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Vaccine-preventable diseases: Immune response in a large population of healthcare students

Paolo Emilio Santoro [a,b,1], Andrea Paladini [c,1], Ivan Borrelli [a], Carlotta Amantea [d,*], Maria Francesca Rossi [d], Corinna Fortunato [e], Maria Rosaria Gualano [f], Antonio Marchetti [g], Chiara Cadeddu [h,2], Umberto Moscato [a,b,d,g,2]

[a] Department of Life Science and Public Health, Università Cattolica del Sacro Cuore, Rome 00168, Italy
[b] Department of Woman and Child Health and Public Health, Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo Francesco Vito 1, 00168 Rome, Italy
[c] Section of Hygiene, Department of Life Sciences and Public Health, Università Cattolica del Sacro Cuore, Rome 00168, Italy
[d] Section of Occupational Health, Department of Life Sciences and Public Health, Università Cattolica del Sacro Cuore, Rome 00168, Italy
[e] Department of Biomedical Sciences and Public Health, Section of Hygiene, Preventive Medicine and Public Health, Università Politecnica delle Marche, Ancona, Italy
[f] Saint Camillus International University of Health Sciences, UniCamillus, Rome, Italy
[g] Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo Francesco Vito 1, 00168 Rome, Italy
[h] Erasmus School of Health Policy and Management, Erasmus University Rotterdam, Rotterdam, Netherlands

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ABSTRACT

Background: Students in medicine and other health professions are exposed to numerous occupational hazards, primarily biological hazards, during their academic careers at university. The aim of the present study was to investigate the seroprevalence characteristics of anti-HBsAg, anti-Measles, anti-Mumps, anti-Rubella and anti-Varicella IgG antibodies in healthcare students of a large teaching hospital in Rome. Methods: To accomplish the study's aims, antibody serology data were gathered from students of Medicine and Surgery, Dentistry, and Health Professions at the Catholic University of the Sacred Heart (Rome Campus) during their first Health Surveillance visit, that took place from 2013 to 2023. Results: Our study sample included 2523 students, 44.4 % were protected against Hepatitis B, 87.3 % against measles, 85.5 % against mumps, 94.6 % rubella and 95.2 % against varicella. Differences in antibody coverage between age groups were statistically significant ($p < 0.001$), except for mumps. It found a lower probability of having seronegative anti-HBVs with an older date since the presumed primary vaccination. Conclusion: In our sample, seropositivity rate against vaccine-preventable diseases, especially for Hepatitis B, was often inadequate to prevent possible biological risks connected with the activities carried out on the ward.

1. Introduction

Students in medicine and other health professions are exposed to numerous occupational hazards, primarily biological hazards, during their academic careers at university [1]. Active immunization is a primary prevention measure that can control and reduce the transmission of Vaccine-Preventable Diseases (VPDs) [2]. Students in the healthcare field spend a portion of their education in healthcare facilities, making them an essential target audience. It is essential to vaccinate healthcare students to prevent them from contracting and transmitting VPDs to high-risk patients and other Healthcare Workers (HCWs). During their training, healthcare students frequently experience accidental blood exposure and lapses in infection control measures [3,4].

There have been multiple clusters of vaccine-preventable diseases in numerous Italian healthcare facilities; therefore, strict infection control and an immunization plan are required to prevent nosocomial outbreaks [5–7]. In Italy, hepatitis B, measles, mumps, rubella, diphtheria-tetanus-pertussis (DTP), and influenza vaccinations are strongly recommended for HCWs and students of the health professions, according to The National Preventive Vaccination Plan (PNPV) 2023–2025 [8–10]; while in

* Corresponding author.
E-mail address: carlotta.amantea01@icatt.it (C. Amantea).
[1] These authors contributed equally to this work.
[2] Equal senior authorship.

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Europe, HBV vaccination is mandatory for healthcare students in five countries (Belgium, Czech Republic, France, Poland, Slovenia) [11]. Furthermore, during the COVID-19 pandemic, the vaccination against SarsCov-2 was mandatory for all healthcare personnel [12], encompassing healthcare students, as observed in Italy and various other nations [13]. The integration of such health policy possesses the capacity to fortify the resolve of students towards the advocacy of public health measures. The comprehension and perceptions of students pursuing health professions concerning public health [14,15] and obligatory immunization form a critical cornerstone for the development of a health system characterized by its resilience and proactive stance. The pedagogical focus on these domains serves not solely to equip students with the requisite acumen for adeptly navigating impending health-related challenges but also to inculcate a commitment to responsible conduct and the adoption of practices grounded in empirical evidence among the forthcoming cadre of health sector professionals.

