European Journal of Public Health, 1–5

doi:10.1093/eurpub/ckaa179

Coverage rates against vaccine-preventable diseases among healthcare workers in Sicily (Italy)

Caterina Ledda[1], Venerando Rapisarda[1], Helena C. Maltezou[2], Eleonora Contrino[3], Arianna Conforto[3], Carmelo Massimo Maida[3], Fabio Tramuto[3], Francesco Vitale[3], Claudio Costantino[3]

1 Occupational Medicine, Department of Clinical and Experimental Medicine, University of Catania, Catania, Italy
2 Directorate of Epidemiological Surveillance and Interventions for Infectious Diseases, National Public Health Organization, Athens, Greece
3 Department of Health Promotion Sciences, Maternal and Infant Care, Internal Medicine and Excellence Specialties, University of Palermo, Palermo, Italy

Correspondence: Caterina Ledda, Occupational Medicine, Department of Clinical and Experimental Medicine, University of Catania, Via Santa Sofia, 87 Edificio B piano 0, 95123 Catania, Italy, Tel/Fax: +39 095 3782049, e-mail caterina.ledda@unict.it

Background: Vaccination of healthcare workers (HCWs) reduces the risk of occupational vaccine-preventable diseases (VPDs), prevents their nosocomial transmission and preserves healthcare delivery during outbreaks. Extensive implementation of vaccination programmes for HCWs allowed the elimination or control of several VPDs within healthcare facilities; despite these, the vaccine adherence rates among HCWs are persistently sub-optimal. **Methods:** A questionnaire was self-administered by HCWs to assess their vaccination rates against several VPDs and self-reported immunity in two university hospitals of Southern Italy (Catania and Palermo). **Results:** A total of 2586 questionnaires were analysed. More than 50% of HCWs did not know their own immunization status against diphtheria, tetanus and pertussis. More than half of the HCWs interviewed at University Hospital (UH) of Catania (UHC) was immune against measles (72.1%), in contrast with data reported at the UH of Palermo (UHP) (45.9%). Immunization status against mumps (67.5% UHC vs. 40.6% UHP), rubella (69.9% UHC vs. 46.6% UHP) and varicella (70.4% UHC vs. 50.7% UHP). Overall, about 30% of HCWs did not know their own immunization status against these VPDs. Moreover, 84.2% at UHC and 66.7% at UHP stated that was previously vaccinated against hepatitis B. **Conclusion:** Vaccination coverage rates reported from the HCWs against influenza during the last three seasons were considerably low. In conclusion, totally inadequate vaccination rates against several VPDs were found in two university hospitals in Sicily, in terms of preventing not only disease transmission by susceptible HCWs, but also nosocomial outbreaks, confirming data from previous national and international studies.

Introduction

World Health Organization (WHO) estimates that all over the world 59 million healthcare workers (HCWs) are exposed every day to multiple occupational hazards, the most common being the risk of exposure to infected patients and/or infectious materials, including body fluids, contaminated medical supplies and equipment, environmental surfaces or air.[1] Furthermore, HCWs are at increased risk of transmitting infectious diseases to their colleagues and vulnerable patients.[2] Vaccination of HCWs reduces the risk of occupational infections, prevents nosocomial transmission of vaccine-preventable diseases (VPDs) and maintains healthcare delivery during outbreaks.[3–6] For this purpose, extensive implementation of vaccination programmes for HCWs allowed to the elimination or control of several VPDs within healthcare facilities.[7] Nevertheless, serious and costly outbreaks of VPDs occur in healthcare facilities, with important morbidity and fatalities, even in European countries with established vaccination programmes,[8–13] despite these the vaccine adherence rates persist suboptimal.[14,15] In particular, in Italy, a significant percentage of HCWs are still susceptible to VPDs.[16–22]

