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CLOSING THE IMMUNITY GAP: A NARRATIVE REVIEW ON IMPROVING HEALTHCARE WORKER PERTUSSIS VACCINATION IN MALAYSIA THROUGH LESSONS FROM THE GLOBAL EXPERIENCE

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Abstract

Pertussis remains a significant public health concern despite widespread vaccination programs, with healthcare workers (HCWs) increasingly recognised as both susceptible populations and potential sources of nosocomial transmission to vulnerable infants. While many high-income countries have established comprehensive HCW pertussis vaccination policies, Malaysia lacks formal national guidelines despite documented infant pertussis burden. This narrative review examines global healthcare worker pertussis vaccination policies and their applicability to Malaysia, evaluating evidence on nosocomial transmission, vaccination strategies, cost-effectiveness, and policy implementation. A narrative review was conducted in accordance with established guidelines for literature synthesis. Multiple databases, including PubMed, Scopus, and Web of Science, were searched for peer-reviewed literature on pertussis vaccination policies, nosocomial outbreaks, HCW immunisation strategies, and economic evaluations. Grey literature from government health agencies was included to capture policy documents. Healthcare workers demonstrate substantial pertussis susceptibility globally, with seroprevalence studies showing 48.3-51.7% lacking protective immunity. Documented nosocomial outbreaks indicate a significant risk of transmission to vulnerable infants. International policies vary considerably: Australia, the United Kingdom, and Canada mandate or strongly recommend Tdap vaccination for HCWs as part of occupational health programs, while Malaysia lacks specific HCW vaccination guidelines. Cost-effectiveness analyses show that HCW vaccination programs yield net savings of $17.84 per dollar spent when productivity losses are included. Substantial evidence supports the implementation of mandatory Tdap vaccination policies for Malaysian healthcare workers. Recommendations include establishing national HCW vaccination guidelines, providing free workplace vaccination programs, and implementing pre-employment vaccination requirements.

Keywords: Pertussis, Healthcare workers, Vaccination policy, Nosocomial transmission, Malaysia, Tdap vaccine, Occupational health

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INTRODUCTION

Pertussis, caused by the Gram-negative bacillus *Bordetella pertussis* (Gabutti et al., 2016), spreads through aerosolized droplets and remains a highly contagious respiratory infection despite the availability of vaccines for over 70 years (Domenech de Cellès et al., 2016). The disease can affect people of all ages; however, the burden is particularly severe among infants under six months, especially those who are unvaccinated or under-vaccinated (Mohamed et al., 2022). Globally, pertussis was estimated to cause approximately 19.5 million cases in 2019, with Southeast Asia experiencing one of the highest regional burdens (Nguyen et al., 2025). In 2014, pertussis was projected to have caused over 160,000 deaths in children under five, with Southeast Asia bearing the second-highest mortality burden (Yeung et al., 2017). The disease has re-emerged with heterogeneous patterns worldwide, with outbreaks reported in at least 42 countries by mid-2025 (Nguyen et al., 2025).

Recent data from Sarawak, Malaysia, revealed that among infants under 12 months admitted to hospital between 2015 and 2021, 18% of tested infants had PCR-confirmed pertussis, with an average annual incidence of 482 per 100,000 infants (Mohan et al., 2024). In a separate national surveillance study, 12.7% of hospitalized infants aged less than six months with symptoms consistent with pertussis had laboratory-confirmed infection, with the majority (89.3%) occurring in infants too young to be fully vaccinated or under-vaccinated for their age (Mohamed et al., 2022). In England, the UK Health Security Agency (UKHSA) reported 10,493 confirmed cases of pertussis between January and June 2024, with 10 infant deaths during

