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Influenza immunization of healthcare personnel in the post-COVID-19 pandemic era: Still a lot to do!

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ABSTRACT

Healthcare-associated influenza is frequently encountered in healthcare settings with significant morbidity and mortality among vulnerable patients, absenteeism among healthcare personnel (HCP), and interruption of healthcare services. Numerous investigations indicate that nosocomial outbreaks are often traced to HCP. Despite the international and national endorsements, seasonal influenza vaccine acceptance among HCP continues suboptimal worldwide. Infection control is the major objective for healthcare risk management in order to guarantee patient safety, limit the cost of hospitalization and assurance health management in controlling influenza seasons. Vigilance and anticipation are required as globally we are moving from a reactive COVID-19 pandemic response phase to one of planning for the co-circulation of viral respiratory infections. Declining to understand HCP perception of influenza risk and acceptance of vaccination might have impact patient safety as well as healthcare services.

Introduction

Healthcare personnel (HCP) are at increased risk for occupational exposure to influenza. A *meta*-analysis over 97 influenza seasons estimated an annual incidence rate of influenza infection of 18.7 % [95 % confidence interval (CI): 15.8–22.1 %) among unvaccinated HCP compared with 6.5 % (95 % CI: 4.6–9.1 %) among vaccinated HCP [38]. Influenza virus can be shed and transmitted by symptomatic, as well as asymptomatic and presymptomatic infected HCP [28,45,69,73]. Influenza outbreaks in healthcare facilities are often traced to unvaccinated HCP and can cause serious morbidity and mortality in high-risk patients and containment costs [18,26,48,73,80,79,95]. In addition, influenza is a significant cause of HCP absenteeism and disruption of healthcare services. For instance, up to 10,000 days of absence per year were estimated in an Italian hospital with 5,544 HCP of whom less than 3 % were vaccinated against influenza [22]. A review of healthcare-associated outbreaks over a 40-year period estimated that influenza/parainfluenza outbreaks had a 38.5 % mean closure rate of affected departments [26]. Lastly, the attitudes of HCP towards vaccinations influence their vaccination recommendations [44,61]. A 2019 French study of 1,795 hospital-based physicians found that vaccine-hesitant physicians were less proactive to recommend vaccinations to patients compared with non vaccine-hesitant physicians [94].

Increased influenza vaccination rates of HCP leads to significant reduction of disease burden among HCP and patients and decreased HCP absenteeism [39,49,54,76,83]. A multi-faceted influenza vaccination program in healthcare facilities in The Netherlands during two influenza seasons ended with a lower risk for healthcare-associated influenza and/or pneumonia in patients admitted in the internal departments of healthcare facilities with higher HCP vaccination rates compared with the control healthcare facilities (3.9 % versus 9.7 %, respectively; p-value = 0.015) [76]. A *meta*-analysis of the impact of influenza vaccination of HCP demonstrated a significant reduction of infections, absenteeism, and absenteeism-related costs which overweighed the expenditures of vaccination [31]. Similarly, a United States (US) study showed that a mandatory influenza vaccination policy for HCP in ambulatory settings significantly reduced their risk for influenza Odds ratio (OR): 0.17; 95 % CI: 0.13–0.22 [87]. Yet, influenza vaccination rates among HCP are almost globally well below the 75 % target set by the World Health Organization (WHO) [8,13,34,41,98].

The COVID-19 pandemic had a considerable impact on healthcare facilities and HCP. Interestingly, emerging research has shown potential

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cross-protective effects of the influenza vaccine against severe outcomes of COVID-19, emphasizing the need for dual vigilance in respiratory infection prevention [100]. Furthermore, during the pandemic, HCP influenza vaccination was encouraged as a strategy to differentiate between influenza and COVID-19 cases due to symptom similarity, thus facilitating timely and accurate diagnosis and management [10,71]. Increased vaccination rates not only have the potential to lessen the burden on already strained healthcare systems but also reduce the overall respiratory infection rates in facilities [13,77]. Given the compounding risks of influenza during the COVID-19 era, it is crucial to implement the best practices for the prevention of both respiratory infections [11,93,97].

Reasons of low influenza vaccine uptake among HCP

Gaps in knowledge about influenza and attitudes toward influenza vaccines are among the most frequent factors for vaccination refusal by HCP [33,52,63,85,101]. These include mainly low-risk perception, concerns about influenza vaccine efficacy and side effects, and misperception that influenza vaccine can cause influenza [17,18,23,33,35,52,50,58,63,82,85,88,96,101]. A study found that vaccine-hesitant physicians in French hospitals less frequently trusted vaccination information sources or took a course about vaccinations, and more frequently questioned vaccines' safety, compared to non vaccine-hesitant physicians [94]. On the other hand, increased occupational risk perception may also influence HCP knowledge and vaccination practices. Ledda et al. found in Italy that the level of knowledge of hospital-based HCP about vaccinations including influenza vaccination, increased significantly during the first year of the COVID-19 pandemic [40]. Influenza vaccination coverage among HCP in an Irish hospital raised from 78 % to 94 % during the COVID-19 pandemic; particularly, more than half of HCP who refused vaccination in the past stated that their vaccination attitudes changed during the pandemic [35].

While there have been observable improvements in vaccination rates through voluntary policies, these efforts have not consistently achieved the desired high vaccination rates.