The Italian National Vaccination Plan (PNPV 2017–19) recommends the vaccination of HCWs against hepatitis B, measles-mumps-rubella (MMR), varicella, seasonal flu and diphtheria–tetanus–acellular pertussis.[23] Subsequently, healthcare institutions habitually check HCWs to identify susceptible personnel and accurately supply with existing vaccines, but a substantial difficulty arises. The growing vaccination hesitancy among HCWs is increasing, apprehension tends to discourage them from highly recommended vaccinations.[24,25] Nevertheless, in Italy, a large measles epidemic occurred during 2017 with 2526 measles cases, Sicily accounting for 44% of all cases, including 115 cases among HCWs, almost exclusively among unvaccinated or partially vaccinated HCWs.[9–11,26] To deal with the emergency, Sicilian Health Department has issued an extraordinary regional decree which, among various measures, provides measles screening for all HCWs.[27]

The purpose of this study was to assess levels of vaccination and immunization status for VPDs, recommended in the Italian National Vaccination Plan 2017–19, of HCWs operating at the University Hospital of Catania (UHC) and Palermo (UHP).

All vaccinations considered in the survey (against diphtheria, tetanus, pertussis, hepatitis B, mumps, rubella, varicella, measles, seasonal influenza) are strongly recommended to all Italian HCWs since the drafting of the National Immunization Plan 2012–14.[28] In Italy in 1991 a universal and compulsory HBV vaccination campaign was introduced. The so-called 'two cohorts' strategies' actively offered HBV vaccination to newborns and 12-year-old adolescent (born since 1979). For these reasons, at the end of 2018, all subjects ≤39 years old were immunized against HBV in Italy, and thus the analysis was carried out dividing HCWs into two age groups (≤39 and >39 years old). Moreover, vaccination against diphtheria (since 1939) and tetanus (since 1968) were mandatory for all Italian newborns.

Table 1 Sociodemographic and working characteristics of HCWs working at the UHs of Catania and Palermo ($n = 2586$)

$n = 2586$	Catania University Hospital ($n = 1016$)	Palermo University Hospital ($n = 1570$)
Response rate (%)	58.1	89.4
Gender, *n* (%)		
Male	458 (45.1)	747 (47.6)
Female	558 (54.9)	823 (52.4)
Age, mean ± SD	46.9 ± 9.1	52.0 ± 9.1
Age groups (years), *n* (%)		
≤39	256 (25.2)	141 (8.9)
40–49	300 (29.5)	376 (23.9)
≥50	431 (42.4)	1053 (67.2)
Healthcare professionals classification, *n* (%)		
Medical doctors	457 (44.9)	538 (34.3)
Nurses, midwives and healthcare assistants	490 (48.2)	821 (52.3)
Healthcare technicians/administrative personnel	69 (6.8)	211 (13.4)

Methods

Data collection

A survey was conducted between October and December 2018 through an anonymous online questionnaire administered to HCWs (medical doctors, nurses, midwives, healthcare assistants, healthcare technicians) working at the UHC and UHP, that accounting for 1748 and 1755 employees, respectively. The questionnaire was self-administered on paper at the UHC and through the personal web page of the UHP (restricted to unauthorized users). Medical residents and healthcare trainees were excluded from the analysis because they cannot access to the personal web page of the UHP and were consequently not included in the analysis also at the UHC.

The questionnaire was managed into the following sections:

- sociodemographic data: age, gender;
- working activity data: type of healthcare professional, University Hospital of affiliation;
- vaccination status and/or immunization status against VPDs recommended for HCWs: diphtheria, tetanus, pertussis, hepatitis B, measles, mumps, rubella, varicella, seasonal influenza 2015/2016, 2016/2017, 2017/2018.