Current evidence indicates an epidemiological shift in pertussis, with increasing recognition of cases among adolescents and adults due to waning vaccine-induced immunity and improved diagnostic capabilities (Nguyen et al., 2025; MacIntyre et al., 2024). Adults and adolescents now serve as under-recognized reservoirs of infection, capable of transmitting pertussis to vulnerable infants who are too young to be fully immunized (Nguyen et al., 2025; Kardos et al., 2024). This transmission dynamic is particularly concerning in healthcare settings, where healthcare workers (HCWs) have been implicated in transmission chains affecting neonates and patients. The global resurgence of pertussis cases underscores the urgent need for enhanced vaccination strategies. Booster vaccinations for adolescents and adults, including HCWs, have gained attention as a measure to reduce transmission within the broader population and provide protection to those at highest risk (Nguyen et al., 2025; MacIntyre et al., 2024). However, implementing adult vaccination remains challenging due to low awareness of the risk of pertussis in adults, limited time or funding for vaccination programs, low prioritization by healthcare providers, misconceptions about the necessity of vaccination, and infrequent proactive recommendations from clinicians (Nguyen et al., 2025; Choi et al., 2022).

Despite the documented burden of pertussis and the recognized role of adults, particularly HCWs in disease transmission, gaps remain in understanding optimal vaccination strategies for HCWs in Malaysia. The objective of this narrative review is to examine pertussis

vaccination policies for HCWs in various countries and conduct a comparative analysis with the situation in Malaysia. Specifically, this review focuses on pertussis outbreaks in healthcare facilities, vaccination strategies and coverage among HCWs, and evidence on the cost-effectiveness of vaccinating HCWs against pertussis. By synthesizing global lessons and best practices, this review aims to inform policy recommendations to close the immunity gap and improve HCW pertussis vaccination in Malaysia.

METHODS

This narrative review followed established guidelines for synthesizing the literature and integrating qualitative evidence (Greenhalgh et al., 2018; Ferrari, 2015). We conducted a comprehensive literature search across three major databases (PubMed, Scopus, and ScienceDirect) for English-language articles published between 2000 and 2025. Our search strategy combined key terms across four domains: (1) disease-related terms ("pertussis," "Bordetella pertussis," "whooping cough"); (2) vaccination terms ("pertussis vaccine," "Tdap," "acellular pertussis vaccine"); (3) population-specific terms ("healthcare workers," "HCW," "hospital staff"); and (4) policy-related terms ("vaccination policy," "immunization guidelines," "outbreak management"). Boolean operators (AND, OR) were applied to construct comprehensive search strings (Bramer et al., 2017). The search was supplemented by backward and forward citation tracking and examination of grey literature from key health organizations, including the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), UK Health Security Agency (UKHSA), and the Malaysian Ministry of Health (Adams et al., 2016; Paez, 2017). Articles were selected based on relevance to HCW pertussis vaccination policies, outbreak evidence, barriers to vaccination, and implementation strategies, with priority given to peer-reviewed studies, clinical guidelines, and policy documents from high-income countries with established HCW vaccination programs.

Two independent reviewers screened titles, abstracts, and full texts using predefined inclusion criteria: studies addressing pertussis epidemiology, vaccine efficacy, outbreak management in healthcare settings, or vaccination policies, with particular focus on Southeast Asia and Malaysia. We excluded case reports, non-English publications without available translations, and studies that were not relevant to healthcare worker vaccination or pertussis control policies. Discrepancies were resolved through discussion or adjudication by a third reviewer. The search identified 1,432 articles; after duplicate removal, 992 remained. Title and abstract screening excluded 823 articles, and full-text review excluded an additional 99 articles. In total, 56 articles were included in the narrative synthesis. Data were synthesized thematically to examine pertussis transmission in healthcare settings, HCW vaccination coverage and effectiveness, barriers to implementation, and cost-effectiveness evidence (Baethge et al., 2019).

