were approached personally and offered the opportunity to participate in the study. Interested staff received oral and written information from one of four physicians involved in the project.

After written informed consent, participants filled-in a hard copy of a structured questionnaire including 1) sociodemographic and professional characteristics (sex, age, number of children at home, profession, year of graduation, years in present job, work place (ward, outpatient clinic or both)), 2) Self-reported immunity status and vaccine uptake (history of infection or vaccination against the following VPDs: varicella, measles, mumps, rubella, pertussis and diphtheria, and history of influenza vaccination), 3) knowledge of side-effects to vaccines against the above mentioned diseases marked as “great knowledge”, “little knowledge” or “no knowledge”), and 4) attitudes towards vaccination of HCWs in Denmark (registered as the answer “yes”, “no” or “don’t know” to the question “Do you approve mandatory vaccination of HCWs” and “Do you approve vaccination as an offer to HCWs” for each of the investigated diseases). Reasons for rejecting or accepting influenza vaccination were written in free text promoting open-minded answers and later arranged into appropriate categories. The questionnaire was developed for the purpose of the study and was pilot-tested in a subset of nurses and doctors. It was reviewed and approved by the Ethics Committee of the Capital region of Denmark and the Data Protection Agency before project start. Data was registered anonymously.

2.3. Definitions

We defined self-reported immunity against varicella and the MMR diseases as either previous infection or vaccination against the disease. Susceptibility was defined as either no history or no knowledge of previous infection or vaccination. Pertussis and diphtheria were not included in these definitions due to waning immunity following disease or vaccination.

2.4. Statistical analysis

Chi-square tests were applied to compare the associations between self-reported history of disease and vaccination with age and occupation. Further, chi-square tests were used to investigate the association between reasons for influenza vaccine refusal and occupation, and to compare opinion on mandatory vaccination with age and own influenza vaccine uptake.

Logistic regression analysis was applied to investigate factors significantly associated with self-reported immunity to VPDs. Self-reported immunity as the outcome variable was coded as a binary variable (yes/no) with *yes* defined as answering *yes* to either vaccination or previous infection and *no* defined as answering *no* or *uncertain* to both vaccination and previous infection. The following independent variables were assessed in the univariate analysis: sex, age, profession, children in household, workplace, years in present job, knowledge of side-effects. Variables with a significance level of $P < 0.1$ in the univariate analysis were entered in the multiple regression model (forward selection). A P -value < 0.05 was considered significant. Data were analysed using the SPSS software, version 25 for Windows.

3. Results

3.1. Study population

We included 555 (90%) of all HCWs from the two departments. Seventeen (2.8%) declined participation, and 47 (7.6%) were never approached mainly due to variable work schedules. Characteristics of participants are shown in Table 1. Almost 90% were females, and more than half were nurses. Of note, at both centres almost one third of participants had been less than two years in their present job, including 39.7% of physicians, which is mainly due to planned rotation among young doctors, and 26.7% of nurses, indicating a great deal of replacement on these wards.

3.2. Immunity status

Participants' self-reported vaccination status and disease history are shown in Table 2. A high proportion of HCWs was not aware of their vaccination status. The lack of knowledge regarding previous vaccination to the MMR diseases was highest in the age group 36–45 (born in 1974–1983), with 30% of respondents in doubt. Similarly, a high proportion of HCWs did not know if they had previously been infected, ranging from 10.7% for varicella to

40.9% for pertussis. As for vaccination, the age group 36–45 years was the group with least knowledge regarding previous infection.

Self-reported immunity was seen in 87.9% for varicella, 79.9% for measles, 69.8% for mumps and 78.6% for rubella. 21.9% of female HCWs below the age of 46 years, and therefore potentially fertile, reported to be non-immune to rubella. Of those with no or uncertain previous infection with measles, mumps or rubella, between 58% and 68% had a positive vaccination status (Fig. 1).

The relation between self-reported immunity and age group is illustrated in Fig. 2. For mumps, immunity declined by age, and for all diseases, immunity was more prevalent in the youngest age group compared to the 36–45 year-olds. Non-clinical personnel had the lowest level of self-reported immunity for all four diseases (Fig. 3), while dieticians and physiotherapists had the highest level of immunity to measles and varicella, followed by physicians. Age and profession were the only variables associated with immunity in the multiple logistic regression analysis: Compared to the oldest age group, self-reported immunity to mumps was higher in the youngest age group (adjusted odds ratio (aOR) 2.4), and immunity to measles was lower in the 36–45 year-olds (aOR 0.45). Compared to nurses, physicians had an aOR of 3.08 of reported immunity to measles, while non-clinical staff had an aOR of 0.5 for immunity to all three MMR diseases (Suppl. Table). There was no difference in immunity according to sex, workplace, or years in present job.