The Department of Prevention and Protection and the Division of Occupational Medicine should promote the vaccination program to all HCWs without serological evidence of vaccination coverage. Since 1982, in Italy, vaccination against the mumps virus has been recommended – but not mandatory – for all susceptible males. In 1999, however, the MMR vaccine was available – although not mandatory – to prevent measles, mumps, and rubella [16]. Since June 2017, the MMR vaccine has been mandatory for infants and children 0–16 years old in Italy, and the National Vaccination Prevention Plan 2023–2025 strongly recommends it for HCWs. Hepatitis B virus (HBV) vaccination is mandated by Italian Law 165/1991 [17,18] for all neonates at three months of age and for all adolescents during their twelfth year. As a result, a national HBV vaccination program was established, targeting all infants born since 1992 (requiring vaccinations at three, five, and eleven months of life) and all adolescents born between January 1, 1980, and December 31, 1991 (requiring vaccinations at zero, one, and six months later). The vaccination campaigns organized in compliance with this law were effective in reducing the non-vaccinated number of people who incurred in the HBV infection [19]. Either a documented history of a complete vaccination cycle (2 doses) or an IgG test for measles, mumps, rubella, and varicella confirms immunization status. Except for varicella, a recollection of illness should not normally be considered proof of immunity. In immunocompetent people, three doses of hepatitis B virus vaccine provide around 95 % long-term immunization coverage, with a protective antibody titer identified in 88 % of vaccinated healthcare professionals 20 years after the first vaccination [20,21]. Although public health campaigns in Italy have reduced HBV transmission, specific professional groups, such as physicians and health professions students, are still deemed to be at high risk of HBV exposure [22–24] since they are four times more likely to be infected than the general population [22].Two doses of MMR vaccine are required to develop an optimal antibody titre [25,26]. Similarly, two doses of live attenuated vaccination against Varicella Zoster Virus (VZV) are considered very effective (in 99 % of vaccines), with an 80 % decrease in cases among healthcare staff exposed to the risk [27–29]. However, among HCWs, sub-optimal immunization rates have been reported for some VPDs, including workers employed in high-risk settings [30–34]. As highlighted by some seroprevalence studies, not all HCWs involved had optimal immunization against measles, mumps, rubella, varicella and hepatitis B [35]. Since healthcare students and trainees are a group of subjects that can be exposed to these pathogens many years after receiving the primary vaccination, and, in addition, could be at higher risk of needle-stick and sharp injuries due to the lack of experience [36], the aim of the present study was to investigate the seroprevalence characteristics of anti-HBsAg, anti-Measles, anti-Mumps, anti-Rubella and anti-Varicella IgG antibodies in the healthcare students of a large teaching hospital in Rome. The analyses also include the descriptive study of demographic factors (age, gender, course of study) correlated with their seropositive rates in the observed sample.

2. Materials and methods

The current study is a cross-sectional study. To accomplish the study's aims, antibody serology data were gathered from healthcare students at the Catholic University of the Sacred Heart (Rome Campus) during their first Health Surveillance visit, that took place from 2013 to 2023. These measurements are routine and annual in Catholic University students, and an informed consent was provided by the Occupational Physician and signed by the student during the visit; only data from students who consented to data collection and processing for research purposes, in accordance with Legislative Decree 196/2003, were used in the present research. The students were divided into two groups:

(1) The six-year single-cycle degrees (medicine and dentistry);
(2) The three-year health professions degrees (nursing, physiotherapy, midwifery, dietician, cosmetology sciences and techniques, biomedical laboratory techniques, speech therapy, cardiocirculatory physiopathology and cardiovascular perfusion techniques, occupational therapy, dental hygiene, health biotechnology, medical radiology techniques, orthoptics and ophthalmology, prevention techniques in the environment and workplace, pharmacy, hearing aid techniques, orthopedic techniques, developmental neuro and psychomotricity therapy students).