RESULTS

Nosocomial Pertussis: Outbreak Evidence and Healthcare Worker Susceptibility

The epidemiological landscape of pertussis has shifted dramatically in recent decades. While infants have historically been the primary affected demographic, adults—particularly healthcare workers and family caregivers—have emerged as critical sources of infection due to waning immunity and atypical clinical presentations (Cherry, 2012). This epidemiological shift has transformed healthcare facilities into potential outbreak epicenters, with documented nosocomial pertussis epidemics resulting in substantial morbidity among vulnerable patient

populations, significant operational disruption, and considerable financial burden for healthcare institutions (Calugar et al., 2006; Yasmin et al., 2014).

Multiple documented outbreaks demonstrate the profound impact of nosocomial pertussis transmission. A neonatal intensive care unit outbreak in Louisville, Kentucky, exposed 72 infant patients and 72 healthcare workers, requiring extensive antibiotic prophylaxis and resulting in four confirmed HCW cases with cough illness duration ranging from 11 to 25 days before identification (Bryant et al., 2006). An Arizona NICU outbreak involved 15 confirmed pertussis cases (5 infants and 10 healthcare professionals) (Yasmin et al., 2014). In a haematology-oncology unit, 10 of 117 employees (8.5%) developed pertussis after exposure to a single infected healthcare worker, although prompt isolation measures prevented patient-to-patient transmission (Boulay et al., 2006). A French hospital outbreak documented transmission from an infected HCW to colleagues who subsequently infected two immunosuppressed patients, highlighting the vulnerability of high-risk populations (Bassinet et al., 2004). These outbreaks consistently demonstrate that HCWs with prolonged unrecognized cough illness serve as primary transmission sources, with diagnostic delays averaging 11-25 days contributing to extensive exposure of vulnerable patient populations (Bryant et al., 2006; Pascual et al., 2006).

Seroprevalence studies reveal substantial susceptibility among healthcare workers worldwide. In Spain, de Juanes et al. (2004) found 51.7% seroprevalence among HCWs during routine health examinations at a Madrid university hospital, with similar findings (51.7%) reported by Urbiztondo et al. (2015) in Catalonia. Asian studies report comparable or lower rates: Higa et al. (2008) reported 43.8% IgG-PT antibody positivity among Japanese university hospital personnel, whereas Choi et al. (2018) reported 33.7% prevalence at a Korean institution. A systematic review of annual pertussis incidence among HCWs reported rates of 1.3% among resident physicians and 3.6% among emergency department staff—significantly higher than those for most other vaccine-preventable diseases targeted for HCW vaccination (Wright et al., 1999). These data collectively demonstrate that a substantial proportion of healthcare workers lack protective immunity against pertussis, creating ongoing risk for nosocomial transmission to vulnerable patients, including neonates, immunocompromised individuals, and those too young for complete vaccination.

Healthcare Worker Pertussis Vaccination Policies: International Comparison

HCWs are at increased risk of contracting vaccine-preventable diseases, including pertussis, due to occupational exposure to infected patients and may serve as potential sources of nosocomial transmission, particularly to vulnerable patients who are immunocompromised, too young for vaccination, or unable to mount adequate immune responses (Kretsinger et al., 2006). The tetanus, diphtheria, and acellular pertussis (Tdap) vaccine, licensed in 1991, is approved for adolescents and adults (aged 11–64 years in the U.S.) and has demonstrated 92% efficacy against culture- or PCR-confirmed pertussis within 2.5 years of vaccination (Kretsinger et al., 2006).

Globally, policies regarding HCW pertussis vaccination vary considerably. The Global Pertussis Initiative (GPI) and the International Consensus Group on Pertussis Immunisation recommend replacing routine tetanus-diphtheria (Td) boosters with Tdap for all adults, prioritising HCWs, parents, and childcare workers (Campins-Martí et al., 2001). In the United States, since February 2006, the CDC's Advisory Committee on Immunisation Practices (ACIP) designated HCWs as a priority group for Tdap vaccination, recommending a single dose for all

