ORIGINAL ARTICLE

Pertussis immunization in healthcare workers working in pediatric settings: Knowledge, Attitudes and Practices (KAP) of Occupational Physicians. Preliminary results from a web-based survey (2017)

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Keywords

Healthcare workers • Pertussis vaccine • Diptheria-Tetanus-acellular Pertussis Vaccines • Occupational physicians

Summary

Introduction. *The present study aims to characterize knowledge, attitudes and practices in a sample of occupational physicians (OPh) towards pertussis immunization in healthcare workers (HCWs) from pediatric settings.*

Material and methods. *A total of 148 OPh (45.9% males, mean age of 40.3 ± 13.2 years) compiled a web questionnaire including a knowledge test on Italian recommendations for HCWs, epidemiology and pathology of pertussis infection, being then investigated about risk perceptions and vaccination practices. A General Knowledge Score (GKS) and a Risk Perception Score (RPS) were calculated. Multivariate odds ratios (OR) for predictors of vaccine propensity were calculated through regression analysis.*

Results. *78 participants regularly recalled pertussis vaccination status and/or performed pertussis vaccination in HCWs (52.7%). Proactive status was correlated with the aim to avoid pertussis infection in HCWs and its diffusion to other adults ($p < 0.001$, both statements). GKS was satisfying (72.4% ± 14.9), but participants underestimated the clinical issues of pertussis infection (RPS 60.8% ± 9.5) when confronted with influenza (73.9% ± 10.9) and HBV infection (68.1% ± 10.1). GKS and RPS were well correlated ($r = 0.244$, $p = 0.003$). Eventually, a better GKS and the aim to avoid pertussis infection in HCWs were predictive of a proactive status for pertussis vaccination (OR 4.186 95%CI 1.809-9.685 and OR 11.459, 95%CI 3.312-39.651, respectively).*

Conclusions. *Adherence of OPh to HCWs pertussis vaccination was unsatisfying. As knowledge status was predictive for vaccine propensity, information programs for OPh should be more appropriately designed, stressing that HCWs may represent a significant reservoir for pertussis infection in high risk groups (e.g. children/newborns, frail elderly).*

Introduction

Pertussis is a highly contagious respiratory illness, caused by Gram Negative pathogen *Bordetella pertussis,* that can have serious, life-threatening consequences, including pneumonia, convulsions, apnea, encephalopathy, acute respiratory distress and even death [1-4]. Prognosis is particularly poor among infants < 6 months of age, a group too young to have completed the primary vaccination schedule. With 51.6 cases per 100,000 population in 2014, infants < 1 year-old are also characterized by highest age-specific rates, followed by the age group 10 to 14 year-old (24.4) [2]. However, pertussis is no longer and not solely a pediatric disease [5, 6]. On the one hand, individuals are believed to become susceptible to pertussis approximately 6 to 10 years after childhood vaccination [4]. On the other hand, because of a mixture of more awareness, better diagnostic, bacterial changes in the circulating pertussis strains, and more frequent vaccine hesitancy, an increasing incidence has also been reported in adolescents and adults [7-10]. Unfortunately, in older age groups the disease is often unrecognized, undiagnosed, and eventually unreported [4, 11, 12].

Due to their occupational contacts and poor vaccination rates, healthcare workers (HCWs) have become a significant reservoir to vulnerable patients in their care, stressing the importance for appropriate immunization programs [13, 14].

Implementation of immunization policies in workplaces is a main issue for Occupational Physicians (OPh), the medical professionals responsible for health promotion and prevention on the workplace [15]. OPh contribute to immunizations programs tailoring and applying official recommendations (i.e., National Immunization Plan or *Piano Nazionale della Prevenzione Vaccinale*, PNPV, in Italy; Standing Committee on Vaccination or *Ständigen Impfkommission*, STIKO, in Germany, etc.) [16-18]. Moreover, OPh are directly involved in the communication of risk, participating to the information and education of the workers [15, 19-21]: in Italy, Occupational Health and Safety Legislation requires that the Occupational physicians inquiry vaccination history, recall the

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vaccination status, and inform the workers about the pros and cons of recommended vaccinations [15-21]. More specifically, PNPV 2017-2019 identifies adult pertussis vaccination, included in tetanus-diphtheria-acellular pertussis (Tdap) formulate, as strongly recommended for all professionals working with newborns or infants: as a consequence, assessing the knowledge, attitudes and practices (collectively, KAP) of OPh on vaccinations of HCWs working in pediatric settings can be useful in order to tailor vaccination campaigns and improving vaccination rates, ultimately improving the patient safety profile [22]. The aim of this study is, therefore, to assess a sample of OPh about KAP on pertussis and relative vaccination policies for HCWs, and how KAP relate to these recommendations. Eventually, we attempted to identify areas that may be targeted for improvement through specific informative and educative campaigns dedicated to OPh.