Voluntary influenza vaccination policies for HCP have largely failed to achieve and sustain high vaccination rates almost universally. For instance, after decade-long efforts, influenza vaccination rates increased from 18.1 % in 2011–2012 to 58.9 % in 2019–2020 in Irish hospitals, and from 17.8 % to 45.5 % in long-term care facilities [66]. These figures highlight the gradual progress made, but they remain short of optimal levels, underscoring the limitations of voluntary approaches.

Organizational, administrative, and financial barriers also impact influenza vaccination rates of HCP [50]. These include among others limited accessibility to vaccination services (e.g. site, time and shift restrictions, inadequate reminding systems), lack of leadership, administrative, and financial support, and gaps in estimating vaccination rates [4,5,17,29,30,35;50,86]. As of early 2020, only half of low- and middle-income studies had influenza vaccination policies for HCP [46]. Most of these countries had no mechanisms to estimate vaccination rates of HCP, which indicates gaps in translating policies to actions [46].

Interventions to increase influenza vaccination rates and their effect

Educational campaigns have been shown to positively impact the HCP knowledge, attitudes, and practices toward influenza vaccination [30,63]. For instance, an educational intervention in an Australian hospital raised influenza vaccination rates from 33 % to 61 % [63]. Strategies to overcome accessibility barriers (e.g. on-site vaccination, mobile vaccination carts), mass vaccination events, support by leaders, declination declarations by vaccination refusers, and incentives also have yielded positive results. On-site influenza vaccination is cost-effective, increases productivity, and reduces absenteeism [2,7,9,16,19,27,30,35,42,43,57,70,74,75,78,81,94]. Interventions have been bundled rendering difficult to estimate the impact of each [9,57,81]. Nevertheless, even with multifaceted interventions and close monitored targets, it took five seasons (2014–2019) to increase influenza vaccination rates from 72.2 % to 87.7 % in public healthcare facilities in Victoria, Australia [6].

The past two decades many US healthcare facilities adopted mandatory influenza vaccination policies with excellent results [7,99]. Finland was the first European country to mandate healthcare facilities to employ vaccinated HCP only [25]. After switching to the mandatory vaccination policy, vaccination rates among HCP in a Finish hospital raised from 59.5 % during 2015–2016 to 99.6 % during 2018–2019 [25]. Increase of HCP influenza vaccination rate above 99 % along with a reduction in healthcare-associated influenza was recorded in a US pediatric hospital over ten years after the implementation of a mandatory vaccination policy [36]. Nevertheless, a "vaccinate-or-wear-a-mask" policy may also raise vaccination rates and patients' safety. A significant reduction of healthcare-associated influenza by nearly 50 % (OR: 0.40, 95 % CI: 0.28–0.56; p-value < 0.001) and mortality by 85 % (OR: 0.15; 95 % CI: 0.02–0.70, p-value $= 0.007$) was recorded in a German hospital during the adoption of a strict mask policy for HCP in 2015–2019, despite the low influenza vaccination rates among physicians and nurses before (42 % and 17 %, respectively) and after the intervention (53 % and 19 %, respectively) [3].

In the realm of public health, vaccination strategies are instrumental in preventing widespread outbreaks and ensuring the overall health of a population. Central to the success of these strategies is an in-depth understanding of the factors that influence individuals' decisions about vaccination. [77]. Among these, cultural and behavioral dimensions surrounding vaccination hesitancy play a pivotal role. For instance, deeply rooted cultural beliefs or historical events can significantly sway perceptions of vaccinations, either endorsing or undermining their acceptance [65]. Behavioral aspects, such as how individuals perceive risk or how they respond to peer behaviors, can also heavily influence their stance on vaccination. Moreover, these factors might not be uniform across different sectors of healthcare. Variances in attitudes and behaviors have been observed across various healthcare professional categories [14]. For instance, physicians might have a different rate of vaccination acceptance compared to nurses or allied health professionals, influenced by their training, professional experiences, or even peer dynamics within their specific fields. These differences are essential to consider when devising and implementing vaccination campaigns [1]. The absence of a comprehensive discussion on these nuances, particularly the disparities among healthcare professionals, can lead to a skewed or incomplete perspective. By delving deeper into these facets, strategies can be tailored more effectively, ensuring broader acceptance and higher vaccination rates, essential for public health success [37,72].

What is needed in the post-COVID-19 era?

Achieving and sustaining high influenza vaccination rates among HCP remain a challenge for healthcare facilities and should be regarded as a key component of infection control programs in the post-pandemic era. Existing vaccination strategies and interventions should be reviewed and modified accordingly, annual vaccination targets should be set, and the results disseminated to HCP and stakeholders [15,47,50,51,53]. Long-term commitment and funding sustainability are also critical [46].

To our knowledge, there is no policy or strategy other than vaccine mandates for skyrocketing influenza vaccination rates of HCP in the short term. Mandatory influenza vaccination policies emerge as ethical and necessary to promote safety in healthcare facilities [12,86]. Nonetheless, the selection of a mandatory vaccination policy should be regarded as a means and not an end in itself, and this should be communicated to HCP, along with the expected benefits [64]. A recent *meta*-analysis estimated a pooled acceptance rate of mandatory vaccinations of 61 % (95 % CI: 53–68 %), with significant variations by region

and HCP group [24]. In many countries, mandatory vaccination policies would be a challenge to implement, in light of concerns about HCP autonomy and the questioning of trust to the authorities. If this is the case, a "vaccinate-or-wear-a-mask" policy could be more easily supported by HCP in the post-COVID-19 pandemic era [55,84,90].