According to the Italian Vaccination Plan, to be considered fully vaccinated against measles, mumps, rubella, seasonal influenza, varicella two doses are needed, against hepatitis B the complete vaccination cycle with three doses is required and, finally, against diphtheria, tetanus, pertussis a periodic 10-year booster dose is necessary.[28]

A stratification in accordance with immunization status for every VPDs analysed was carried out. In particular were considered as 'immune' all HCWs:

- naturally immunized or vaccinated with two doses against measles, mumps, rubella and varicella;
- having received a booster dose of diphtheria, tetanus, pertussis vaccination during the last 10 years;
- naturally immunized or fully vaccinated against hepatitis B;
- vaccinated against seasonal influenza.

On the contrary were considered 'not immune' all HCWs:

- not naturally immunized, vaccinated with only one dose or with an unknown immunization status against measles, mumps, rubella and varicella;
- never vaccinated, having received a booster dose of diphtheria, tetanus, pertussis vaccination more than 10 years ago or with an unknown immunization status;
- never vaccinated, not fully vaccinated or with an unknown immunization status against hepatitis B;
- not vaccinated against seasonal influenza.

Ethical approval was obtained from the Ethics Committee of the University Hospital of Palermo, Italy, in the month of September 2017 (n.10/2017).

All vaccinations considered in the survey (against diphtheria, tetanus, pertussis, hepatitis B, mumps, rubella, varicella, seasonal influenza) are strongly recommended to all Italian HCWs since the drafting of the National Immunization Plan 2012–14.[28] In Italy in 1991 a universal and compulsory HBV vaccination campaign was introduced. The so-called 'two cohorts' strategies' actively offered HBV vaccination to newborns and 12-year-old adolescent (born since 1979). For these reasons, at the end of 2018, all subjects ≤39 years old were immunized against HBV in Italy, and thus the analysis was carried out dividing HCWs into two age groups (≤39 and >39 years old). Moreover, vaccination against diphtheria (since 1939) and tetanus (since 1968) were mandatory for all Italian newborns.

Statistical analysis

All the data collected through the questionnaire were entered into an electronic database created by Excel 16.0 software. Data analysis was performed using STATA14® software.

Quantitative variables were normally distributed and summarized as means with their standard deviations. Absolute and relative frequencies were calculated for qualitative variables. Categorical variables for sociodemographic, working characteristics, and the differences in the percentage of immunization and vaccination coverages between subjects younger than 39 years old (≤39) and older than 39 years old (>39) were stratified with the ANOVA test. The significance level chosen was *P*-values <0.05 (two-tailed).

Results

A total of 1016 out of 1748 working at the UHC (response rate 58.1%) and of 1570 out of 1755 HCWs working at the UHP (response rate 89.4%) replied to the questionnaire. Table 1 shows their characteristics per site of work.

In Table 2, the differences of self-reported vaccination and immunization status of the HCWs were showed, according to age group, gender, University hospital and HCWs group. A significantly higher HBV immunization rate was observed among HCWs

Table 2 Immunization rates (natural or artificial) against vaccine-preventable diseases among healthcare professionals enrolled in the study ($n = 2586$), by age groups ($\leq$39 vs. >39 years old), gender, university hospital and healthcare professionals