Table 1
Demographic characteristics of 555 paediatric healthcare workers by study location

	Total (N=555)	Tertiary care centre (N=351)	General hospital (N=204)
Sex (%)			
Female	496 (89.4)	318 (90.6)	178 (87.3)
Male	59 (10.6)	33 (9.4)	26 (12.7)
Age, y (%)			
<26	49 (8.8)	31 (8.8)	18 (8.8)
26–35	158 (28.5)	119 (33.9)	39 (19.1)
36–45	142 (25.6)	84 (23.9)	58 (28.4)
46–55	110 (19.8)	63 (17.9)	47 (23)
56–65	78 (14.1)	45 (12.8)	33 (16.2)
66–75	18 (3.2)	9 (2.6)	9 (4.4)
Profession (%)			
Nurse	303 (54.6)	201 (57.3)	102 (50)
Physician	131 (23.6)	78 (22.2)	53 (26)
Student ^a	40 (7.2)	20 (5.7)	20 (9.8)
Dietician or physiotherapist	17 (3.1)	16 (4.6)	1 (0.5)
Secretary	27 (4.9)	16 (4.6)	11 (5.4)
Other non-clinical personnel ^b	37 (6.7)	20 (5.7)	17 (8.3)
Children in household (%)			
No	260 (46.8)	176 (50.1)	84 (41.2)
Yes	292 (52.6)	172 (49)	120 (58.8)
N/A	3 (0.5)	3 (0.9)	0
Year of graduation (%)			
Before 2000	175 (31.5)	97 (27.6)	78 (38.2)
2000–2009	145 (26.1)	91 (25.6)	54 (26.5)
2010–2019	200 (36)	146 (41.6)	54 (26.5)
Not graduated yet	23 (4.1)	9 (2.6)	14 (6.9)
N/A	12 (2.2)	8 (2.3)	4 (2)
Years in present job (%)			
0–1	175 (31.5)	113 (32.2)	62 (30.4)
2–4	119 (21.4)	81 (23.1)	38 (18.6)
5–7	52 (9.4)	36 (10.3)	16 (7.8)
8–10	35 (6.3)	30 (8.5)	5 (2.5)
>10	166 (29.9)	90 (25.6)	76 (37.3)
N/A	8 (1.4)	1 (0.3)	7 (3.4)
Job location (%)			
Ward only	274 (49.4)	180 (51.3)	94 (46.1)
Out-patient clinic only	74 (13.3)	62 (17.7)	12 (5.9)
Both	200 (36)	107 (30.5)	93 (45.6)
N/A	7 (1.3)	2 (0.6)	5 (2.5)

^a 23 nursing students and 17 medical students.

^b 2 musicians, 3 kitchen assistants, 2 pedagogues, 1 social worker, 6 hospital clowns, 17 service assistants, cleaning assistants and technicians, 6 red cross volunteers.

3.3. Influenza vaccination

During the season 2018/19, 214 (38.6%) HCWs from the two departments received the influenza vaccine, including 20.3% of non-clinical staff, 34.8% of nurses and 56.5% of doctors ($P < 0.001$). Staff > 36 years were vaccinated in 43.2% of cases compared to 30.9% of those below 36 years ($P < 0.01$). Only 30.9% of those with no knowledge of side-effects received the influenza vaccine compared to 51.2% of those with great knowledge and 34.6% of those with little knowledge ($p < 0.001$).

All but one recipient stated self-protection as the reason to get the vaccine, and all recipients mentioned the protection of patients and others as the reason. Three nurses felt a pressure from colleagues to receive the vaccine. Reasons for vaccine refusal are illustrated in Table 3. Decliners most frequently regarded themselves as healthy individuals who rarely got sick and therefore considered the influenza vaccine redundant. Only 6.8% did not want the vaccine and 12.9% were concerned of side-effects. Physicians most often did not have time or forgot to get vaccinated.