Overall, influenza-risk reduction strategies are essential at the local (healthcare facility) and the national level. This involves integrating lessons from the COVID-19 pandemic, building resilient healthcare systems, robust surveillance mechanisms, early warning systems to promptly detect healthcare outbreaks, and effective communication channels [21,56,91]. Particularly in healthcare settings, the co-circulation of SARS-CoV-2, influenza and other respiratory viruses renders the use of rapid multi-target diagnostic tests necessary to guide infection control [11]. Paid sick leave may reduce ill presenteeism among HCP due to healthcare-associated influenza and other respiratory infections [62].

The simultaneous risk posed by both the influenza epidemic and the COVID-19 pandemic represents a significant global public health challenge. Given the unpredictable nature of influenza circulation during the upcoming winter, especially in the context of ongoing COVID-19 transmissions, the situation becomes even more complex. Several epidemiological observational studies have delved into the effects of co-circulation of SARS-CoV-2 and influenza viruses, specifically examining prevalence rates, clinical outcomes, and the consequent burden on health systems [20,67,68].

Lastly, international collaboration is crucial for the success of influenza vaccination programs worldwide. Sharing knowledge, technologies, and best practices can strengthen vaccination programs and build capacity for the next pandemic [32,59]. In countries with no influenza vaccination programs for HCP, a mixture of already proven effective policies and interventions can be implemented. The WHO may coordinate collaborative efforts and support the equity of vaccinations, particularly in low-income countries [60,89,92].

Data Statement

The data that support the findings of this study are available on request from the corresponding author, [CL]. The data are not publicly available due to [restrictions e.g. their containing information that could compromise the privacy of research participants].

CRediT authorship contribution statement

Caterina Ledda: Conceptualization, Methodology, Validation, Formal analysis, Writing – original draft. **Giuseppe Motta:** Investigation, Data curation. **Venerando Rapisarda:** Investigation, Data curation, Visualization. **Helena C. Maltezou:** Methodology, Writing – review & editing, Supervision.

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

Data will be made available on request.

References

[1] Ahamed SHR, Shakil S, Lyu H, Zhang X, Luo J. Doctors vs. Nurses: Understanding the Great Divide in Vaccine Hesitancy among Healthcare Workers. In: 2022 IEEE International Conference on Big Data (Big Data). Presented at the 2022 IEEE International Conference on Big Data (Big Data). Osaka, Japan: IEEE; 2022. p. 5865–70. https://doi.org/10.1109/BigData55660.2022.10020853.

[2] Ajenjo MC, Woeltje KF, Babcock HM, Gemeinhart N, Jones M, Fraser VJ. Influenza Vaccination among Healthcare Workers: Ten-Year Experience of a Large Healthcare Organization. Infect Control Hosp Epidemiol 2010;31:233–40. https://doi.org/10.1086/650449.

[3] Ambrosch A, Luber D, Klawonn F, Kabesch M. A strict mask policy for hospital staff effectively prevents nosocomial influenza infections and mortality: monocentric data from five consecutive influenza seasons. J Hosp Infect 2022; 121:82–90. https://doi.org/10.1016/j.jhin.2021.12.010.

[4] Arghittu A, Dettori M, Azara A, Gentili D, Serra A, Contu B, et al. Flu Vaccination Attitudes, Behaviours, and Knowledge among Health Workers. IJERPH 2020;17: 3185. https://doi.org/10.3390/ijerph17093185.

[5] Barbadoro P, Marigliano A, Di Tondo E, Chiatti C, Di Stanislao F, D'Errico MM, et al. Determinants of influenza vaccination uptake among Italian healthcare workers. Hum Vaccin Immunother 2013;9:911–6. https://doi.org/10.4161/hv.22997.

[6] Bennett N, Crouch S, Hoskins A, Malloy MJ, Walker K, Worth LJ. 'Closing the gap': Evaluating the success of non-mandatory strategies for influenza vaccination of Victorian healthcare workers. Vaccine 2020;38:6363–6. https://doi.org/10.1016/j.vaccine.2020.08.013.

[7] Black CL, Yue X, Ball SW, Fink RV, de Perio MA, Laney AS, et al. Influenza Vaccination Coverage Among Health Care Personnel — United States, 2017–18 Influenza Season. MMWR Morb Mortal Wkly Rep 2018;67:1050–4. https://doi.org/10.15585/mmwr.mm6738a2.

[8] Blank PR, Schwenkglenks M, Szucs TD. Vaccination coverage rates in eleven European countries during two consecutive influenza seasons. J Infect 2009;58: 446–58. https://doi.org/10.1016/j.jinf.2009.04.001.

[9] Bryant KA, Stover B, Cain L, Levine GL, Siegel J, Jarvis WR. Improving influenza immunization rates among healthcare workers caring for high-risk pediatric patients. Infect Control Hosp Epidemiol 2004;25:912–7. https://doi.org/10.1086/502319.

[10] Cheng MP, Papenburg J, Desjardins M, Kanjilal S, Quach C, Libman M, et al. Diagnostic Testing for Severe Acute Respiratory Syndrome-Related Coronavirus 2: A Narrative Review. Ann Intern Med 2020;172:726–34. https://doi.org/10.7326/M20-1301.