healthcare personnel with direct patient contact, regardless of interval since last tetanus-containing vaccine (Kretsinger et al., 2006). Whereas in the United Kingdom, the Joint Committee on Vaccination and Immunisation (JCVI) advised in 2016 that HCWs with direct contact with vulnerable patients (pregnant women and/or infants) are priority groups for immunisation. From July 2019, following an improvement in vaccine supply, occupational pertussis vaccination became available for HCWs who have not received a pertussis-containing vaccine in the last 5 years and have regular contact with pregnant women or young infants under 3 months of age (UK Health Security Agency [UKHSA], 2024). In Australia, the Australian Immunisation Handbook recommends that all healthcare workers receive the dTpa vaccine every 10 years, given the significant risk of transmitting pertussis to vulnerable patients and the waning of vaccine immunity (Australian Government Department of Health and Aged Care, 2023). This recommendation is incorporated into occupational health policies across Australian states and territories. In Canada, healthcare workers are recommended to receive Tdap vaccination as part of occupational health programs, with provincial policies varying in implementation details but uniformly aligned to protect vulnerable patient populations, particularly infants (Public Health Agency of Canada, 2018).

Malaysia's Pertussis Vaccination Programme and Policy Gaps

Malaysia incorporated pertussis vaccination into its National Immunization Programme (NIP) in 1976, protecting infants and children through doses administered at 2, 3, and 5 months of age, with a booster at 18 months In 2020, the vaccine formulation was updated from pentavalent Pentaxim to hexavalent Hexaxim, maintaining the acellular pertussis component while protecting against additional diseases (Aljunid et al., 2022). However, unlike several developed nations with comprehensive adult pertussis vaccination guidelines, Malaysia currently lacks official recommendations for adult immunization, particularly for high-risk groups such as HCWs. Malaysia's Ministry of Health has yet to implement a national vaccination policy for HCWs against pertussis despite documented disease burden and nosocomial transmission risks (Nguyen et al., 2025). A multi-country study demonstrated that pertussis remains under-recognized as a substantial disease burden among adults in Asia, including Malaysia. In Malaysia, Taiwan, and Thailand, approximately 5% of adult patients presenting with a cough lasting at least two weeks had serological evidence of pertussis infection.

In contrast, more than two-thirds lacked immunity (Koh et al., 2016). However, a 2021 study in Sabah and Sarawak found that 86.9% of HCWs were willing to receive the vaccine if officially recommended (Michal et al., 2021), suggesting high acceptability should a policy be introduced. This presents a significant opportunity for Malaysia to leverage existing HCW support to establish comprehensive vaccination guidelines aligned with international best practices.

Economic Burden and Cost-Effectiveness of Healthcare Worker Vaccination

The financial impact of nosocomial pertussis outbreaks is substantial, with documented costs ranging from $6,500 per case in neonatal units to $43,893 per case in general hospitals (Baggett et al., 2007; Yasmin et al., 2014). Major expenditures include post-exposure prophylaxis, workforce furloughs, contact tracing, diagnostic testing, and infection control measures, with single outbreaks exceeding $260,000 (Calugar et al., 2006; Leekha et al., 2009). Preventive HCW immunisation demonstrates strong cost-effectiveness. Economic modelling indicates that Tdap vaccination could reduce pertussis incidence by more than 46% annually, yielding net savings of $2.38 per dollar invested (Sandora et al., 2008). Hospitals that implement mandatory

vaccination policies report fewer outbreaks and lower containment costs than those that use voluntary programs (Zhang et al., 2011).