Materials and methods

Study design. A cross-sectional questionnaire-based study was performed in the first half of 2017, involving OPh participating to six different private Facebook group pages and four closed forums focusing on occupational medicine, whose application was officially limited to OPh. As in Italy the only commercially available vaccine against pertussis in adulthood is the combined formulation Tdap, the invitation text was formulated as "*What do you think about Tdap vaccine*?". In total, the group pages had approximately 1,034 unique members (14.4% of all Italian OPh), but no information could be obtained regarding how many of these members were actively using Facebook. To post the study invitation on the closed (non-public) Facebook pages, the principal researcher contacted the group administrator and asked to be invited. Facebook users who clicked on the invitation text were provided with the full study information, an opportunity to give their informed consent, and a web link to the survey (Google Forms; Google LLC; Menlo Park, Carlifornia, USA). The survey was conducted in Italian. To be included in the sample, the OPh was supposed to be living and working in Italy in 2017, and to assist at least one healthcare provider that offers assistance to newborns and/or pediatric age (i.e. age < 14 years) patients: if a potential participant was found not to match the inclusion criteria, the survey closed down. The survey was anonymous, and no personal data such name, IP address, email address, or personal information unnecessary to the survey was requested, saved or tracked. No monetary or other compensation was offered to the participants.

Questionnaire

The questionnaire was formulated in Italian, and its test-retest reliability was preventively assessed through a survey on 10 OPh completing the questionnaire at two different points in time. The testing questionnaires were ultimately excluded from the final analyses. All questions were self-reported, and not externally validated. The final questionnaire comprised the following areas of inquiry:

1. **Individual characteristics.** Included: age, working age, sex, and medical specialization (i.e. in Italy, qualification as OPh is primarily obtained through specialization in occupational medicine, but also specialists in Hygiene and Public Health and in Legal/Forensic Medicine are legally authorized to work as OPh, if they complete a specific master's course, as well as all physicians who were operating as OPh before 1991). Finally, household characteristics were recalled (i.e. any children *vs* no children), and whether they had any previous professional interaction with cases of pertussis (yes *vs* no).
2. **General knowledge.** The questionnaire included a general knowledge test that contained a set of 12 true-false statements, elaborated through extensive literature review, covering typical misconceptions on Tdap (e.g. "*Vaccinating an adult against pertussis is useless"*; FALSE) [5, 9, 23-30]. A General Knowledge Score (GKS) was then calculated as the sum of correctly and incorrectly marked recommendations: when the participants correctly answered, +1 was added to a sum score, whereas a wrong indication or a missing "*don't know*" answer added 0 to the sum score.
3. **Risk perception.** Perceived risk has been defined as a function of the perceived probability of an event and its expected consequences, and therefore assessed as the mathematical product of subjective probability and disease severity [18, 31]. We inquired the risk perception of participants about the three components of Tdap vaccine and two further immunizations of occupational interest among HCWs, i.e. Hepatitis B Virus (HBV) and influenza. OPh were asked about: the probability of natural infection (I^{INF}) in HCW, the frequency of vaccine-related adverse effects (I^{VAC}), and whether they perceived the severity of the natural infections (C^{INF}) and vaccine-related adverse effects (C^{VAC}). In order to summarize the results, we used a fully labeled 1 to 10 scale. A Risk Perception Score (RPS) was eventually calculated for all diseases as a cumulative score as follows:

$$\text{Risk perception} = I^{INF} * C^{INF} - I^{VAC} * C^{VAC}$$

4. **Attitudes**. Participants were asked to rate 1 (totally disagree) to 5 (totally agree) the perceived usefulness pertussis vaccination in (a) avoiding natural infection in HCWs; (b) avoiding diffusion to other adults; (c) avoiding diffusion to children/newborns. Attitudes were eventually dichotomized in somehow agree (i.e. totally agree, agree) *vs* somehow disagree (totally disagree, disagree, neuter/no opinion).
5. **Practices.** Participants were initially asked whether they usually recall immunization status towards pertussis of HCWs, recommending/performing Tdap when requested. Again, as tetanus vaccine is compulsory for certain professionals, being OPh very familiar with this specific vaccination, and pertussis

immunization is commercially available only associated with tetanus vaccine, participants recalled their preferred formulation for tetanus vaccine, i.e. monovalent (T/t), divalent (Td), or Tdap.