The research project was approved by the Ethics Committee for Scientific Research (CERS) of the Catholic University of the Sacred Heart (protocol n. 4883). The study was conducted under the Declaration of Helsinki and under the requirements of privacy and informed consent laid down by current Italian law (Law Decree 196/2003).

2.1. Data collection

Data collection has been anonymised and processed in compliance with European Regulation 2016/679 on privacy (so-called GDPR), D. Lgs. 196/2003 ("Code on the protection of personal data" and subsequent supplements) and D. Lgs.101/2018. The collected data has been recorded on a single anonymised and computerized database accessible only to researchers and kept in accordance with current legislation.

2.2. Antibody measurement

Anti-HBsAg and anti-Rubella IgG antibodies were detected by chemiluminescence immunoassay (CLIA) on the Atellica platform of the Siemens company; anti-Measles, anti-Mumps and anti-Varicella IgG antibodies were analyzed by enzyme-linked immunosorbent assay (ELISA) on Analyzer platform with kit from EUROIMMUN company. Antibodies were categorized into qualitative outcomes (positive, negative, or equivocal) based on the manufacturer's specified criteria. In instances where the serologic test yielded equivocal results, they were interpreted as negative in alignment with the guidelines from the Centers for Disease Control and Prevention [37].

2.3. Inclusion criteria

Age $\geq$ 18 years;

Having carried out a health surveillance visit during their studies in Medicine, Dentistry or Health Professions at the Catholic University of the Sacred Heart in Rome;

To have the result of at least one of the five tests (anti-HBsAg, anti-rubella, anti-measles, anti-mumps or anti-varicella IgG);

To accept the informed consent to the processing of data, self-declaring that they have read and understood the information notice.

2.4. Statistical analysis

The dependent variables were serum anti-HBsAg, anti-rubella, anti-measles, anti-mumps and anti-varicella IgG. The independent variables were gender (male or female), study field and years of birth. The latter was stratified into four categories to make the groups numerically homogeneous, following the quartile division, as shown in table 1; we chose to include all the data because, even though the range may appear extensive, most patients (n = 510) are concentrated between 1994 and 1997.

Antibody levels were reported as 'positive' or 'negative' and bivariate analyses were performed to study the association of presence of antibody positivity, assuming that this result indicates an immunization against the virus, with relevant variables using Chi-square tests; logistic regression was performed to evaluate the factors independently associated with antibody positivity for anti-measles, hepatitis B, mumps, rubella and varicella IgG. The level of significance was set at 0.05. Analyses have been performed with STATA, version 17 (StataCorp. 2021. Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC).

3. Results

A total of 2523 students were examined, of which 68.5 % were females and the mean age was 22.2 ± 3.8 years; they were almost equally divided in two categories based on study field (49.9 % three-year health professions degrees students and 50.1 % six-year single-cycle degree students) (Table 1).

Based on antibody serology, 44.4 % (n = 1119) of the students were protected against Hepatitis B, 87.3 % (n = 2165) against measles, 85.5 % (n = 2121) against mumps, 94.6 % (n = 2348) against rubella and 95.2 % (n = 2363) against varicella (Table 2).

Table 3 highlights the results of the bivariate analyses. There were no statistically significant differences observed between genders and areas of study concerning seropositivity rate for the investigated infections, except for mumps where a notable distinction ($p < 0.02$) was observed among students with diverse educational backgrounds; on the other hand, differences in antibody coverage between age groups were statistically significant ($p < 0.001$) for hepatitis b, measles, rubella and varicella, with the exception of mumps this time (Table 3).

Table 4 highlights the results of the logistic regression analyses. The prevalence of antiHBVs seronegative appeared to have an inverse correlation with older age, so younger students were more likely to be negative (1998–99 OR = 0.75, CI 0.61–0.93; 2000–01 OR 0.50, CI 0.41–0.62; 2002–04 OR 0.40, CI 0.31–0.52). (Table 4) Regarding antibody coverage of measles (1998–99 OR = 1.37, CI 1.01–1.86; 2000–01 OR = 1.86, CI 1.35–2.56; 2002–04 OR = 2.08, CI 1.40–3.10) rubella (1998–99 OR = 2.82, CI 1.75–4.55; 2000–01 OR = 2.64, CI 1.66–4.18; 2002–04 OR = 4.38, CI 2.21–8.68) and varicella (1998–99 OR = 1.98, CI 1.26–3.11; 2000–01 OR = 3.34, CI 1.95–5.70; 2002–04 OR = 4.23, CI 1.98–9.04), younger students were more likely to be positive. (Table 4)

Table 1
Characteristics of the study population.