3.4. Opinions on vaccination

Most participants were in favour of mandatory vaccination of non-immune HCWs ranging from 54% for varicella to 68.9% for measles. As seen from Table 4, significantly more personnel from the younger age group < 36 years favoured mandatory vaccination. An exception was the influenza vaccine, where only 37.8% of all participants were positive to mandatory vaccination. Only 55.9% of HCWs in favour of mandatory influenza vaccine received the vaccine themselves in the season 2018/2019.

A large group (13–21% depending on the disease) was in doubt regarding their opinion for or against mandatory vaccinations. However, among those not in favour of mandatory vaccinations, between 83.7% and 89.8% thought vaccinations should be offered HCWs at hospitals. In total, any kind of vaccination (mandatory or as an offer at hospitals) was approved by 91.4% (varicella) to 95.3% (rubella) of all participants depending on the disease. There was no difference in attitudes between occupational groups (data not shown).

Table 2
Self-reported history of disease and vaccination according to age and profession in 555 paediatric healthcare workers

Disease	Age					P-value	Profession			P-value
	Total (N=555)	<36 years (N=207)	36–45 years (N=142)	46–55 years (N=110)	>55 years (N=96)		Nurse (N=303)	Physician (N=131)	Other (N=121)	
History of infection										
Varicella (%), N=553										
Yes	481 (87)	183 (88.4)	124 (87.3)	89 (82.4)	85 (88.5)	0.46	256 (84.8)	125 (95.4)	102 (82.9)	<0.01
Uncertain	59 (10.7)	18 (8.7)	16 (11.3)	16 (14.8)	9 (9.4)	0.39	37 (12.3)	6 (4.6)	16 (13)	<0.05
Measles (%), N=552										
Yes	203 (36.8)	6 (2.9)	44 (31)	76 (69.1)	77 (80.2)	<0.001	87 (29)	72 (55)	46 (37.1)	<0.001
Uncertain	121 (21.9)	46 (22.5)	39 (27.5)	20 (18.2)	16 (16.7)	0.17	79 (26.3)	11 (8.4)	32 (25.8)	<0.001
Parotitis (%), N=549										
Yes	148 (27)	4 (2)	40 (28.2)	51 (47.7)	53 (55.2)	<0.001	72 (24.2)	47 (36.2)	32 (25.8)	<0.05
Uncertain	156 (28.4)	53 (26)	37 (26.1)	34 (31.8)	32 (33.3)	0.44	85 (28.5)	25 (19.2)	46 (37.1)	<0.01
Rubella (%), N=551										
Yes	186 (33.8)	4 (2)	44 (31)	72 (66.1)	66 (68.8)	<0.001	87 (29.1)	60 (45.8)	41 (33.1)	<0.01
Uncertain	143 (26)	51 (25)	46 (32.4)	20 (18.3)	26 (27.1)	0.09	80 (26.8)	27 (20.6)	37 (29.8)	0.22
Pertussis (%), N=550										
Yes	62 (11.3)	8 (3.9)	7 (4.9)	13 (11.9)	34 (35.8)	<0.001	30 (10.1)	18 (13.7)	15 (12.2)	0.46
Uncertain	225 (40.9)	63 (30.9)	69 (48.6)	55 (50.5)	38 (40)	<0.01	112 (37.6)	51 (38.9)	62 (50.4)	0.05
History of vaccination										
Varicella (%), N=531										
Yes	14 (2.6)	8 (4)	2 (1.5)	3 (2.9)	1 (1.1)	0.18	5 (1.7)	1 (0.8)	8 (6.6)	<0.05
Uncertain	125 (23.5)	48 (24)	35 (25.7)	21 (20.2)	21 (23.1)	0.79	77 (26.6)	7 (5.6)	44 (36.4)	<0.001
Measles (%), N=543										
Yes	267 (49.2)	170 (82.5)	72 (51.1)	21 (20)	4 (4.4)	<0.001	155 (52)	59 (47.2)	53 (43.1)	0.19
Uncertain	121 (22.3)	33 (16)	45 (31.9)	22 (21)	21 (23.1)	<0.01	72 (24.2)	13 (10.4)	38 (30.9)	<0.001
Parotitis (%), N=540										
Yes	257 (47.6)	160 (77.7)	71 (50.4)	22 (21)	4 (4.5)	<0.001	149 (50.3)	60 (48.4)	49 (39.8)	0.14
Uncertain	134 (24.8)	40 (19.4)	46 (32.6)	25 (23.8)	23 (26.1)	<0.05	78 (26.4)	16 (12.9)	42 (34.1)	<0.001
Rubella (%), N=543										
Yes	278 (51.2)	166 (80.6)	79 (55.6)	25 (24)	8 (8.8)	<0.001	164 (55)	61 (48.8)	54 (43.9)	0.09
Uncertain	120 (22.1)	36 (17.5)	40 (28.2)	22 (21.2)	22 (24.2)	0.19	69 (23.2)	16 (12.8)	37 (30.1)	<0.01
Pertussis (%), N=544										
Yes	304 (55.9)	139 (67.5)	87 (61.7)	47 (43.9)	31 (34.4)	<0.001	166 (55.7)	83 (65.9)	56 (45.5)	<0.01
Uncertain	172 (31.6)	58 (28.2)	48 (34)	38 (35.5)	28 (31.1)	0.52	98 (32.9)	24 (19)	53 (43.1)	<0.001
Diphtheria (%), N=548										
Yes	372 (67.9)	156 (76.1)	97 (69.3)	60 (55.6)	59 (62.1)	<0.001	200 (67.3)	111 (84.7)	61 (49.6)	<0.001
Uncertain	151 (27.6)	46 (22.4)	40 (28.6)	36 (33.3)	29 (30.5)	0.17	84 (28.3)	14 (10.7)	56 (45.5)	<0.001