[11] Chotpitayasunondh T, Fischer TK, Heraud J, Hurt AC, Monto AS, Osterhaus A, et al. Influenza and COVID-19: What does co-existence mean? Influenza Other Respi Viruses 2021;15:407–12. https://doi.org/10.1111/irv.12824.

[12] COMMITTEE ON INFECTIOUS DISEASES, Byington CL, Maldonado YA, Barnett ED, Davies HD, Edwards KM, et al. Influenza Immunization for All Health Care Personnel: Keep It Mandatory. Pediatrics 2015;136:809–18. https://doi.org/10.1542/peds.2015-2922.

[13] Costantino C, Ledda C, Squeri R, Restivo V, Casuccio A, Rapisarda V, et al. Attitudes and Perception of Healthcare Workers Concerning Influenza Vaccination during the 2019/2020 Season: A Survey of Sicilian University Hospitals. Vaccines 2020;8:686. https://doi.org/10.3390/vaccines8040686.

[14] Crawshaw J, Konnyu K, Castillo G, Van Allen Z, Grimshaw JM, Presseau J. Behavioural determinants of COVID-19 vaccination acceptance among healthcare workers: a rapid review. Public Health 2022;210:123–33. https://doi.org/10.1016/j.puhe.2022.06.003.

[15] de Figueiredo A, Simas C, Karafillakis E, Paterson P, Larson HJ. Mapping global trends in vaccine confidence and investigating barriers to vaccine uptake: a large-scale retrospective temporal modelling study. Lancet 2020;396:898–908. https://doi.org/10.1016/S0140-6736(20)31558-0.

[16] Dettori M, Arghittu A, Deiana G, Azara A, Masia MD, Palmieri A, et al. Influenza Vaccination Strategies in Healthcare Workers: A Cohort Study (2018–2021) in an Italian University Hospital. Vaccines 2021;9:971. https://doi.org/10.3390/vaccines9090971.

[17] Dini G, Toletone A, Sticchi L, Orsi A, Bragazzi NL, Durando P. Influenza vaccination in healthcare workers: A comprehensive critical appraisal of the literature. Hum Vaccin Immunother 2018;14:772–89. https://doi.org/10.1080/21645515.2017.1348442.

[18] Dionne B, Brett M, Culbreath K, Mercier R-C. Potential Ceiling Effect of Healthcare Worker Influenza Vaccination on the Incidence of Nosocomial Influenza Infection. Infect Control Hosp Epidemiol 2016;37:840–4. https://doi.org/10.1017/ice.2016.77.

[19] Drees M, Wroten K, Smedley M, Mase T, Schwartz JS. Carrots and Sticks: Achieving High Healthcare Personnel Influenza Vaccination Rates without a Mandate. Infect Control Hosp Epidemiol 2015;36:717–24. https://doi.org/10.1017/ice.2015.47.

[20] Ehrlich H, Boneva D, Elkbuli A. The intersection of viral illnesses: A seasonal influenza epidemic amidst the COVID-19 pandemic. Annals of Medicine and Surgery 2020;60:41–3. https://doi.org/10.1016/j.amsu.2020.10.021.

[21] Evans RA, McAuley H, Harrison EM, Shikotra A, Singapuri A, Sereno M, et al. Physical, cognitive and mental health impacts of COVID-19 following hospitalisation – a multi-centre prospective cohort study. medRxiv 2022.

[22] Gianino MM, Politano G, Scarmozzino A, Stillo M, Amprino V, Di Carlo S, et al. Cost of sickness absenteeism during seasonal influenza outbreaks of medium intensity among health care workers. Int J Environ Res Public Health 2019;16. https://doi.org/10.3390/ijerph16050747.

[23] Glenton C, Carlsen B, Lewin S, Wennekes MD, Winje BA, Eilers R, on behalf of the VITAL consortium. Healthcare workers' perceptions and experiences of communicating with people over 50 years of age about vaccination: a qualitative evidence synthesis. Cochrane Database Syst Rev 2021;2021. https://doi.org/10.1002/14651858.CD013706.pub2.

[24] Gualano MR, Corradi A, Voglino G, Catozzi D, Olivero E, Corezzi M, et al. Healthcare Workers' (HCWs) attitudes towards mandatory influenza vaccination:

A systematic review and meta-analysis. Vaccine 2021;39:901–14. https://doi.org/10.1016/j.vaccine.2020.12.061.
[25] Hämäläinen A, Patovirta R-L, Mauranen E, Hämäläinen S, Koivula I. Support among healthcare workers for the new mandatory seasonal influenza vaccination policy and its effects on vaccination coverage. Ann Med 2021;53:384–90. https://doi.org/10.1080/07853890.2021.1889022.
[26] Hansen S, Stamm-Balderjahn S, Zuschneid I, Behnke M, Rüden H, Vonberg R-P, et al. Closure of medical departments during nosocomial outbreaks: data from a systematic analysis of the literature. J Hosp Infect 2007;65:348–53. https://doi.org/10.1016/j.jhin.2006.12.018.
[27] Harbarth S, Siegrist C-A, Schira J-C, Wunderli W, Pittet D. Influenza Immunization: Improving Compliance of Healthcare Workers. Infect Control Hosp Epidemiol 1998;19:337–42. https://doi.org/10.1086/647825.
[28] Haviari S, Bénet T, Saadatian-Elahi M, André P, Loulergue P, Vanhems P. Vaccination of healthcare workers: A review. Hum Vaccin Immunother 2015;11:2522–37. https://doi.org/10.1080/21645515.2015.1082014.
[29] Hayward AC, Harling R, Wetten S, Johnson AM, Munro S, Smedley J, et al. Effectiveness of an influenza vaccine programme for care home staff to prevent death, morbidity, and health service use among residents: Cluster randomised controlled trial. Br Med J 2006;333:1241–4. https://doi.org/10.1136/bmj.39010.581354.55.
[30] Hollmeyer H, Hayden F, Mounts A, Buchholz U. Review: Interventions to increase influenza vaccination among healthcare workers in hospitals. Influenza Other Respi Viruses 2013;7:604–21. https://doi.org/10.1111/irv.12002.
[31] Imai C, Toizumi M, Hall L, Lambert S, Halton K, Merollini K. A systematic review and meta-analysis of the direct epidemiological and economic effects of seasonal influenza vaccination on healthcare workers. PLoS One 2018;13:e0198685.
[32] Jit M, Ananthakrishnan A, McKee M, Wouters OJ, Beutels P, Teerawattananon Y. Multi-country collaboration in responding to global infectious disease threats: lessons for Europe from the COVID-19 pandemic. The Lancet Regional Health - Europe 2021;9:100221. https://doi.org/10.1016/j.lanepe.2021.100221.
[33] Johansen LJ, Stenvig T, Wey H. The Decision to Receive Influenza Vaccination Among Nurses in North and South Dakota: The Decision to Receive Influenza Vaccination. Public Health Nurs 2012;29:116–25. https://doi.org/10.1111/j.1525-1446.2011.00966.x.
[34] Jorgensen P, Mereckiene J, Cotter S, Johansen K, Tsolova S, Brown C. How close are countries of the WHO European Region to achieving the goal of vaccinating 75% of key risk groups against influenza? Results from national surveys on seasonal influenza vaccination programmes, 2008/2009 to 2014/2015. Vaccine 2018;36:442–52. https://doi.org/10.1016/j.vaccine.2017.12.019.
[35] Kearns EC, Callanan I, O'Reilly A, Purcell A, Tuohy N, Bulfin S, et al. Changing attitudes towards annual influenza vaccination amongst staff in a Tertiary Care Irish University Hospital. Ir J Med Sci 2022;191:629–36. https://doi.org/10.1007/s11845-021-02636-w.
[36] Kitt E, Burt S, Price SM, Satchell L, Offit PA, Sammons JS, et al. Implementation of a Mandatory Influenza Vaccine Policy: A 10-Year Experience. Clin Infect Dis 2021;73:e290–6. https://doi.org/10.1093/cid/ciaa782.
[37] Kumar D, Chandra R, Mathur M, Samdariya S, Kapoor N. Vaccine hesitancy: understanding better to address better. Isr J Health Policy Res 2016;5:2. https://doi.org/10.1186/s13584-016-0062-y.
[38] Kuster SP, Shah PS, Coleman BL, Lam P-P, Tong A, Wormsbecker A, et al. Incidence of Influenza in Healthy Adults and Healthcare Workers: A Systematic Review and Meta-Analysis. PLoS One 2011;6:e26239.
[39] Kyu HH, Vongpradith A, Sirota SB, Novotney A, Troeger CE, Doxey MC, et al. Age–sex differences in the global burden of lower respiratory infections and risk factors, 1990–2019: results from the Global Burden of Disease Study 2019. Lancet Infect Dis 2022;22:1626–47. https://doi.org/10.1016/S1473-3099(22)00510-2.
[40] Ledda C, Costantino C, Cuccia M, Maltezou HC, Rapisarda V. Attitudes of Healthcare Personnel towards Vaccinations before and during the COVID-19 Pandemic. IJERPH 2021;18:2703. https://doi.org/10.3390/ijerph18052703.
[41] Ledda C, Rapisarda V, Maltezou HC, Contrino E, Conforto A, Maida CM, et al. Coverage rates against vaccine-preventable diseases among healthcare workers in Sicily (Italy). Europ J Public Health 2021;31:56. https://doi.org/10.1093/eurpub/ckaa179.
[42] Lemaitre M, Meret T, Rothan-Tondeur M, Belmin J, Lejonc J-L, Luquel L, et al. Effect of influenza vaccination of nursing home staff on mortality of residents: A cluster-randomized trial. J Am Geriatr Soc 2009;57:1580–6. https://doi.org/10.1111/j.1532-5415.2009.02402.x.
[43] Lester RT, McGeer A, Tomlinson G, Detsky AS. Use of, Effectiveness of, and Attitudes Regarding Influenza Vaccine among House Staff. Infect Control Hosp Epidemiol 2003;24:839–44. https://doi.org/10.1086/502146.
[44] Lin C, Mullen J, Smith D, Kotarba M, Kaplan SJ, Tu P. Healthcare Providers' Vaccine Perceptions, Hesitancy, and Recommendation to Patients: A Systematic Review. Vaccines 2021;9:713. https://doi.org/10.3390/vaccines9070713.
[45] Maltezou HC, Botelho-Nevers E, Brantsæter AB, Carlsson R-M, Heininger U, Hübschen JM, et al. Vaccination of healthcare personnel in Europe: Update to current policies. Vaccine 2019;37:7576–84. https://doi.org/10.1016/j.vaccine.2019.09.061.
[46] Maltezou HC, Dedoukou X, Tseroni M, Tsonou P, Raftopoulos V, Papadima K, et al. SARS-CoV-2 Infection in Healthcare Personnel With High-risk Occupational Exposure: Evaluation of 7-Day Exclusion From Work Policy. Clin Infect Dis 2020;71:3182–7. https://doi.org/10.1093/cid/ciaa888.
[47] Maltezou HC, Dounias G, Rapisarda V, Ledda C. Vaccination policies for healthcare personnel: Current challenges and future perspectives. Vaccine 2022;X 11:100172. https://doi.org/10.1016/j.jvacx.2022.100172.