Variable	n	%
Gender		
Female	1728	68.5
Male	795	31.5
Study field		
Three-year health professions degrees students	1259	49.9
Six-year single-cycle degree students (Medicine and dentistry)	1264	50.1
Years of birth		
2002–2004	407	16.1
2000–2001	678	26.9
1998–1999	693	27.5
1966–1997	745	29.5

Table 2
Antibody serology.

	n	%
HBV		
Pos	1119	44.4
Neg	1399	55.6
MEASLES		
Pos	2165	87.3
Neg	314	12.7
MUMPS		
Pos	2121	85.5
Neg	359	14.5
RUBELLA		
Pos	2348	94.6
Neg	133	5.4
VARICELLA		
Pos	2363	95.2
Neg	120	4.8

According to the study field, students of six-year single-cycle degree (Medicine and dentistry) (OR 0.83, CI 0.70–0.99) were less likely to be positive for anti-HBsAg IgG while were more likely (OR 1.34, CI 1.05–1.71) for anti-mumps IgG. (Table 4) Gender did not show statistically significant differences in the likelihood of having a positive antibody titre. (Table 4).

4. Discussion

Our study revealed a concerning trend, indicating that a significant number of healthcare students might be vulnerable to vaccine-preventable infections.

Within our sample, seropositivity coverage rates for specific antibodies exhibit variability among different diseases. Specifically, rates are 95.2 % for varicella, 94.6 % for rubella, 87.3 % for measles, 85.5 % for mumps, and notably lower at less than 50 % for hepatitis B antibodies. This rate is lower than those reported in other Italian and European studies [38–41]. Statistically significant differences in antibody coverage were observed between age groups, with p-values below 0.001 for measles, rubella, and varicella. The higher seropositivity rates among younger students can potentially be explained by a combination of compulsory vaccinations (for measles and rubella) and the natural immunity acquired during childhood, primarily due to the high contagiousness of these disease. Our study reveals a seropositivity rate of 87.3 % against measles. This finding is significant considering the vaccination coverage against measles is below 95 % in most European countries, as reported by the European Centre for Disease Prevention and Control (ECDC) [42]. Notably, France, Italy, Germany, Belgium, and Poland had the highest number of confirmed cases, accounting for 98 cases of the 127 notified cases reported in Europe in 2022 [42]. Several clusters of measles have been reported in Italian and European healthcare settings [43,44]; therefore, strict infection control and immunization plans are essential to prevent nosocomial outbreaks among healthcare operators with presumed immunity [45]. Equally important is achieving a vaccine coverage exceeding 95 %, as it is essential for establishing effective herd immunity against measles [27]. Concerning mumps, our seropositivity rate stands at 85.5 %, consistent with the results reported by Coppeta et al. in their study on the seroprevalence of HCWs [46]. In 2018, a total of 11,312 mumps cases were reported among 28 EU/EEA countries, with 6,082 (54 %) being laboratory-confirmed. Notably, the epidemiology of mumps in the EU/EEA was significantly influenced by four countries: Italy, Poland, Spain, and the United Kingdom, collectively accounting for 79 % of the total notified cases. Spain alone contributed a substantial 48 % of all cases [47]. The high occurrence of the mumps disease in several European nations is probably caused by a significant prevalence of seronegativity linked to inadequate vaccination rates. As noted by Eriksen et al. [48], antibody titers were low in countries experiencing mumps outbreaks, and despite receiving two doses of the vaccine, there

Table 3
Bivariate analysis: seropositivity.