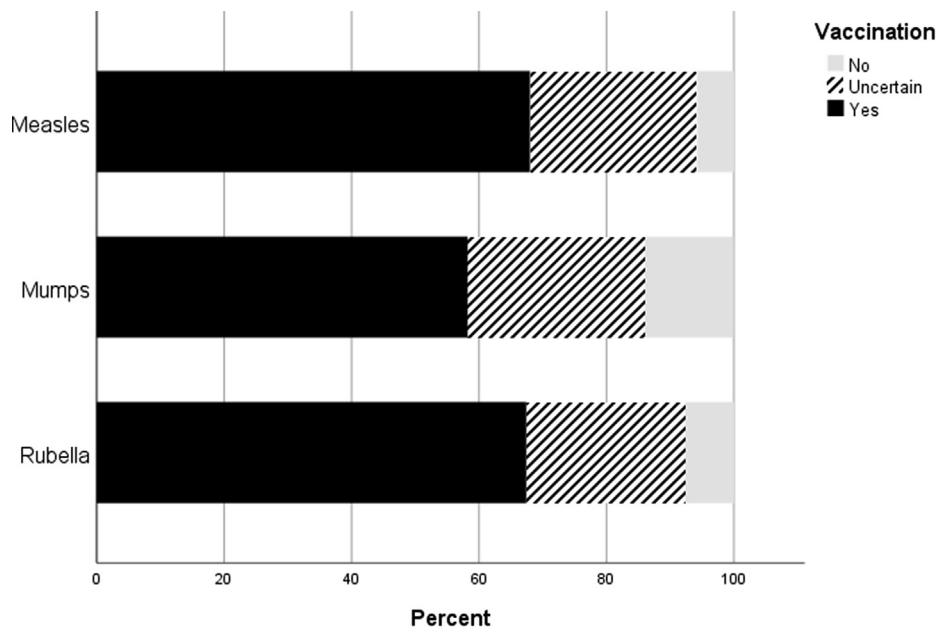


Fig. 1. Vaccination status of healthcare workers with no or uncertain previous MMR disease.

A quarter of participants anticipated to have great knowledge of side effects to the varicella, MMR, pertussis and diphtheria vaccines. However, half mentioned they had limited knowledge. A quarter did not know anything about the side effects, and this

group was more often in doubt about their opinion on mandatory vaccination or not. A great difference in knowledge was seen according to profession (Fig. 4). Physicians was the only occupational group with >25% having great knowledge of side-effects.