		Age groups			Gender			University Hospital			Healthcare professionals			
		<39, *n* (%)	>39, *n* (%)	*P*-value	Female, *n* (%)	Male, *n* (%)	*P*-value	Catania, *n* (%)	Palermo, *n* (%)	*P*-value	Medical doctor, *n* (%)	Nurse and midwives, *n* (%)	Other HCPs, *n* (%)	*P*-value
Measles	Immune	238 (59.9)	1217 (55.6)	0.1	820 (59.4)	635 (52.7)	<0.001	733 (72.1)	722 (45.9)	<0.001	670 (67.3)	672 (51.2)	113 (40.3)	<0.001
Mumps	Immune	205 (51.6)	1118 (51.1)	0.8	738 (53.4)	585 (48.5)	<0.001	686 (67.5)	637 (40.6)	<0.001	599 (60.2)	619 (47.2)	105 (37.5)	<0.001
Rubella	Immune	214 (53.9)	1228 (56.1)	0.4	831 (60.2)	611 (50.7)	<0.001	710 (69.9)	732 (46.6)	<0.001	626 (63.2)	700 (53.4)	116 (41.4)	<0.001
Varicella	Immune	262 (65.9)	1250 (57.1)	<0.001	874 (63.3)	638 (52.9)	<0.001	715 (70.4)	797 (50.7)	<0.001	692 (69.5)	702 (53.5)	118 (42.1)	<0.001
Hepatitis B	Immune	350 (88.2)	1617 (73.9)	<0.001	1098 (79.5)	869 (72.1)	<0.001	883 (86.8)	1112 (70.8)	<0.001	772 (77.6)	1050 (80.1)	145 (51.8)	<0.001
Diphtheria tetanus pertussis	Immune	116 (29.2)	438 (20.0)	<0.001	292 (18.9)	262 (21.7)	0.7	88 (8.6)	466 (29.7)	<0.001	207 (20.8)	279 (21.3)	68 (24.3)	0.6
Influenza 2017/2018	Immune	56 (14.1)	369 (16.8)	0.1	181 (13.1)	244 (20.2)	<0.001	116 (11.4)	309 (19.7)	<0.001	243 (24.4)	144 (10.9)	38 (13.6)	<0.001
Influenza 2016/2017	Immune	28 (7)	205 (9.4)	0.1	96 (6.9)	137 (11.4)	<0.001	84 (8.3)	149 (9.5)	0.16	148 (14.9)	62 (4.7)	23 (8.2)	<0.001
Influenza 2015/2016	Immune	12 (8.5)	121 (8.5)	0.9	51(6.2)	82(10.9)	<0.001	–	133 (8.4)	–	90 (16.7)	29 (3.5)	14 (6.6)	<0.001

$\leq$39 years old (88.2%) in comparison with HCWs older than 39 years (73.9%) ($P < 0.001$). Higher immunization rates were also observed among HCWs younger than 39 years for varicella (65.9% vs. 57.1%; $P < 0.001$), hepatitis B (88.2% vs. 73.9%; $P < 0.001$) and diphtheria, tetanus and pertussis (DTP) (29.2% vs. 20%; $P < 0.001$), while no substantial differences by age groups were observed for other VPDs considered.

Female HCWs were significantly more immunized against measles (59.4% vs. 52.7%; $P < 0.001$), mumps (53.4% vs. 48.5%; $P < 0.001$), rubella (60.2% vs. 50.7%; $P < 0.001$), varicella (63.3% vs. 52.9%; $P < 0.001$) and HBV (79.5% vs. 72.1%; $P < 0.001$) than male HCWs. There were no statistically significant differences in the sample according to hospital units.

An increasing influenza vaccination coverage trend in the last three seasons was observed in our sample, with higher coverage rates observed among HCWs older than 39 years (from 8.5% in 2015/2016 to 16.8% in 2017/2018) and males (from 10.9% in 2015/2016 to 20.2% in 2017/2018).

More than a half of the HCWs interviewed at UHC reported immunity against measles (vaccinated with two doses or naturally infected: 72.1%), in contrast with data reported at the UHP (45.9% of HCWs reported immunity) ($P < 0.001$).

Comparable values and significant differences ($P < 0.001$) were observed also analysing immunization status against mumps (67.5% UHC vs. 40.6% UHP), rubella (69.9% UHC vs. 46.6% UHP) and varicella (70.4% UHC vs. 50.7% UHP).

Furthermore, 84.2% of the respondents at UHC and 66.7% at UHP stated that was previously vaccinated against hepatitis B ($P < 0.001$).

More than 50% of HCWs surveyed did not know their own immunization status against DTP (data not shown in table).

Almost 30% of HCWs working at UHP ($n = 466$) declared to have received a booster dose within last 10 years, in comparison with 8.6% of HCWs of UHC ($P < 0.001$).