	Seropositive No. (%)	Seronegative No. (%)	*P-Value*
HBV			
Gender			
Female	770 (30.6 %)	955 (37.9 %)	>0.05
Male	349 (13.9 %)	444 (17.6 %)	
Study field			
Three-year health professions degrees students	568 (22.5 %)	690 (27.4 %)	>0.05
Six-year single-cycle degree students (Medicine and dentistry)	551 (21.9 %)	709 (28.1 %)	
Years of birth			
1966–1997	406 (16.1 %)	337 (13.4 %)	<0.001*
1998–1999	321 (12.7 %)	371 (14.7 %)	
2000–2001	254 (10.1 %)	423 (16.8 %)	
2002–2004	138 (5.5 %)	268 (10.6 %)	
MEASLES			
Gender			
Female	1497 (60.4 %)	206 (8.4 %)	>0.05
Male	668 (27.8 %)	108 (4.4 %)	
Study field			
Three-year health professions degrees students	1088 (43.9 %)	162 (6.6 %)	>0.05
Six-year single-cycle degree students (Medicine and dentistry)	1077 (43.4 %)	152 (6.1 %)	
Years of birth			
1966–1997	609 (24.6 %)	125 (5.0 %)	<0.001*
1998–1999	600 (24.2 %)	87 (3.5 %)	
2000–2001	594 (24.0 %)	65 (2.6 %)	
2002–2004	362 (14.6 %)	37 (1.5 %)	
MUMPS			
Gender			
Female	1464 (59.0 %)	240 (9.7 %)	>0.05
Male	657 (26.5 %)	119 (4.8 %)	
Study field			
Three-year health professions degrees students	1049 (42.3 %)	201 (8.1 %)	<0.02*
Six-year single-cycle degree students (Medicine and dentistry)	1072 (43.2 %)	158 (6.4 %)	
Years of birth			
1966–1997	618 (25.0 %)	117 (4.7 %)	>0.05
1998–1999	597 (24.1 %)	90 (3.6 %)	
2000–2001	566 (22.8 %)	93 (3.7 %)	
2002–2004	340 (13.7 %)	59 (2.4 %)	
RUBELLA			
Gender			
Female	1616 (65.1 %)	88 (3.5 %)	>0.05
Male	732 (29.5 %)	45 (1.8 %)	
Study field			
Three-year health professions degrees students	1184 (47.7 %)	69 (2.8 %)	>0.05
Six-year single-cycle degree students (Medicine and dentistry)	1164 (46.9 %)	64 (2.6 %)	
Years of birth			
1966–1997	661 (26.6 %)	72 (2.9 %)	<0.001*
1998–1999	661 (26.6 %)	25 (1.0 %)	
2000–2001	633 (25.5 %)	26 (1.1 %)	
2002–2004	393 (15.9 %)	10 (0.4 %)	
VARICELLA			
Gender			
Female	1622 (65.3 %)	81 (3.3 %)	>0.05
Male	741 (29.8 %)	39 (1.6 %)	
Study field			
Three-year health professions degrees students	1197 (48.2 %)	53 (2.1 %)	>0.05
Six-year single-cycle degree students (Medicine and dentistry)	1166 (47.0 %)	67 (2.7 %)	
Years of birth			
1966–1997	672 (27.1 %)	62 (2.5 %)	<0.001*
1998–1999	656 (26.4 %)	32 (1.3 %)	
2000–2001	644 (25.9 %)	18 (0.7 %)	
2002–2004	391 (15.8 %)	8 (0.3 %)	

* statistically significant.

have recently been much more incidences of mumps than rubella or measles [49]. Mumps is the only infectious disease that shows no significant difference between age groups. This is likely due to its low vaccination coverage, even among the youngest; in Italy, from 2000 to 2016, the national average vaccination coverage in children under two years of age increased from 74.1 % to 87.2 %, but it never reached 95 % [50], the critical threshold to stop the circulation of the virus.