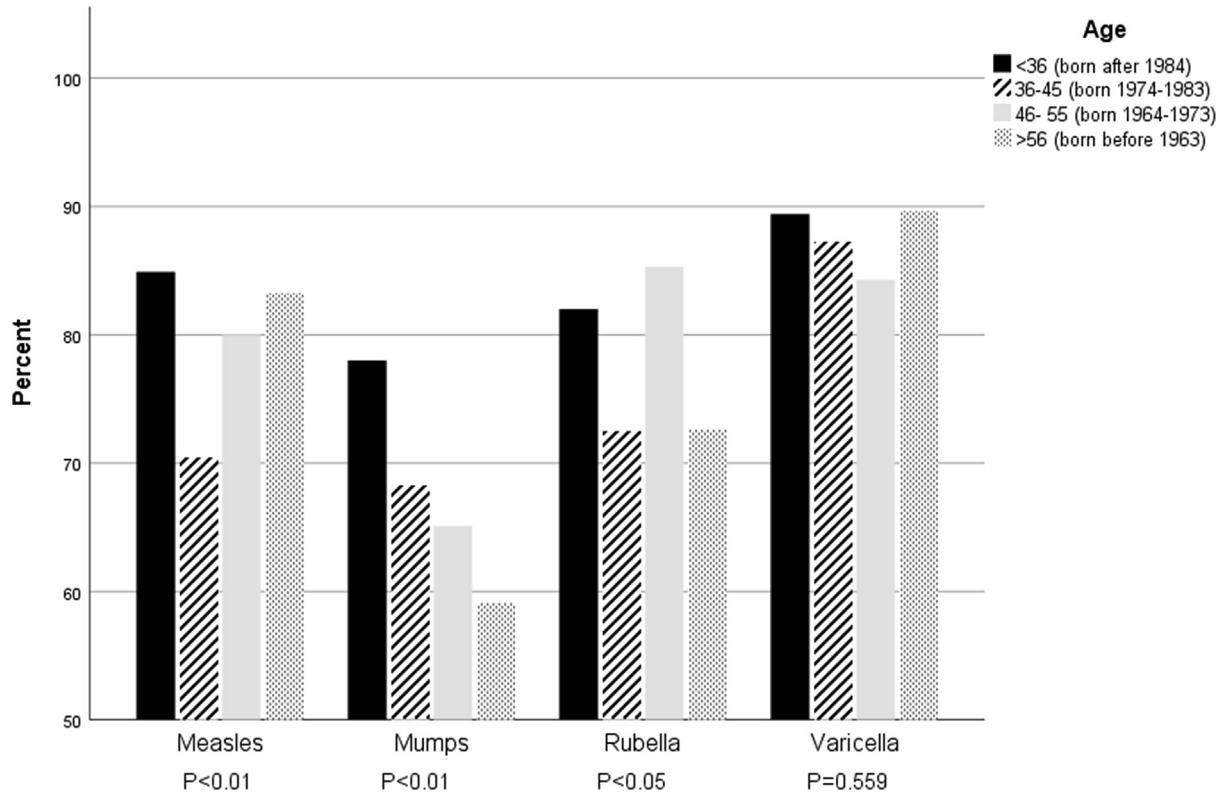


Fig. 2. Self-reported immunity by age in 555 paediatric healthcare workers.