Finally, vaccination coverage reported from the HCWs against influenza during the last three seasons (2015/2016–2016/2017–2017/2018) was considerably low, reaching 8.4%, 9.5% and 19.7% at UHP, respectively and 8.3%, 11.4% for seasons 2016/2017–2017/2018 at UHC.

During the 2017/2018 season, a significant higher influenza vaccination coverage was observed among HCWs operating at UHP ($P < 0.001$).

According to the type of HCW profession, medical doctors resulted significantly more immunized than nurses, midwives and other HCWs against measles, mumps, rubella, varicella and influenza, during all the three seasons examined. Otherwise, nurses and midwives showed higher coverage rates for HBV, while no substantial differences were observed in immunization rates against dTPa.

Discussion

This study revealed low vaccination coverage rates among a representative sample of Sicilian HCWs. The response rate between the two institutions is given by the difference in administration of the study. Such coverage rates are totally inadequate in terms of preventing not only disease transmission by susceptible HCWs, but also nosocomial outbreaks (an example being the recent outbreaks of measles among HCWs in Italy), confirming data from previous studies at the national and international levels.[9,11,13–22] Higher vaccination coverage rates were observed mostly in younger and female HCWs; this is according to the literature data, where the higher rates in women are due to the prevention of risks related to some infections in pregnant women.[15] The youngest showed higher rates of vaccination against hepatitis B with significant difference than older 39 years old ($P < 0.001$), which could be attributed to the introduction of hepatitis B in Italy in 1991 for newborns and preadolescents.

These positive results reflect the effectiveness of mandatory vaccination policies in children and adolescents.

Instead, the seasonal influenza vaccination coverage was very far from the minimum recommended level[29] even though was observed an increasing trend.

Influenza vaccination among HCWs is considered to be the most important strategy for preventing the transmission of influenza viruses to vulnerable patients and minimizing absenteeism among HCWs during annual epidemics.[29] There is greater coverage at UHC probably because the average age is lower, and there are a greater number of female HCWs than UHP. Instead, for the flu vaccination UHP records better numbers because it has an *ad hoc* hospital service for this vaccination.

Biological risk assessment and management is one of the primary goals concerning preventive medicine in healthcare settings.[30]

For this reason, HCWs, compared with the general population, are further exposed to the risk of contracting VPDs, mainly those HCWs working in high-risk units, for example, intensive care, oncology, infectious disease or neonatal.

Vaccination against HCWs is also essential for preventing sickness among them, to decrease absenteeism and to guarantee an effective health service to workers and to reduce costs.[6,24,28] Despite this, vaccinations practice has been the focus of several debates. Adherence to vaccination is not always respected by HCWs, and the motives for low vaccination coverage are numerous and dissimilar. Main reasons comprise lack of information, apprehensions over the safety and effectiveness of a vaccine, anxiety of adverse reactions or of needles.[31] These behaviours determine the 'vaccine hesitancy', the reluctance or refusal to vaccinate despite the accessibility of vaccines[31] and were registered among the 10 major concerns in 2019 that request public health attention in accordance with WHO.[32] To combat vaccine hesitancy among HCWs, it should be promoted clear and effective communication regarding vaccinations and occupational innovative strategies (e.g. promoting vaccination via social networks, training HCWs, providing vaccination in the workplace).[31,32]

In this investigation, HCWs self-reported vaccination coverage against diphtheria, tetanus, pertussis, measles, mumps, rubella, varicella and influenza was insufficient; for hepatitis B suboptimal. This outcome reflects a discrepancy between stated beliefs and vaccination practices.