The coverage rate for varicella seropositive rate has been found to be commendably high (95.2 %) and it is utmost significance to uphold this elevated level. Notably, studies investigating VZV exposure within healthcare facilities have revealed that a single unnoticed case of varicella among employees can potentially expose more than 30 patients and 30 healthcare workers (HCWs) [51]. Furthermore, considerable variations in VZV seroepidemiology exist across the European region [49]. Antibody coverage against rubella was also found to be considerably high (94.6 %), which, as of 13 July 2023, was announced by the WHO to no longer be endemic in Italy [52], proving the effectiveness of the vaccination. We observed an interesting trend in the prevalence of seronegative antibodies for HBV based on year of birth. Assuming a similar duration of follow-up between vaccination and surveillance sampling, an inverse correlation has been found between age and seronegativity; this correlation indicates a lower probability of having seronegative antibodies with an older date since the presumed primary vaccination, suggesting that the persistence of the measurable antibodies could be influenced by variables [53] as the type of vaccine employed [54] and the dosage [55]. Prior to the introduction of combined vaccine formulations in 2000, two primary recombinant vaccines were commonly used to vaccinate children and adolescents against HBV. Engerix-B® (10 μg dose) was the most widely employed vaccine from 1991 to 1993, while Recombivax HB® (5 μg dose) was specifically designed for pediatric use [56]. Various studies have supported the different effectiveness based on the type of vaccine employed [54], showing that individuals vaccinated with Engerix-B® exhibited a lower rate of non-protected individuals and higher levels of HBV antibodies compared to those who received Recombivax HB® [53]. A possible explanation for this clear difference in efficacies is the dosage employed for each of these vaccines. Likewise, the influence of dosage on vaccine efficacy was previously already demonstrated with another vaccine, the hexavalent ®, that was marketed by the same manufacturer of Recombivax HB® [57]. Delving into the details, in October 2000 Hexavac® [57] and INFANRIX hexa®, two hexavalent vaccines, were approved for primary and booster vaccination of children in the European Union, to prevent several infections as diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B, and invasive Haemophilus influenzae type b infections [54]. After Hexavac® was administered to many infants from the end of 2000 until September 2005, especially in Germany, Austria and Italy, the European Medicines Agency recommended the suspension of Hexavac® marketing authorization because the routine under-dosing (5 μg) resulted in reduced effectiveness of the HBV component [58]. From an occupational health perspective, adherence to vaccination campaigns is becoming an important issue, as participation from employees has been decreasing in recent years [59]. To ensure the safety and health in the workplace for all future healthcare professionals, it is essential to develop and promote workplace vaccination campaigns, not only for seasonal diseases, but for all communicable diseases for which a vaccination is available; this approach ensures that all employees have access to the appropriate preventive measures. Moreover, assessing antibody titers is crucial to identify workers who may require a booster dose. This is particularly important as a decline in titers has been observed in vaccinated individuals for various mandatory vaccinations, such as hepatitis B [60,61]. Previous data has indicated that 5–13 years after the primary vaccination with monovalent recombinant vaccines, nearly 90 % of individuals with initially low anti-HBs concentrations responded to

Table 4
Multivariate logistic regression analyses. Relationship between students' characteristics and HBV, measles, mumps, rubella and varicella seropositivity was assessed.

	Odds ratio	95 % CI	*P-value*
HBV			
Gender			
Female (Reference)	1.00		
Male	0.98	0.82–1.17	0.823
Study field			
Three-year health professions degrees students	1.00		
Six-year single-cycle degree students (Medicine and dentistry)	0.83	0.70–0.99	0.049 *
Years of birth			
1966–1997 (Reference)	1.00		
1998–1999	0.75	0.61–0.93	0.008 *
2000–2001	0.50	0.41–0.62	0.001 *
2002–2004	0.40	0.31–0.52	0.001 *
MEASLES			
Gender			
Female (Reference)	1.00		
Male	0.84	0.65–1.08	0.178
Study field			
Three-year health professions degrees students	1.00		
Six-year single-cycle degree students (Medicine and dentistry)	1.17	0.90–1.51	0.238
Years of birth			
1966–1997 (Reference)	1.00		
1998–1999	1.37	1.01–1.86	0.041 *
2000–2001	1.86	1.35–2.56	0.001 *
2002–2004	2.08	1.40–3.10	0.001 *
MUMPS			
Gender			
Female (Reference)	1.00		
Male	0.84	0.66–1.08	0.172
Study field			
Three-year health professions degrees students	1.00		
Six-year single-cycle degree students (Medicine and dentistry)	1.34	1.05–1.71	0.019 *
Years of birth			
1966–1997 (Reference)	1.00		
1998–1999	1.17	0.87–1.59	0.298
2000–2001	1.13	0.84–1.52	0.402
2002–2004	1.18	0.83–1.67	0.347
RUBELLA			
Gender			
Female (Reference)	1.00		
Male	0.88	0.59–1.28	0.498
Study field			
Three-year health professions degrees students	1.00		
Six-year single-cycle degree students (Medicine and dentistry)	1.11	0.76–1.62	0.59
Years of birth			
1966–1997 (Reference)	1.00		
1998–1999	2.82	1.75–4.55	0.001 *
2000–2001	2.64	1.66–4.18	0.001 *
2002–2004	4.38	2.21–8.68	0.001 *
VARICELLA			
Gender			
Female (Reference)	1.00		
Male	1.02	0.68–1.53	0.925
Study field			
Three-year health professions degrees students	1.00		
Six-year single-cycle degree students (Medicine and dentistry)	0.82	0.55–1.23	0.344
Years of birth			
1966–1997 (Reference)	1.00		
1998–1999	1.98	1.26–3.11	0.003 *
2000–2001	3.34	1.95–5.70	0.001 *
2002–2004	4.23	1.98–9.04	0.001 *