Ethical considerations. Before giving their consent to the survey, participants were briefed that all information would be gathered anonymously and handled confidentially. Participation was voluntary, and the questionnaire was collected only from subjects who had expressed consent for study participation. As individual participants cannot be identified based on the presented material, this study caused no plausible harm or stigma to participating individuals. As the study neither included clinical data about patients nor configured itself as a clinical trial, while its anonymous designs assured an adequate protection of study participants, a preliminary evaluation by the Ethical Committee of the competent Provincial Agency for Health Services (in Italian: Azienda Provinciale per i Servizi Sanitari, APSS) was statutorily not required.

Data analysis. The described indices for general knowledge (GKS) and risk perception (RPS) were calculated as previously described, and then presented as percent values in order to be more easily comparable. All synthetic indices were eventually dichotomized by median value as > median *vs* ≤median. Continuous variables were tested for normal distribution (D'Agostino & Pearson omnibus normality test): where the corresponding p value was < 0.10, normality distribution was assumed as rejected and variables were compared through Mann-Whitney or Kruskal-Wallis test for multiple independent samples. On the other hand, variables passing the normality check (D'Agostino & Pearson p value ≥ 0.10) were compared using the Student's t test or ANOVA, where appropriate. In multiple comparisons, Pertussis Vaccine was assumed as the referent category. Categorical variables were reported as per cent values, and their distribution in respect of the outcome variable of proactive status for pertussis vaccination in HCWs was initially analyzed through chi-squared test. In comparisons, age (≤ 40 years *vs* > 40 years), seniority (< 10 years *vs* ≥ 10 years), medical specialization (occupational medicine *vs* all others) were dichotomized. All categorical variables that at univariate analysis were significantly associated with a positive attitude towards Pertussis Vaccine (i.e. $p < 0.05$) were included in a stepwise binary logistic regression analysis model in order to calculate multivariate odds ratios (OR) and their respective 95% confidence intervals (95%CI). Regression analysis was also controlled for age and sex of participants. All statistical analyses were performed by means of IBM SPSS Statistics 24.0 for Macintosh (IBM Corp. Armonk, NY).

Results

Descriptive analysis. As shown in Table I, a total of 148 OPh (14.3% of the eligible population) participated to the inquiry. Respondents had a mean age of 40.3 ± 13.2 years, and a seniority of 12.9 ± 13.8 years; 45.9% were males, and 54.1% females, while 45.9% reported that their household included at least a child aged < 14 years. The majority of respondents referred practicing as specialist in occupational medicine (45.9%), followed by specialists in Hygiene and Public Health (32.4%), legal medicine (11.5%). Overall, 40.5% had previous interactions with at least one patient affected by pertussis.

Assessment of vaccine knowledge (Tab. II). After normalization, the mean GKS was 72.3% ± 20.9 (actual range 33.3-100; median 75.0%), and internal consistency coefficient amounted to Cronbach's alpha = 0.718. Focusing on most frequently reported misbeliefs, even though 70.3% of participants had knowledge that adults should receive at least a Tdap dose at periodic immunizations, only 45.9% of participants followed official PNPV recommendation towards preferential use of combined formulations (Td/Tdap) for adult immunizations, with an even lower share of respondents preferentially using Tdap formulation (16.2%). Moreover, only 47.2% correctly recalled that receiving a new dose of tetanus vaccine or Td less than 2 years after a dose of Tdap does not increase the risk for side effects. Overall, a significant share of respondents exhibited some uncertainties about pertussis in older age groups, as 40.5% of them were unaware that a previously vaccinated adult may contract pertussis even after natural infection or a previous vaccination in pediatric age, and then diffuse pertussis in susceptible subjects (i.e. 35.1%).

Assessment of attitudes. As shown in Figure 1, 75% of identified HCWs pertussis vaccination as useful in order to avoid workers' infection, and diffusion to other adults, while 97.3% acknowledged the usefulness of HCWs immunization for preventing infection of children and newborns.