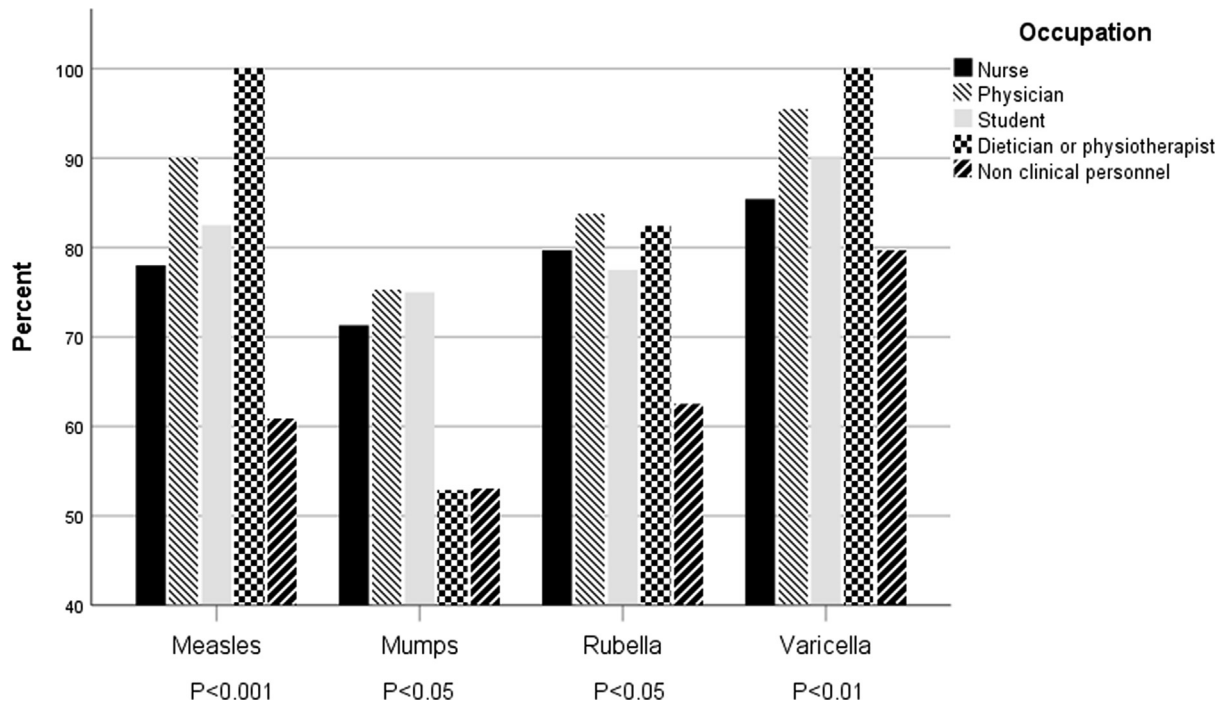


Fig. 3. Self-reported immunity by occupational group in 555 paediatric healthcare workers.

4. Discussion

Despite a significant reduction and control of several infectious diseases after universal implementation of vaccination programs, outbreaks of VPDs continue to occur. In our study, a high

proportion of HCWs was not aware of their immunity status to the VPDs investigated. Another large proportion claimed not to be immune, so totally 20–30% of HCWs were potentially at risk of transmitting diseases in the health-care setting. In paediatrics, diseases like measles and pertussis and their complications are

Table 3
Reasons for influenza vaccination refusal in the season 2018/2019

	Total (N=340)	Nurse (N=195)	Physician (N=57)	Other (N=88)	P-value
I am rarely sick (%)	76 (22.4)	51 (26.2)	9 (15.8)	16 (18.2)	0.141
Not necessary (%)	52 (15.3)	27 (13.8)	4 (7)	21 (23.9)	0.016
Concerned of side-effects (%)	44 (12.9)	29 (14.9)	6 (10.5)	9 (10.2)	0.469
Forgot/too busy (%)	52 (15.3)	25 (12.8)	22 (38.6)	5 (5.7)	<0.001
Not wanted (%)	23 (6.8)	16 (8.2)	2 (3.5)	5 (5.7)	0.414
Not offered (%)	20 (5.9)	12 (6.2)	1 (1.8)	7 (8)	0.292
Other reason ^a (%)	47 (13.8)	28 (14.4)	12 (21.1)	7 (8)	0.078

^a Lack of information about how and where to get it, maternity leave, travelling, don't know, not at work, sick.

Table 4
Opinions on mandatory occupational vaccinations of non-immune healthcare workers employed in hospital.

Age	Total N=555	<36 years N=207	≥36 years N=348	P-value overall	P-value yes vs. no and uncertain ^a
Varicella (%), N=550					
Yes	297 (54)	122 (59.2)	175 (50.9)	0.160	0.064
No	144 (26.2)	47 (22.8)	97 (28.2)		
Uncertain	109 (19.8)	37 (18)	72 (20.9)		
Measles (%), N=550					
Yes	379 (68.9)	153 (74.3)	226 (65.7)	0.077	<0.05
No	98 (17.8)	33 (16)	65 (18.9)		
Uncertain	73 (13.3)	20 (9.7)	53 (15.4)		
Mumps (%), N=551					
Yes	344 (62.4)	144 (69.6)	200 (58.1)	<0.05	<0.01
No	111 (20.1)	34 (16.4)	77 (22.4)		
Uncertain	96 (17.4)	29 (14)	67 (19.5)		
Rubella (%), N=551					
Yes	352 (63.9)	147 (71)	205 (59.6)	<0.05	<0.01
No	108 (19.6)	34 (16.4)	74 (21.5)		
Uncertain	91 (16.5)	26 (12.6)	65 (18.9)		
Pertussis (%), N=548					
Yes	328 (59.9)	137 (66.8)	191 (55.7)	<0.05	<0.05
No	114 (20.8)	33 (16.1)	81 (23.6)		
Uncertain	106 (19.3)	35 (17.1)	71 (20.7)		
Diphtheria (%), N=551					
Yes	342 (62.1)	142 (68.6)	200 (58.1)	0.055	<0.05
No	109 (19.8)	34 (16.4)	75 (21.8)		
Uncertain	100 (18.1)	31 (15)	69 (20.1)		
Influenza (%), N=426					
Yes	161 (37.8)	61 (42.7)	100 (35.3)	0.254	0.169
No	172 (40.4)	56 (39.2)	116 (41)		
Uncertain	93 (21.8)	26 (18.2)	67 (23.7)		

^a Fisher's exact test.

well-known, and HCWs regularly provide advice and remind parents to vaccinate their children. Therefore, it is of concern that such a large proportion of the staff had not thought of their own immunity and risk of getting sick.