[48] Maltezou HC, Drancourt M. Nosocomial influenza in children. J Hosp Infect 2003;55:83–91. https://doi.org/10.1016/S0195-6701(03)00262-7.
[49] Maltezou HC, Giannouchos TV, Pavli A, Tsonou P, Dedoukou X, Tseroni M, et al. Costs associated with COVID-19 in healthcare personnel in Greece: a cost-of-illness analysis. J Hosp Infect 2021;114:126–33. https://doi.org/10.1016/j.jhin.2021.04.018.
[50] Maltezou HC, Ioannidou E, De Schrijver K, François G, De Schryver A. Influenza Vaccination Programs for Healthcare Personnel: Organizational Issues and Beyond. IJERPH 2021;18:11122. https://doi.org/10.3390/ijerph182111122.
[51] Maltezou HC, Ledda C, Gagneux-Brunon A, Botelho-Nevers E. Mandatory COVID-19 vaccination for healthcare personnel in the era of new SARS-CoV-2 variants. Vaccine 2022;40:7167–9. https://doi.org/10.1016/j.vaccine.2022.10.053.
[52] Maltezou HC, Lourida A, Katragkou A, Grivea IN, Katerelos P, Wicker S, et al. Attitudes regarding occupational vaccines and vaccination coverage against vaccine-preventable diseases among healthcare workers working in pediatric departments in Greece. Pediatr Infect Dis J 2012;31:623–5. https://doi.org/10.1097/INF.0b013e31824ddc1e.
[53] Maltezou HC, Pavli A, Dedoukou X, Georgakopoulou T, Raftopoulos V, Drositis I, et al. Determinants of intention to get vaccinated against COVID-19 among healthcare personnel in hospitals in Greece. Infection, Disease & Health 2021;26:189–97. https://doi.org/10.1016/j.idh.2021.03.002.
[54] Maltezou HC, Poland GA. Immunization of healthcare personnel in Europe: Time to move forward with a common program. Vaccine 2020;38:3187–90. https://doi.org/10.1016/j.vaccine.2020.02.090.
[55] Maniaci A, Ferlito S, Bubbico L, Ledda C, Rapisarda V, Iannella G, et al. Comfort rules for face masks among healthcare workers during COVID-19 spread. Ann Ig 2021;33:615–27. https://doi.org/10.7416/ai.2021.2439.
[56] Marmo R, Pascale F, Diana L, Sicignano E, Polverino F. Lessons learnt for enhancing hospital resilience to pandemics: A qualitative analysis from Italy. Int J Disaster Risk Reduct 2022;81:103265. https://doi.org/10.1016/j.ijdrr.2022.103265.
[57] McArthur MA, Simor AE, Campbell B, McGeer A. Influenza Vaccination in Long-Term–Care Facilities: Structuring Programs for Success. Infect Control Hosp Epidemiol 1999;20:499–503. https://doi.org/10.1086/501659.
[58] Mitchell G, Leonard L, Carter G, Santin O, Brown Wilson C. Evaluation of a 'serious game' on nursing student knowledge and uptake of influenza vaccination. PLoS One 2021;16. https://doi.org/10.1371/journal.pone.0245389.
[59] Moore KA, Ostrowsky JT, Kraigsley AM, Mehr AJ, Bresee JS, Friede MH, et al. A Research and Development (R&D) roadmap for influenza vaccines: Looking toward the future. Vaccine 2021;39:6573–84. https://doi.org/10.1016/j.vaccine.2021.08.010.
[60] Morales KF, Brown DW, Dumolard L, Steulet C, Vilajeliu A, Ropero Alvarez AM, et al. Seasonal influenza vaccination policies in the 194 WHO Member States: The evolution of global influenza pandemic preparedness and the challenge of sustaining equitable vaccine access. Vaccine 2021;X 8:100097. https://doi.org/10.1016/j.jvacx.2021.100097.
[61] Morales KF, Menning L, Lambach P. The faces of influenza vaccine recommendation: A Literature review of the determinants and barriers to health providers' recommendation of influenza vaccine in pregnancy. Vaccine 2020;38:4805–15. https://doi.org/10.1016/j.vaccine.2020.04.033.
[62] Most ZM. Beyond personal protective equipment: adjunctive methods for control of healthcare-associated respiratory viral infections. Curr Opin Infect Dis 2020;33:312–8. https://doi.org/10.1097/QCO.0000000000000655.
[63] Nowak GJ, Sheedy K, Bursey K, Smith TM, Basket M. Promoting influenza vaccination: Insights from a qualitative meta-analysis of 14 years of influenza-related communications research by U.S. Centers for Disease Control and Prevention (CDC). Vaccine 2015;33:2741–56. https://doi.org/10.1016/j.vaccine.2015.04.064.
[64] Nunn A, Campbell AC, Naus M, Kwong JC, Puddicombe D, Quach S, et al. Implementing a province-wide mandatory vaccinate-or-mask policy at healthcare facilities in British Columbia, Canada. Vaccine 2018;36:395–9. https://doi.org/10.1016/j.vaccine.2017.11.072.
[65] Nuwarda RF, Ramzan I, Weekes L, Kayser V. Vaccine Hesitancy: Contemporary Issues and Historical Background. Vaccines 2022;10:1595. https://doi.org/10.3390/vaccines10101595.
[66] O'Lorcain P, Cotter S, Walsh C. Influenza vaccine uptake among healthcare workers and residents in public health care facilities in Ireland over nine influenza seasons (2011–2012 to 2019–2020). Vaccine 2021;39:5954–62. https://doi.org/10.1016/j.vaccine.2021.07.082.
[67] Ozaras R, Cirpin R, Duman H, Duran A, Arslan O, Leblebicioglu H. An open call for influenza vaccination pending the new wave of COVID-19. J Med Virol 2021;93:172–3. https://doi.org/10.1002/jmv.26272.
[68] Ozaras R, Cirpin R, Duran A, Duman H, Arslan O, Bakcan Y, et al. Influenza and COVID-19 coinfection: Report of six cases and review of the literature. J Med Virol 2020;92:2657–65. https://doi.org/10.1002/jmv.26125.
[69] Patrozou E, Mermel LA. Does influenza transmission occur from asymptomatic infection or prior to symptom onset? Public Health Rep 2009;124:193–6. https://doi.org/10.1177/003335490912400205.
[70] Pearson ML, Bridges CB, Harper SA, Committee HICPA, (HICPAC), Advisory Committee on Immunization Practices (ACIP),. Influenza vaccination of health-care personnel: recommendations of the Healthcare Infection Control Practices Advisory Committee (HICPAC) and the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2006;55:1–16.
[71] Perrone PM, Biganzoli G, Lecce M, Campagnoli EM, Castrofino A, Cinnirella A, et al. Influenza Vaccination Campaign during the COVID-19 Pandemic: The