Assessment of the risk perception. As shown in Tab. III, participants acknowledged pertussis natural infection as significantly less severe (C^{INF} = 72.1% ± 20.2 *vs* 94.6% ± 11.9 and 88.6% ± 11.3 for tetanus and diphtheria, respectively), but also more probable in HCWs (I^{INF} = 36.8% ± 20.7 *vs* 30.3% ± 17.6 and 23.2% ± 13.3) than other components of Tdap vaccine. On the contrary, pertussis natural infection was identified as both less probable and severe than seasonal influenza (C^{INF} = 66.5% ± 21.9; I^{INF} = 80.5% ± 15.3; p = 0.018 and < 0.001, respectively), while HBV infection was reported as not significantly more severe (C^{INF} = 74.1% ± 19.4, p = 0.752) but significantly more probable (I^{INF} = 53.0% ± 19.6, p < 0.001). Focusing on frequency and severity of vaccine-related adverse effects for the presented immunizations, no significant differences were reported regarding the assessed C^{VAC}, while participants reported a perceived increased risk for side effects associated with seasonal influenza vaccine (I^{VAC} = 23.0% ± 14.7 *vs* 18.9% ± 11.3 for pertussis, p = 0.012).

As a consequence (Figure 2), OPh scored the highest cumulative RPS for seasonal influenza (73.9% ± 10.9), followed by HBV (68.1% ± 10.1), tetanus (62.1% ± 8.1), pertussis (60.8% ± 9.5), while the lower score was re-

Tab. I. Demographics of Attitudes of 148 Italian Occupational Physicians participating to an internet survey on knowledge, attitudes, practices about pertussis vaccination in healthcare workers from pediatric settings (HCWs) (2017). Note: S.D. = standard deviation; T/t = tetanus toxoid vaccine, monovalent; Td = combined tetanus/diphtheria vaccine, divalent; Tdap = combined tetanus/diphtheria/pertussis acellular vaccine, trivalent.

Variables	
Gender (No., %)	
Male	68, 45.9%
Female	80, 54.1%
Age (years, mean ± S.D.)	40.3 ± 13.2
Seniority (years, mean ± S.D.)	12.9 ± 13.8
Children in the household (any; No., %)	68, 45.9%
Medical specialization (No., %)	
Occupational medicine	68, 45.9%
Hygiene and Public Health	48, 32.4%
Legal medicine	17, 11.5%
Other	15, 10.1%
Previous interaction with patient(s) with pertussis (No., %)	60, 40.5%
Knowledge Score	
mean ± S.D.	72.4% ± 14.9
> median (75.0%)	68, 45.9%
Risk Perception Score	
mean ± S.D.	60.8% ± 9.5
> median (59.6%)	76, 51.4%
Acknowledging pertussis vaccination as useful for ... (No., %)	
... avoiding infection in HCW	111, 75.0%
... avoiding diffusion to other adults	111, 75.0%
... avoiding diffusion to children/newborns	131, 88.5%
Preferred formulation for tetanus vaccination (No., %)	
monovalent formulations (T/t)	96, 64.9%
combined formulations, Td	12, 8.1%
combined formulations, Tdap	24, 16.2%
none	16, 10.8%
Proactive status towards Tdap in HCW (No., %)	78, 52.7%

Tab. II. General Knowledge Test on Tdap vaccine of 148 Italian Occupational Physicians participating to an internet survey on knowledge, attitudes, practices about pertussis vaccination in healthcare workers from pediatric settings (HCW) (2017).

Statement	Correct answer	No., %
01. Adult tetanus vaccination should be preferentially performed with combined formulations (Td, Tdap)	True	68, 45.9%
02. Adults should receive at least a Tdap dose at periodic immunizations	True	104, 70.3%
03. Vaccinating an adult against pertussis is useless	False	116, 78.4%
04. Formulations containing pertussis antigens should be used only in subjects living with subjects < 14 year-old	False	112, 75.7%
05. Pertussis is a diseases of children and young adults (< 20 year-old)	False	120, 81.1%
06. Pertussis is scarcely contagious	False	132, 89.2%
07. In a previously vaccinated adult, pertussis may exhibit unusual, incomplete clinical patterns	True	120, 81.1%
08. A previously vaccinated adult may develop pertussis being unable to diffuse it	False	96, 64.9%
09. Children < 1 year-old are naturally protected against pertussis infection	False	132, 89.2%
10. Adult may contract pertussis even after natural infection or a previous vaccination in pediatric age (< 14 year-old)	True	88, 59.5%
11. Vaccination with Tdap may be performed alongside other formulations	True	132, 89.2%
12. Receiving a dose of tetanus vaccine or combined diphtheria-tetanus vaccine less than 2 years after a dose of Tdap increases the risk for side effects	False	68, 47.2%

ported for diphtheria (57.4% ± 5.9). In multiple comparisons, risk perception for pertussis was significantly higher than that reported for diphtheria ($p < 0.01$), while being significantly lower than that for seasonal flu ($p < 0.001$), and HBV ($p < 0.001$).