A seroprevalence study carried out in UHC highlight a protection for measles of 86% among HCWs;[22] this comparison leads us to think that HCWs tend not to remember or underestimate their adherence to vaccinations. The general insufficient vaccination VPDs in association with the higher corresponding completed vaccination percentages among the younger groups matched with older age groups reflect the advancement of the Italian vaccination programme, together with the prevalence of measles, rubella and varicella in Italy in the last two decades. Similar to our study, other HCWs were not compliant with their vaccination recommendations for HCWs, similar in studies conducted in Greek and French hospitals.[14]

In line with investigation from other countries,[33] the self-reported susceptibility against VPDs ranged from 12.7% to 18.9%. This study, on the other hand, tends to emphasize that HCWs do not remember their status.

Eradication of measles and rubella, and control of hepatitis B, is the aim for European member states of the WHO, specified in the European Vaccine Action Plan 2015–2020.[34] Present national vaccinations coverage against VPDs is critically under the recommended threshold of 95% vaccination coverage, consistent with WHO guidelines, to support herd immunity.[7]

Recent studies support the effectiveness of mandatory policies in improving vaccination rates.[33,35] In addition to legislation, high vaccination coverage also requires efficient hospital platforms for vaccine delivery to HCWs using the current healthcare infrastructure and procedures. HCWs vaccinations should be established, and follow-up vaccination coverage should be available in real-time according to the Italian law 81/2008 the biological risk should be evaluated and vaccines should be offer to the employee. A system to easily identify non-immune HCWs should be in place in association with efficient reminder systems (e.g. short message service, emails).

To increase the vaccination coverage, HCWs on-site immunization programmes in the hospital environment are documented as actual in reducing the costs related to the VPDs, particularly regarding the costs associated to work absenteeism.[36–39]

Another idea, in addition to improving mandatory policies, is mitigating the decisional conflict or uncertainty when HCWs are deciding about the VDPs vaccine. To support decisional conflict, healthcare organizations must include an education expert; this expert in health-care organizations could be involved in decision aid for HCWs.

This study has the limitations of a study based on self-reported immunity and thus is subject to recall bias. Advantages include the large number of studied HCWs, including all employed professions, and a large number of studied VPDs in a country where vaccine hesitancy is a major public health concern.

Attitudes towards immunization of VPDs observed in this study are generally positive, mostly in younger and female HCWs, as a result of introduction MMR and hepatitis B vaccination in the last three decades, but relatively low for influenza, even though an increase in vaccination coverage was observed recently. Generally, preventing VPDs means reducing costs, cases and outbreaks, demonstrating responsibility towards patients, and progressing general welfare.[4–6]

So as to increase vaccination coverage rates and promote safety within the healthcare setting, actions should be taken to comprehend the barriers to vaccination among HCWs and to overwhelm these barriers.

Vaccination is a keystone intervention, different from others, by reducing risk in all encounters without repeated effort or time from busy HCWs. Educational programme on the risk of being infected working in a hospital should be implemented in order to increase the risk perception towards infectious diseases among HCWs.

Funding

This study was carried out without specific funds.

Conflicts of interest: None declared.

Key points

- Vaccination of healthcare workers (HCWs) reduces the risk of occupational vaccine-preventable diseases (VPDs), prevents their nosocomial transmission and preserves healthcare delivery during outbreaks.
- Extensive implementation of vaccination programmes for HCWs allowed the elimination or control of several VPDs within healthcare facilities.
- Vaccination coverage rates reported from the HCWs against influenza during the last three seasons were considerably low.
- Totally inadequate vaccination rates against several VPDs were found in two university hospitals in Sicily.

References

1 World Health Organization (WHO). Occupational Health. Health Workers. Health Worker Occupational Health. Available at: http://www.who.int/occupational_health/topics/hcworkers/en/ (21 April 2020, date last accessed).

2 Galanakis E, Jansen A, Lopalco PL, Giesecke J. Ethics of mandatory vaccination for health-care workers. *Euro Surveill* 2013;18:20627.

3 Advisory Committee on Immunization Practices; Centers for Disease Control and Prevention (CDC). Immunization of health-care personnel: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 2011;60:1–45.