DISCUSSION

Barriers and Strategies for Healthcare Worker Pertussis Vaccination

Despite recommendations for Tdap (tetanus, diphtheria, and acellular pertussis) vaccination, HCW immunization rates remain suboptimal globally due to multiple interconnected barriers. At the individual level, vaccine hesitancy persists due to concerns about side effects, perceived low risk, and misconceptions about vaccine safety (Fortunato et al., 2015; Yaqub et al., 2014). Recent evidence indicates that low awareness of adult pertussis burden and insufficient recognition of HCWs' role in nosocomial transmission contribute to low prioritization (Kardos et al., 2024; MacIntyre et al., 2024). Unlike influenza, pertussis is not consistently recognized as an occupational hazard, which can lead to complacency, particularly among HCWs not working directly with neonates (Weber & Rutala, 1998; Sandora et al., 2008). (Weber & Rutala, 1998; Sandora et al., 2008). At the institutional level, logistical and financial barriers impede uptake. Many healthcare facilities do not provide free on-site vaccinations, forcing HCWs to seek immunization externally, which substantially reduces uptake (Maltezou et al., 2014; See, 2025). Time constraints, particularly among shift workers, further limit vaccination opportunities (MacIntyre et al., 2024). Additionally, poor surveillance and reporting of HCW vaccination coverage obscure gaps and prevent targeted interventions (Regan, 2025).

Successful intervention strategies fall into three key categories. **Access interventions** include providing free on-site vaccination during working hours, mobile vaccination teams visiting different departments, extended clinic hours for shift workers, and walk-in availability. **Educational and promotional strategies** comprise targeted education addressing misconceptions, leadership modelling through visible vaccination of institutional leaders, active offers during onboarding, and campaigns communicating disease risk and vaccine benefits (de Koning et al, 2024). **Systems-level approaches** involve standing orders authorizing vaccination without physician approval, provider reminder systems, departmental audit and feedback on vaccination rates, and routine surveillance with public reporting to identify low-coverage areas requiring intervention (Wennekes et al., 2024). Evidence consistently demonstrates that multicomponent interventions that combine elements from multiple categories achieve superior outcomes than single-strategy approaches (Clari et al., 2024).

Policy Implications and Recommendations for Malaysia

The evidence reviewed has direct implications for Malaysia's pertussis control strategy. Malaysia currently lacks a national policy on adult pertussis vaccination, including specific recommendations for HCWs, despite documented pertussis burden and high HCW willingness (86.9%) to be vaccinated if officially recommended (Michal et al., 2021). Based on international best practices and evidence from implementation science, we propose the following actionable recommendations. First, the Malaysian Ministry of Health should establish a national policy recommending Tdap vaccination for all HCWs, with priority for those in neonatal, paediatric, and maternity settings. The policy should specify a single Tdap dose for HCWs without prior adult pertussis vaccination and include Tdap in pre-employment health screening. Second, healthcare institutions should implement employer-funded, on-site vaccination programmes led by occupational health units. These should provide free vaccinations during routine

occupational health visits and at employee onboarding, establish mobile clinics that accommodate all shifts, and eliminate out-of-pocket costs for HCWs (Maltezou et al., 2014). Third, pertussis vaccination training should be integrated into mandatory Continuing Medical Education and Continuing Professional Development requirements, emphasizing HCWs' role in preventing nosocomial transmission and addressing safety misconceptions through peer-led educational sessions (Choi et al., 2022). Fourth, Malaysia should establish systematic monitoring by requiring healthcare facilities to report HCW Tdap vaccination coverage annually to the Ministry of Health, with a target of 80% within two years and a linkage to hospital accreditation standards (Regan, 2025). Fifth, implementation should leverage existing National Immunization Programme infrastructure for vaccine procurement and distribution and collaborate with ASEAN countries—particularly Thailand and Singapore—to share best practices and harmonize approaches (Nguyen et al., 2025). Finally, a phased implementation approach is recommended: pilot programmes in selected tertiary hospitals with high neonatal and paediatric caseloads; expansion to all tertiary and selected secondary hospitals; and nationwide coverage, with impact evaluation. This approach allows iterative learning, stakeholder engagement, and resource mobilization while demonstrating feasibility. Improving HCW pertussis vaccination in Malaysia has broader implications beyond direct protection. HCWs serve as role models for vaccination behaviour, their vaccination reduces healthcare system disruptions from outbreaks, and the infrastructure developed can be leveraged for other adult vaccines and high-risk groups (Choi et al., 2022). Establishing a successful HCW pertussis vaccination programme represents a strategic investment in strengthening Malaysia's broader adult immunization system.