For both measles and rubella, the lack of self-reported immunity was highest in employees born in 1974–1983. In Denmark, the MMR vaccine was introduced in 1987 with a catch-up program for those born in 1974–85. A proportion from this generation may not have received the vaccine, and due to herd immunity, they have not had the diseases either. This age group constitutes a large part of the workforce in most centres including ours, making it of utmost importance to act upon.

Non-clinical personnel have previously been involved in outbreaks of VPDs [9,18]. In our study, this occupational group had the lowest level of self-reported immunity, emphasizing the importance of including all groups of HCWs in immunisation programs. Likewise, healthcare students can go unnoticed because of their shared time between hospital wards and universities. Implementing (mandatory) immunisation programs at medical and nursing schools could contribute to the promotion of a sense of care and increase immunity of future employed HCWs [19].

The uptake of influenza vaccination in our study was 38.6%. Other European countries have reported influenza vaccine cover-

age ranging from 5% to 54.9% in 2014/2015 [20], and uptakes of 94.8–99.3% are reality in places with a mandatory vaccination policy [17,21]. Like in our setting, most studies report lower vaccination uptake by nurses compared to physicians, which is of concern as nurses commonly spend more time with the patients than physicians do. The finding reflects different levels of knowledge and attitudes about influenza and its prevention, suggesting a need for specific and profession-tailored programs [22–25].

Self-protection and protection of patients were the main motivators for getting the influenza vaccine, which is in line with findings from others that self-protection is the strongest and most consistent driver of HCW's decisions to accept vaccination followed by prevention of illness in patients [22,26]. Vaccine refusal was mainly explained by the assumption that healthy individuals were not in need of the vaccine. Inattention and a lack of time as a barrier to vaccination was more than tripled in physicians compared to nurses and increased six-fold compared to other occupational groups, emphasizing a need for easier vaccine access for certain groups.

In our study, 54–69% of HCWs supported a mandatory vaccination policy for measles, mumps, rubella, varicella, pertussis and diphtheria, most pronounced in those under 36 years of age. On the other hand, the majority of HCWs did not support the idea of mandatory occupational influenza vaccination. Reasons for this