* = statistically significant.

booster vaccination [62]. Indeed, a rapid increase in anti-HBs antibodies has been documented in both children [63,64] and adults [65,66,67] after a booster dose of the vaccine, that is the best way to maintain long-term immunity; moreover, Yoshida and Saito cite data that show that low responders to hepatitis B vaccination developed HBsAg-positive infection [68]. The students included in this study were largely from Italy, but the sample also included international students from other European and non-European countries. The results highlighted in this study showcase the need to establish supra-national regulations concerning vaccinations policies for exanthematous diseases and HBV, to ensure that all future healthcare professionals are vaccinated against these diseases and have an appropriate antibody titer. Healthcare facilities typically have procedures in place for the screening and immunisation of their staff [69], but these procedures differ in how they handle healthcare students. Bianchi et al. found that despite hospital procedures and dedicated human resources, satisfactory vaccine coverage cannot be achieved without federal regulations; then, public health policymakers must also improve the promotion of vaccine prophylaxis and education to achieve higher vaccine coverage [70]. Our study has limitations. Since it is a cross-sectional study, we could only collect one sample per student, with no possibility of follow-up. We studied healthcare students only from a single Italian University and we were not able to retrieve either the type of vaccine administered or the date of the last vaccine inoculation, also in light of the fact that several studies show that vaccine-induced immunity in subjects vaccinated during adolescence is higher both in terms of antibody titre and the percentage of subjects anti-HBVs seropositive, regardless of the time elapsed between the last dose and the serological test [71]. In addition, recent evidence has shown that specific memory B cells are more affected by age than serum antibody levels and immunoglobulin levels in plasma might not reflect the actual status of B-cell compartment in real time [72], so that an individual could therefore continue to be protected despite being seronegative. Furthermore, we lack information regarding the occurrence of prior infections among the sample subjects. Additionally, vaccinated healthcare students who show negative or equivocal titers might still have detectable measles antibodies when using more sensitive tests. Our research also has several strengths such as a large sample of individuals, a multidisciplinary of students' degree courses, different birth years and a ten-year visit range.

5. Conclusions

In our sample, a seropositivity rate for vaccine-preventable diseases, especially Hepatitis B, was often inadequate to prevent possible biological risks connected with the activities carried out on the ward. Therefore, in the field of occupational prevention, checking antibody coverage in students and healthcare staff exposed to biological risk for the above-mentioned diseases is confirmed to be a fundamentally important tool during the health surveillance visit, also with a view to protecting the increasingly frequent international travel of students, which sometimes occurs in areas where these diseases are endemic. Therefore, it is vital for occupational doctors to raise immunization rates by reducing the number of unvaccinated individuals working in the medical field. This policy aims to enhance the overall safety of healthcare professionals and patients.

6. Institutional review board statement

Not applicable.

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CRediT authorship contribution statement

Paolo Emilio Santoro: Project administration, Supervision, Conceptualization. **Andrea Paladini:** Writing – original draft. **Ivan Borrelli:** Supervision. **Carlotta Amantea:** Writing – original draft. **Maria Francesca Rossi:** Writing – review & editing, Writing – original draft. **Corinna Fortunato:** Methodology. **Maria Rosaria Gualano:** Supervision. **Antonio Marchetti:** Data curation. **Chiara Cadeddu:** Conceptualization. **Umberto Moscato:** Project administration.

Declaration of competing interest

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

Data availability

The data that has been used is confidential.

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