4 Rapisarda V, Ledda C, Maltezou HC. Vaccination in health-care workers: risk assessment, planning, strategy of intervention and legal implications. *Future Microbiol* 2019;14:1–3.

5 Costantino C, Restivo V, Tramuto F, et al. Influenza vaccination of health-care workers in Italy: could mandatory vaccination be a solution to protect patients? *Future Microbiol* 2019;14:45–9.

6 Amodio E, Restivo V, Firenze A, et al. Can influenza vaccination coverage among health-care workers influence the risk of nosocomial influenza-like illness in hospitalized patients? *J Hosp Infect* 2014;86:182–7.

7 Maltezou HC, Botelho-Nevers E, Brantsæter AB, et al. Vaccination of healthcare personnel in Europe: update to current policies. *Vaccine* 2019;37:7576–84.

8 Fiebelkorn AP, Seward JF, Orenstein WA. A global perspective of vaccination of health-care personnel against measles: systematic review. *Vaccine* 2014;32:4823–39.

9 Porretta A, Quattrone F, Aquino F, et al. A nosocomial measles outbreak in Italy, February-April 2017. *Euro Surveill* 2017;22:30597.

10 Depledge DP, Brown J, Macanovic J, et al. Viral genome sequencing proves nosocomial transmission of fatal varicella. *J Infect Dis* 2016;214:1399–402.

11 Amendola A, Bianchi S, Frati ER, et al. Ongoing large measles outbreak with nosocomial transmission in Milan, northern Italy, March-August 2017. *Euro Surveill* 2017;22:30596.

12 Bryant KA, Humbaugh K, Brothers K, et al. Measures to control an outbreak of pertussis in a neonatal intermediate care nursery after exposure to a health-care worker. *Infect Control Hosp Epidemiol* 2006;27:541–5.

13 Maltezou HC, Dedoukou X, Vernardaki A, et al. Measles in health-care workers during the ongoing epidemic in Greece, 2017–2018. *J Hosp Infect* 2018;100: e261–e263.

14 Maltezou HC, Gargalianos P, Nikolaidis P, et al. Attitudes towards mandatory vaccination and vaccination coverage against vaccine-preventable diseases among health-care workers in tertiary-care hospitals. *J Infect* 2012;64:319–24.

15 Maltezou HC, Lourida A, Katragkou A, et al. Attitudes regarding occupational vaccines and vaccination coverage against vaccine-preventable diseases among health-care workers working in pediatric departments in Greece. *Pediatr Infect Dis J* 2012;31:623–5.

16 Fortunato F, Tafuri S, Cozza V, et al. Low vaccination coverage among Italian health-care workers in 2013: contributing to the voluntary vs. mandatory vaccination debate. *Hum Vaccines Immunother* 2015;11:133–9.

17 Verso MG, Costantino C, Vitale F, Amodio E. Immunization against hepatitis B surface antigen (HBsAg) in a cohort of nursing students two decades after vaccination: surprising feedback. *Vaccines* 2019;8:1.

18 Genovese C, Picerno IAM, Trimarchi G, et al. Vaccination coverage in healthcare workers: a multicenter cross-sectional study in Italy. *J Prev Med Hyg* 2019;60:E12–7.

19 Costantino C, Ledda C, Genovese C, et al. Immunization status against measles of health-care workers operating at three Sicilian university hospitals: an observational study. *Vaccines* 2019;7:175.

20 Rapisarda V, Nunnari G, Senia P, et al. Hepatitis B vaccination coverage among medical residents from Catania University Hospital, Italy. *Future Microbiol* 2019;14: 41–4.

21 Ledda C, Cinà D, Garozzo SF, et al. Tuberculosis screening among health-care workers in Sicily, Italy. *Future Microbiol* 2019;14:37–40.

22 Ledda C, Cinà D, Garozzo SF, et al. Vaccine-preventable disease in health-care workers in Sicily (Italy): seroprevalence against measles. *Future Microbiol* 2019;14: 33–6.