Limitations and Future Research

This review has limitations, including the narrative (non-systematic) approach, limited country-specific policy data for middle-income settings, scarcity of cost-effectiveness analyses applicable to Malaysia, and potential underreporting of nosocomial pertussis cases in Malaysian facilities. Future research should establish HCW seroprevalence baselines, conduct Malaysia-specific cost-effectiveness analyses, implement and evaluate pilot vaccination programmes, strengthen nosocomial surveillance, and explore HCWs' perceptions to inform culturally appropriate interventions. Regional ASEAN collaboration could accelerate evidence generation and implementation.

CONCLUSION

This narrative review examined healthcare worker pertussis vaccination policies globally and revealed a critical gap in Malaysia's approach. While high-income countries have established comprehensive HCW vaccination policies that successfully reduced nosocomial outbreaks, Malaysia lacks formal national guidelines despite documented disease burden and high HCW willingness to be vaccinated. Three key findings emerge: healthcare workers face elevated occupational risk and serve as documented sources of outbreaks affecting vulnerable patients; low vaccination rates stem from limited awareness, complacency, inadequate workplace access, and the absence of monitoring systems; and multicomponent interventions combining on-site vaccination, targeted education, and surveillance achieve superior, cost-effective outcomes. Malaysia's opportunity is clear—with 86.9% of HCWs willing to accept Tdap if officially recommended, decisive policy action can protect vulnerable patients, strengthen the adult immunisation system, and position Malaysia as a regional leader in healthcare worker vaccination within ASEAN.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

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REFERENCES

Adams, J., Hillier-Brown, F. C., Moore, H. J., Lake, A. A., Araujo-Soares, V., White, M., & Summerbell, C. (2016). Searching and synthesising "grey literature" and "grey information" in public health: Critical reflections on three case studies. *Systematic Reviews*, *5*(1), 164. https://doi.org/10.1186/s13643-016-0337-y

Aljunid, S. M., Al Bashir, L., Ismail, A. B., Rashid, S. A. Z. A., Zafar, A., Aziz, A. F. A., Amrizal, M. N., Lim, K. S., Abdullah, N., Ghazali, N. A. B., Jamaluddin, R., & Azzeri, A. (2022). Economic impact of switching from partially combined vaccine "Pentaxim® and hepatitis B" to fully combined vaccine "Hexaxim®" in the Malaysian National Immunization Program. *BMC Health Services Research*, *22*(1), 34. https://link.springer.com/article/10.1186/s12913-021-07428-7

Baethge, C., Goldbeck-Wood, S., & Mertens, S. (2019). SANRA-a scale for the quality assessment of narrative review articles. *Research Integrity and Peer Review*, *4*, 5. https://doi.org/10.1186/s41073-019-0064-8

Baggett, H. C., Duchin, J. S., Shelton, W., Zerr, D. M., Heath, J., Ortega-Sanchez, I. R., & Tiwari, T. (2007). Two nosocomial pertussis outbreaks and their associated costs—King County, Washington, 2004. *Infection Control and Hospital Epidemiology*, *28*(5), 537–543. https://doi.org/10.1086/513497

Bassinet, L., Matrat, M., Njamkepo, E., Aberrane, S., Housset, B., & Guiso, N. (2004). Nosocomial pertussis outbreak among adult patients and healthcare workers. *Infection Control and Hospital Epidemiology*, *25*(11), 995–997. https://doi.org/10.1086/502332

Boulay, B. R., Murray, C. J., Ptak, J., Kirkland, K. B., Montero, J., & Talbot, E. A. (2006). An outbreak of pertussis in a hematology-oncology care unit: Implications for adult vaccination policy. *Infection Control and Hospital Epidemiology*, *27*(1), 92–95. https://doi.org/10.1086/500420