Experience of a Research and Teaching Hospital in Milan. IJERPH 2021;18:5874. https://doi.org/10.3390/ijerph18115874.
[72] Peterson CJ, Lee B, Nugent K. COVID-19 Vaccination Hesitancy among Healthcare Workers—A Review. Vaccines 2022;10:948. https://doi.org/10.3390/vaccines10060948.
[73] Petrie JG, Talbot TR. Health Care-Acquired Viral Respiratory Diseases. Infect Dis Clin North Am 2021;35:1055–75. https://doi.org/10.1016/j.idc.2021.07.007.
[74] Poland G, Tosh P, Jacobson R. Requiring influenza vaccination for health care workers: seven truths we must accept. Vaccine 2005;23:2251–5. https://doi.org/10.1016/j.vaccine.2005.01.043.
[75] Polgreen PM, Septimus EJ, Parry MF, Beekmann SE, Cavanaugh JE, Srinivasan A, et al. Relationship of Influenza Vaccination Declination Statements and Influenza Vaccination Rates for Healthcare Workers in 22 US Hospitals. Infect Control Hosp Epidemiol 2008;29:675–7. https://doi.org/10.1086/588590.
[76] Riphagen-Dalhuisen J, Burgerhof JG, Frijstein G, van der Geest-Blankert AD, Danhof-Pont MB, de Jager HJ, et al. Hospital-based cluster randomised controlled trial to assess effects of a multi-faceted programme on influenza vaccine coverage among hospital healthcare workers and nosocomial influenza in the Netherlands, 2009 to 2011. Eurosurveillance 2013;18. https://doi.org/10.2807/1560-7917.ES2013.18.26.20512.
[77] Rodrigues CMC, Plotkin SA. Impact of Vaccines; Health, Economic and Social Perspectives. Front Microbiol 2020;11:1526. https://doi.org/10.3389/fmicb.2020.01526.
[78] Saito R, Suzuki H, Oshitani H, Sakai T, Seki N, Tanabe N. The Effectiveness of Influenza Vaccine Against Influenza A (H3N2) Virus Infections in Nursing Homes in Niigata, Japan, During the 1998–1999 and 1999–2000 Seasons. Infect Control Hosp Epidemiol 2002;23:82–6. https://doi.org/10.1086/502011.
[79] Salgado CD, Farr BM, Hall KK, Hayden FG. Influenza in the acute hospital setting. Lancet Infect Dis 2002;2:145–55. https://doi.org/10.1016/S1473-3099(02)00221-9.
[80] Salgado CD, Giannetta ET, Hayden FG, Farr BM. Preventing nosocomial influenza by improving the vaccine acceptance rate of clinicians. Infect Control Hosp Epidemiol 2004;25:923–8. https://doi.org/10.1086/502321.
[81] Sartor C, Tissot-Dupont H, Zandotti C, Martin F, Roques P, Drancourt M. Use of a mobile cart influenza program for vaccination of hospital employees. Infect Control Hosp Epidemiol 2004;25:918–22. https://doi.org/10.1086/502320.
[82] Saunier F, Berthelot P, Mottet-Auselo B, Pelissier C, Fontana L, Botelho-Nevers E, et al. Impact of a decision-aid tool on influenza vaccine coverage among HCW in two French hospitals: A cluster-randomized trial. Vaccine 2020;38:5759–63. https://doi.org/10.1016/j.vaccine.2020.07.011.
[83] Saxén H, Virtanen M. Randomized, placebo-controlled double blind study on the efficacy of influenza immunization on absenteeism of health care workers. Pediatr Infect Dis J 1999;18:779–83. https://doi.org/10.1097/00006454-199909000-00007.
[84] Schumacher S, Salmanton-García J, Cornely OA, Mellinghoff SC. Increasing influenza vaccination coverage in healthcare workers: a review on campaign strategies and their effect. Infection 2021;49:387–99. https://doi.org/10.1007/s15010-020-01555-9.
[85] Seale H, Wang Q, Yang P, Dwyer DE, Wang X, Zhang Y, et al. Influenza vaccination amongst hospital health care workers in Beijing. Occup Med 2010;60:335–9. https://doi.org/10.1093/occmed/kqq037.
[86] Short E, Zimmerman P-A, van de Mortel T. Barriers associated with mandatory influenza vaccination policies for healthcare workers: an integrative review. J Infect Prev 2020;21:212–20. https://doi.org/10.1177/1757177420935629.