Univariate analysis. As shown in Tab. IV, distribution of a proactive status for pertussis vaccination among participating OPh had no significant differences based on demographics. On the contrary, a proactive Tdap status was positively associated with GKS ($p = 0.048$),

Fig. 1. Attitudes of 148 Italian Occupational Physicians participating to an internet survey on knowledge, attitudes, practices about pertussis vaccination in Healthcare Workers (HCWs). Participants were asked to rate 1 (totally disagree) to 5 (totally agree) the perceived usefulness pertussis vaccination in (a) avoiding natural infection in HCWs; (b) avoiding diffusion to other adults; (c) avoiding diffusion to children/ newborns.

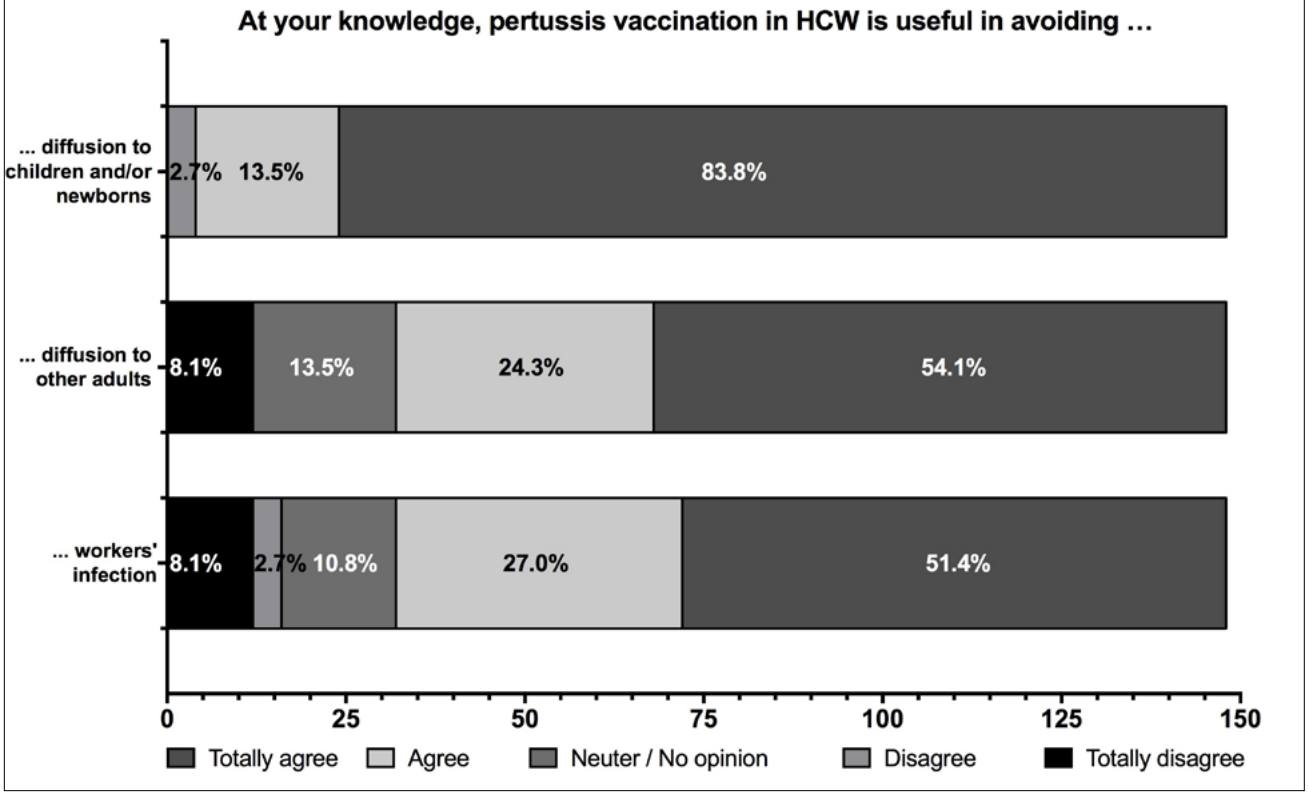
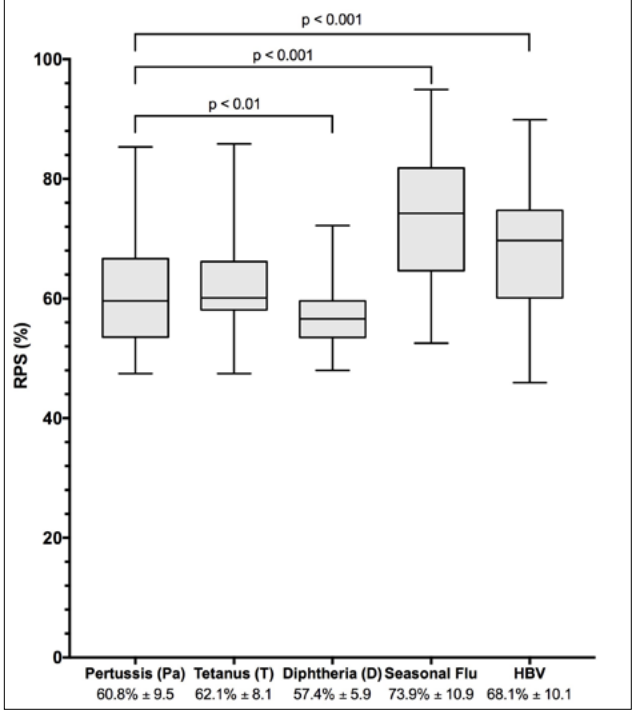