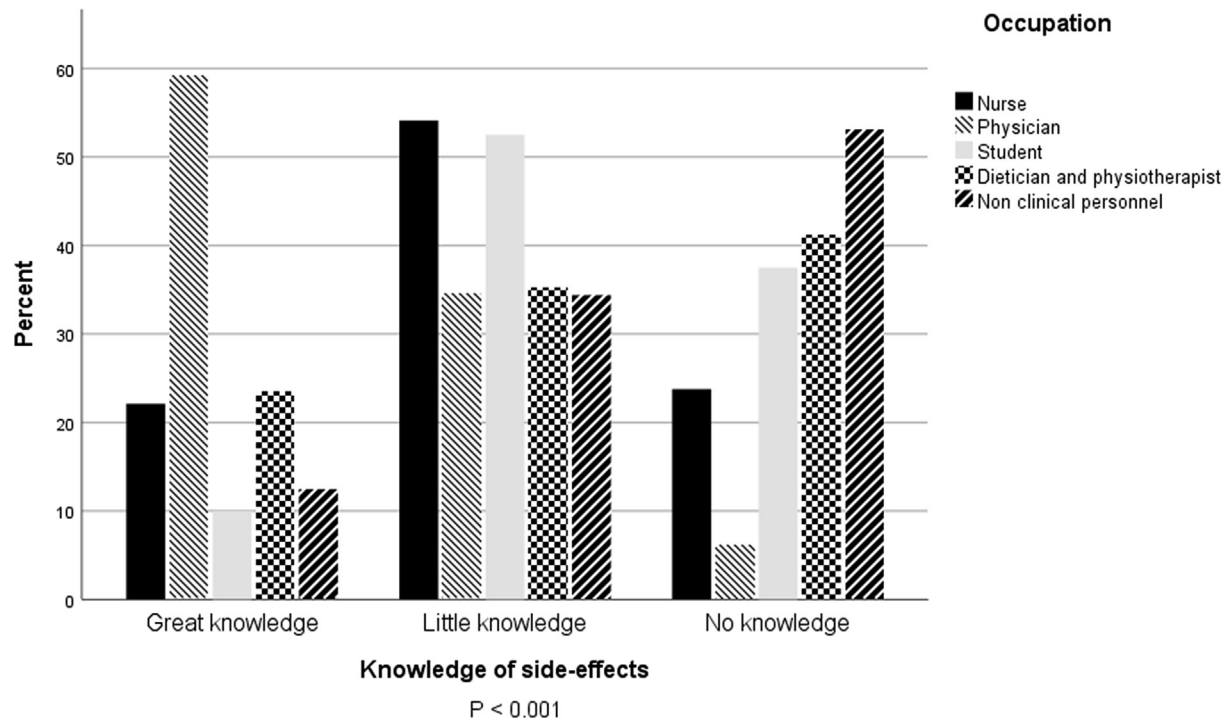


Fig. 4. Knowledge of side-effects to vaccinations for measles, mumps, rubella, pertussis and diphtheria by occupational group in 555 paediatric healthcare workers.

can be many such as suboptimal efficacy, which varies by influenza season, and the fact that the vaccination is needed every year. The finding is different from attitudes in paediatric HCWs in Greece with 70.6% supporting mandatory vaccinations, less for mumps (13.4%) and most for influenza (77.8%) [27]. In a paediatric tertiary care hospital in Philadelphia, 75.2% of employees supported a mandatory influenza vaccination policy, but a majority also felt that the policy was coercive [21]. A recent study involving 14 European countries found an overall of 65.7% HCWs favouring mandatory immunisation for HCWs involved in clinical work. However, rates differed significantly among countries [28]. Interestingly, when asking the public, >90% agree that HCWs have an obligation to be vaccinated against influenza and pertussis and just as many support vaccination for childcare workers [29].

Several ethical issues are associated with HCW immunisation and mandatory vaccination is far from Danish principles. A voluntary vaccination program seems the best approach to foster greater employee cooperation and trust in the system [28]. Education regarding the potential health consequences for patients, diagnosis, treatment, modes of transmission and easy access to free vaccines including worksite vaccination during all shifts will undoubtedly increase vaccination uptake and must be prioritised before considering mandatory programs. However, in countries experiencing increasing vaccination hesitancy and refusal, mandatory vaccination policies might increasingly be implemented in the next years [29].

A strength of this study is the high response rate of 90%, which was possible due to in-person contact with each employee and distribution of hard-copy questionnaires, which would not have been possible in a larger setting. We are not aware of similar studies involving all HCW categories including non-clinical personnel, students and volunteers thus considering the voice of groups that are often not perceived as HCWs.

The opportunity to provide anonymous responses increases the probability of honest responses and comments. However, the findings that just over half of those supporting the idea of mandatory influenza vaccination were vaccinated themselves, could lead to the assumption that some workers stating they would accept

vaccination, would in reality not. However, the main reason for abstaining was a lack of time and not an active choice against vaccination.

This study has some limitations. Information about previous disease and vaccination was self-reported based on memory and knowledge and not on vaccination cards or health files. A larger part than registered in this study may have been protected from VPDs. A mandatory electronic vaccination registry was implemented in 2015, but vaccinations given prior to 2015 are not all found electronically explaining why some respondents could not find proof of previous vaccinations and had to rely on information from their parents if possible. This could, however, lead to both an under- and overestimate of immunity. As this is a cross-sectional study the results are limited in time.

In conclusion, large immunity gaps might exist in Danish paediatric HCWs. There is a great interest in improving protection from VPDs with up to 95.3% of all HCWs supporting vaccination depending on the disease and two out of three HCWs supporting mandatory MMR, pertussis and diphtheria vaccination of unprotected employees. However, the support for mandatory influenza vaccination was markedly lower. Educational campaigns about the benefit of vaccinations and implementation of national recommendations for vaccination of HCWs in Denmark is warranted.

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.

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Author's contributions

MLL, AP and AYN initiated and designed the study. MLL, TNW, AE and ABN coordinated the study, organized recruitment, and collected data. MLL performed statistical analyses and prepared the first draft of the manuscript. All authors participated in manuscript preparation and approved the final manuscript.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2020.08.010>.

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