[87] Simberkoff MS, Rattigan SM, Gaydos CA, Gibert CL, Gorse GJ, Nyquist A-C, et al. Impact of mandatory vaccination of healthcare personnel on rates of influenza and other viral respiratory pathogens. Infect Control Hosp Epidemiol 2021;1–5. https://doi.org/10.1017/ice.2021.324.
[88] Smith DR, Van Cleave B. Influenza vaccination as a condition of employment for a large regional health care system. Wis Med J 2012;111:68–71.
[89] Soni GK, Seth S, Arora S, Singh K, Kumari A, Kanagat N, et al. Harnessing the Power of Collaboration to Expand the Coverage and Equity of COVID-19 Vaccinations in India: A Community Collaboration Model. Vaccines 2023;11:1022. https://doi.org/10.3390/vaccines11061022.
[90] Stuart RL, Gillespie EE, Kerr PG. A pilot study of an influenza vaccination or mask mandate in an Australian tertiary health service. Med J Aust 2014;200:83–4. https://doi.org/10.5694/mja13.10947.
[91] Sundararaman T, Muraleedharan VR, Ranjan A. Pandemic resilience and health systems preparedness: lessons from COVID-19 for the twenty-first century. J Soc Econ Dev 2021;23:290–300. https://doi.org/10.1007/s40847-020-00133-x.
[92] Syed U, Kapera O, Chandrasekhar A, Baylor BT, Hassan A, Magalhães M, et al. The Role of Faith-Based Organizations in Improving Vaccination Confidence & Addressing Vaccination Disparities to Help Improve Vaccine Uptake: A Systematic Review. Vaccines 2023;11:449. https://doi.org/10.3390/vaccines11020449.
[93] Vella F, Senia P, Ceccarelli M, Vitale E, Maltezou H, Taibi R, et al. Transmission mode associated with coronavirus disease 2019: a review. Eur Rev Med Pharmacol Sci 2020;24:7889–904. https://doi.org/10.26355/eurrev_202007_22296.
[94] Verger P, Dualé C, Lenzi N, Scronias D, Pulcini C, Launay O. Vaccine hesitancy among hospital staff physicians: A cross-sectional survey in France in 2019. Vaccine 2021;39:4481–8. https://doi.org/10.1016/j.vaccine.2021.06.053.
[95] Voirin N, Barret B, Metzger M-H, Vanhems P. Hospital-acquired influenza: a synthesis using the Outbreak Reports and Intervention Studies of Nosocomial Infection (ORION) statement. J Hosp Infect 2009;71:1–14. https://doi.org/10.1016/j.jhin.2008.08.013.
[96] von Linstow M-L, Nordmann Winther T, Eltvedt A, Bybeck Nielsen A, Yde Nielsen A, Poulsen A. Self-reported immunity and opinions on vaccination of hospital personnel among paediatric healthcare workers in Denmark. Vaccine 2020;38:6570–7. https://doi.org/10.1016/j.vaccine.2020.08.010.
[97] WHO. Coronavirus disease (COVID-19): Similarities and differences between COVID-19 and Influenza [WWW Document], 2020. URL https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19-similarities-and-differences-with-influenza [accessed 2.20.22].
[98] WHO. Influenza (Seasonal) [WWW Document]; 2018. URL https://www.who.int/news-room/fact-sheets/detail/influenza-(seasonal) [accessed 2.20.22].
[99] Woolf K, Gogoi M, Martin CA, Papineni P, Lagrata S, Nellums LB, et al. Healthcare workers' views on mandatory SARS-CoV-2 vaccination in the UK: A cross-sectional, mixed-methods analysis from the UK-REACH study. eClinicalMedicine 2022;46:101346. https://doi.org/10.1016/j.eclinm.2022.101346.
[100] Xie Z, Hamadi HY, Mainous AG, Hong Y-R. Association of dual COVID-19 and seasonal influenza vaccination with COVID-19 infection and disease severity. Vaccine 2023;41:875–8. https://doi.org/10.1016/j.vaccine.2022.12.043.
[101] Zhang J, While AE, Norman IJ. Nurses' knowledge and risk perception towards seasonal influenza and vaccination and their vaccination behaviours: A cross-sectional survey. Int J Nurs Stud 2011;48:1281–9. https://doi.org/10.1016/j.ijnurstu.2011.03.002.