Fig. 2. Risk Perception Score (RPS) towards pertussis (Pa), Tetanus (T), Diphtheria (D), Seasonal Flu, Hepatitis B Virus (HBV) infection in 148 Italian Occupational Physicians participating to an internet survey on knowledge, attitudes, practices about pertussis vaccination in Healthcare Workers (HCWs). Multiple comparisons were performed through ANOVA, with Dunnet post-hoc test assuming RPS for pertussis as the referent one.



and acknowledging pertussis vaccination as useful for avoiding infection in HCWs ($p < 0.001$) and diffusion to other adults ($p < 0.001$). Consistently, RPS for Tdap was significantly associated with GKS ($r = 0.244$, $p = 0.003$). In other words, a better knowledge status (i.e., less misconceptions and/or less personal attitudes guiding the vaccine decisions) was associated with a greater risk perception for pertussis infection.

Regression analysis. Regression analysis model for Tdap included GKS > median, and acknowledging pertussis vaccination as useful for avoiding infection in HCWs and diffusion to other adults. Also in regression analysis, GKS was a significant predictor for a proactive attitude towards pertussis vaccination (OR 4.186; 95% CI 1.809-9.685), and similarly acknowledging pertussis vaccine as useful in avoiding infection in HCWs (OR 11.459; 95% CI 3.312-39.651). On the contrary, acknowledging pertussis vaccine as useful in order to avoid pathogen diffusion to other adult was not (OR 1.503; 95% CI 0.514-4.397).

Discussion

HCWs are at increased risk of pertussis infection compared to the general population, and their preventive immunization represents an evidence based approach to prevent pertussis spread among institutions, eventually reducing pathogen transmission to the patients,

Tab. III. Risk perception of pertussis, diphtheria, tetanus, seasonal influenza and HBV infections in 148 Italian OPh participating to the present study. Participants were asked to rate 1 (minimum) to 10 (maximum) the probability that HCWs get natural infection (I^{INF}), the frequency of vaccine-related adverse effects (I^{VAC}), and whether they perceived the severity of the natural infections (C^{INF}) and vaccine-related adverse effects (C^{VAC}). Results are presented in per cent values.

	Natural infection				Side effects of vaccination			
	C^{INF}	P value	I^{INF}	P value	C^{VAC}	P value	I^{VAC}	P value
Pertussis	72.1% ± 20.2	Ref	36.8% ± 20.7	Ref	29.5% ± 25.8	Ref	18.9% ± 11.3	Ref
Tetanus	94.6% ± 11.9	< 0.001	30.3% ± 17.6	0.005	27.0% ± 26.1	0.817	17.8% ± 10.8	0.770
Diphtheria	88.6% ± 11.3	< 0.001	23.2% ± 13.3	< 0.001	28.9% ± 26.0	0.999	18.3% ± 11.3	0.870
Influenza	66.5% ± 21.9	0.018	80.5% ± 15.3	< 0.001	28.9% ± 22.9	0.999	23.0% ± 14.7	0.012
HBV	74.1% ± 19.4	0.752	53.0% ± 19.6	< 0.001	26.8% ± 25.0	0.757	17.6% ± 9.5	0.665