23 Ministero della Salute. Piano Nazionale Prevenzione Vaccinale 2017-2019. Available at: http://www.salute.gov.it/imgs/C_17_pubblicazioni_2571_allegato.pdf (21 April 2020, date last accessed).

24 Gori D, Costantino C, Odone A, et al. The impact of mandatory vaccination law in Italy on MMR coverage rates in two of the largest Italian regions (Emilia-Romagna and Sicily): an effective strategy to contrast vaccine hesitancy. *Vaccines* 2020;8:57.

25 Costantino C, Caracci F, Brandi M, et al. Determinants of vaccine hesitancy and effectiveness of vaccination counseling interventions among a sample of the general population in Palermo, Italy. *Hum Vaccines Immunother* 2020.

26 Available at: https://www.epicentro.iss.it/morbillo/bollettino/RM_News_2018_48%20def.pdf (21 April 2020, date last accessed).

27 Available at: https://www.usr.sicilia.it/attachments/article/1644/Nota%20Prot.%20n°%2029454%20del%2012%20aprile%202018%20Direttiva%20Morbillo.pdf (21 April 2020, date last accessed).

28. Italian Ministry of Health. National Immunization Plan 2012-2014. Available at: http://www.salute.gov.it/imgs/C_17_pubblicazioni_1721_allegato.pdf (21 April 2020, date last accessed).

29 Costantino C, Casuccio A, Caracci F, et al. Impact of communicative and informative strategies on influenza vaccination adherence and absenteeism from work of health care professionals working at the university hospital of Palermo, Italy: a quasi-experimental field trial on twelve influenza seasons. *Vaccines* 2019;8:5.

30 Rapisarda V, Loreto C, Vitale E, et al. Incidence of sharp and needle-stick injuries and mucocutaneous blood exposure among health-care workers. *Future Microbiol* 2019;14:27–31.

31 Kennedy J. Populist politics and vaccine hesitancy in Western Europe: an analysis of national-level data. *Eur J Public Health* 2019;29:512–6.

32 World Health Organization. Ten Threats to Global Health in 2019. Geneva: WHO, 2019. Available at: https://www.who.int/news-room/feature-stories/ten-threats-to-global-health-in-2019 (21 April 2020, date last accessed).

33 Maltezou HC, Theodoridou K, Ledda C, et al. Vaccination of health-care workers: is mandatory vaccination needed? *Expert Rev Vaccines* 2019;18:5–13.

34 World Health Organization Regional Office for Europe. Regional Committee for Europe, Sixty-Fourth Session. Committee Resolution EUR/RC64/R5 on European Vaccine Action Plan 2015-2020. Available at: http://www.euro.who.int/__data/assets/pdf_file/0007/255679/WHO_EVAP_UK_v30_WEBx.pdf (21 April 2020, date last accessed).

35 Maltezou HC, Theodoridou K, Ledda C, Rapisarda V. Vaccination of health-care personnel: time to rethink the current situation in Europe. *Future Microbiol* 2019; 14:5–8.

36 Vimercati L, Bianchi FP, Mansi F, et al. Influenza vaccination in health-care workers: an evaluation of an on-site vaccination strategy to increase vaccination uptake in HCWs of a south Italy hospital. *Hum Vaccines Immunother* 2019;715: 2927–32.

37 Barbara A, Milia DIL, Di Pumpo M, et al. Strategies to increase flu vaccination coverage among healthcare workers: a 4 years study in a large Italian teaching hospital. *Vaccines* 2020;8:85.

38 Bianchi FP, Vimercati L, Mansi F, et al. Compliance with immunization and a biological risk assessment of health care workers as part of an occupational health surveillance program: the experience of a university hospital in southern Italy. *Am J Infect Control* 2020;48:368–74.

39 Boccia S, Colamesta V, Grossi A, et al. Improving vaccination coverage among healthcare workers in Italy. *Epidemiol Biostat Public Health* 2018;15.