Tab. IV. Factors associated with proactive status towards pertussis vaccine (Tdap pos.; i.e. assessing pertussis immunization status, and/or performing Tdap vaccine) for healthcare workers in 148 occupational physicians participating to the survey. Multivariate odds ratio (OR) with respective 95% Confidence Intervals (95%CI) were calculated through a regression analysis model including all factors associated with Tdap in univariate analysis ($p < 0.05$), and controlled for age and sex. Note: GKS = general knowledge score; RPS = risk perception score; HCW = healthcare workers; Tdap = tetanus-diphtheria-acellular pertussis formulate).

	Tdap pos. (No./78, %)	Tdap neg. (No./70, %)	P value	OR (95%CI)
Age > 40 years (No., %)	27, 34.6%	25, 35.7%	1.000	
Seniority > 10 years (No., %)	31, 39.7%	21, 30.0%	0.286	
Male sex	35, 44.9%	33, 47.1%	0.911	
Children in the household (No., %)	40 (52.6%)	40 (55.6%)	0.848	
GKS > median	42, 53.8%	26, 37.1%	0.048	4.186 (1.809; 9.685)
RPS > median	35, 44.9%	41, 58.6%	0.134	
Previous interaction with pertussis cases (No., %)	36 (46.2%)	24 (34.3%)	0.193	
Acknowledging pertussis vaccination as useful for ...				
... avoiding infection in HCW	72, 92.3%	39, 55.7%	< 0.001	11.459 (3.312; 39.651)
... avoiding diffusion to other adults	69, 88.5%	42, 60.0%	< 0.001	1.503 (0.514; 4.397)
... avoiding diffusion to children/newborns	70, 89.7%	61, 87.1%	0.812	
Specialization in Occupational Medicine	31, 39.7%	37, 52.9%	0.152	

particularly on pediatric and gynecology/obstetric wards [32-34]. Pregnant women and infants under 6 months are at serious risk of morbidity, mortality and adverse pregnancy outcomes from pertussis [35-37], but maximal protection against the pathogen is attained only after the third dose of the vaccine, usually performed at 6 months of age in North America, and 11 months in Italy [38, 39]. Nevertheless, available reports suggest increasing difficulties in promoting adherence of HCWs to evidence-based immunization recommendations, including pertussis [32-34, 40-46].

Numerous studies have assessed why HCWs do not receive the recommended vaccinations, being knowledge gaps and lack of confidence in vaccinations the main determinants of such behaviours [19, 22, 47-49]. On the contrary, KAP of OPh have been scarcely investigated [16-18]. This is a critical issue, as OPh are not only HCWs themselves (potentially contributing to the pathogen transmission), but they also perform and promote vaccinations, and may implement acceptance and knowledge among other HCWs [18]. Appropriate interventions on OPh could then maximize the consent for vaccination programs, contributing to overcome the mutual misunderstanding between public health professionals and vaccine hesitant individuals or even vaccine objectors [16-18].

Unfortunately, evidence suggests that even OPh may be significantly affected by false beliefs and misconceptions on vaccines and vaccination policies, that ultimately hinder their contribute to vaccination programs [18]. Also in our study, only half of participants actively assessed and promoted vaccination against pertussis in their clinical practice, and knowledge status was identified among the main determinants of a proactive attitude. These results were not unexpected, being substantially in line with previous reports and with the base assumption of KAP studies, i.e. higher the understanding, better the practices [18, 50-54]. However, even though GKS and RPS were well correlated, the latter was relatively low, and not significantly associated with a proactive status. Actually, the understanding of actual risks associated with pertussis infection was substantially inappropriate. More specifically, OPh apparently underestimated both the severity and potential communicability of pertussis, both in comparison with other components of Tdap vaccine, and with HBV and even seasonal influenza. In particular, we should stress that the positive attitude towards Tdap was associated with the aims of avoiding HCWs infection, whereas prevention of pertussis infection in other adults and children/newborns was apparently unrelated. In other words, OPh were apparently focused on the workers they directly assist, not under-

standing the risk that HCWs may eventually transmit the illness to other subjects, and particularly high risk groups [19, 21 32]. Not coincidentally, around 40% of respondents was apparently unaware that adults may contract and spread pertussis, even if previously vaccinated, and identified in T/t monovalent formulation the preferred one for tetanus vaccination, implicitly losing the opportunity to improve vaccination rates against pertussis, as otherwise recommended by PNPV [55]. Again, such results are consistent with previous reports on HCWs, and more specifically on OPh [16, 18], and collectively suggest that factors involved in the promotion of HCWs vaccinations are very complex, not residing only in knowledge and rational understanding of pathogen associated risks, being also characterized by a complicated interplay of individual (e.g. previous experiences, confidence in the vaccine, etc.) and organizational factors (e.g. availability of vaccines, content of medical protocols, etc.) [21 22, 32 33, 40, 49].

However, our study is affected by several limitations. First and foremost, it shares the implicit limits of Internet-based surveys [56, 57]. Web surveys have been shown as reliable and cost-effective as they usually require fewer resources, being also much faster than a paper-based survey. However, participants are somehow "self-selected", and the final sample may potentially over-represent some sub-groups of the original population, i.e. subjects from younger age groups, with a greater literacy, and more accustomed to the internet access. Therefore, it is not possible to rule out the existence of a significant selection bias. Participating voluntarily could be due to a proactive attitude or greater knowledge about vaccination. In the same way, the fact of not participating could be understood as a negative attitude or a lack of knowledge about vaccinations.

Again, we cannot rule out that results of knowledge score may have been affected by a significant social desirability bias, with participants reporting the "*socially appropriated*" rather than their authentic behaviors, so that our result could have ultimately overstated the share of OPh having an effective understanding of Tdap associated issues [16, 17, 32, 32, 34, 58].

Moreover, our sample was of limited size, including only 148 out of 7166 OPh from the national list of OPh [59], and their geographic origin was deliberately not assessed in order to improve the protection of study participants. As Italy has been repetitively acknowledged for very heterogeneous vaccination rates, our results should be cautiously interpreted as representative of the National level [60-62]. On the other hand, while a certain selection is usually performed by social media managers of specific discussion groups (e.g. by registering only subjects who receive a specific invitation by the manager; answering to specific "selection" questions; etc), often requesting to certificate their professional activity, we cannot rule out that some of the study participants were not actively working as OPh, limitedly or even not fulfilling our initial selection criteria.

Finally, data we collected were not externally validated, lacking an estimate of HCWs followed by sampled OPh. More specifically, we are unable to ascertain how often sampled professionals interact with HCWs from pediatric settings, and which share of their practice they actually represent. In fact, it should be stressed that even in the specific field of pediatric cares, the spreading of pertussis infection among HCWs may be severely influenced by the setting in which the interaction between spreaders and potential recipients actually occurs (i.e. nurseries, acute hospitals, ambulatory care, etc.), with a subsequently heterogeneous attention level in both OPh and HCWs they care [63, 64]. Similarly, we are unable to assess how reliable are the practices reported by respondents, that which share of HCWs followed by participants actually receive vaccines and/or specific recommendations [16-18, 62]. As a consequence, we were unable to estimate the effective extent of the social desirability bias, being the actual vaccination rates for Tdap potentially even lower than those self-reported by study participants.

Conclusions

In conclusion, our results are consistent with previous reports on HCWs, and with the limited evidence on OPh. More specifically, participants significantly underestimated the risks associated with pertussis infection, not only in the high-risk group of HCWs operating in pediatric settings, but more broadly in the general population interacting with HCWs. Moreover, our results suggest that a significant share of OPh actually ignores or only partially applies official recommendations on vaccine formulations to be used in clinical practice. As knowledge status was identified as the main predictor of a proactive attitude towards Tdap in HCWs, it is reasonable that filling information gaps may improve vaccine propensity of OPh, and possibly increase vaccine acceptance in HCWs. As the only way to counter pertussis infection is achieving and maintaining over time high vaccination rates, at least in high risk groups, a better interaction of OPh with HCWs, particularly in pediatric settings, would be therefore instrumental in increasing reducing the potential spreading of such infectious disease, not only in the occupational settings, HCWs, but also in general population.

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Conflict of interest statement

The authors declare no conflict of interest.

Authors' contributions

MR, GG, LV and FB equally contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. NLB contributed by editing the final text of the paper, performing the amendments and contributing to the revision of the discussion and conclusion section. However, as primary investigator, MR was asked to assess unclear responses of the questionnaires to determine the correct answers, whereas GG and LV performed the majority of preliminary data analysis.

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