Bramer, W. M., Rethlefsen, M. L., Kleijnen, J., & Franco, O. H. (2017). Optimal database combinations for literature searches in systematic reviews: A prospective exploratory study. *Systematic Reviews*, *6*(1), 245. https://doi.org/10.1186/s13643-017-0644-y

Bryant, K. A., Humbaugh, K., Brothers, K., Wright, J., Pascual, F. B., Moran, J., & Murphy, T. V. (2006). Measures to control an outbreak of pertussis in a neonatal intermediate care nursery after exposure to a healthcare worker. *Infection Control and Hospital Epidemiology*, *27*(6), 541–545. https://doi.org/10.1086/505666

Calugar, A., Ortega-Sánchez, I. R., Tiwari, T., Oakes, L., Jahre, J. A., & Murphy, T. V. (2006). Nosocomial Pertussis: Costs of an Outbreak and Benefits of Vaccinating Health Care Workers. *Clinical Infectious Diseases*, *42*(7), 981–988. https://doi.org/10.1086/500321

Campins-Martí, M., Cheng, H. K., Forsyth, K., Guiso, N., Halperin, S., Huang, L. M., Mertsola, J., Oselka, G., Ward, J., Wirsing von König, C. H., Zepp, F., & International Consensus Group on Pertussis Immunisation. (2001). Recommendations are needed for adolescent and adult pertussis immunisation: Rationale and strategies for consideration. *Vaccine*, *20*(5–6), 641–646. https://doi.org/10.1016/s0264-410x(01)00393-0

Cherry, J. D. (2012). Epidemic Pertussis in 2012—The Resurgence of a Vaccine-Preventable Disease. *New England Journal of Medicine*, *367*(9), 785–787. https://doi.org/10.1056/NEJMp1209051

Choi, J.-H., Correia de Sousa, J., Fletcher, M., Gabutti, G., Harrington, L., Holden, M., Kim, H., Michel, J.-P., Mukherjee, P., Nolan, T., Welte, T., & Maggi, S. (2022). Improving vaccination rates in older adults and at-risk groups: Focus on pertussis. *Aging Clinical and Experimental Research*, *34*(1), 1–8. https://doi.org/10.1007/s40520-021-02018-3

Choi, W. S., Kim, S. H., & Park, D. W. (2018). Seroprevalence of Pertussis in Healthcare Workers without Adult Pertussis Vaccine Use at a University Hospital in Korea. *Journal of Korean Medical Science*, *33*(50). https://doi.org/10.3346/jkms.2018.33.e321

Clari, M., Albanesi, B., Comoretto, R. I., Conti, A., Renzi, E., Luciani, M., Ausili, D., Massimi, A., & Dimonte, V. (2024). Effectiveness of interventions to increase healthcare workers' adherence to vaccination against vaccine-preventable diseases: A systematic review and meta-analysis, 1993 to 2022. *Euro Surveillance: Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin*, *29*(9), 2300276. https://doi.org/10.2807/1560-7917.ES.2024.29.9.2300276

Dede Juanes, J.-R., Gil, A., González, A., Arrazola, M.-P., San-Martín, M., & Esteban, J. (2004). Seroprevalence of pertussis antibody among health care personnel in Spain. *European Journal of Epidemiology*, *19*(1), 69–72. https://doi.org/10.1023/b:ejep.0000013270.63515.e6

De Koning, R., Gonzalez Utrilla, M., Spanaus, E., Moore, M., & Lomazzi, M. (2024). Strategies used to improve vaccine uptake among healthcare providers: A systematic review. *Vaccine: X*, *19*, 100519. https://doi.org/10.1016/j.jvacx.2024.100519

Domenech de Cellès, M., Magpantay, F. M. G., King, A. A., & Rohani, P. (2016). The pertussis enigma: Reconciling epidemiology, immunology and evolution. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1822), 20152309. https://doi.org/10.1098/rspb.2015.2309

Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing*, *24*(4), 230–235. https://doi.org/10.1179/2047480615Z.000000000329

Fortunato, F., Tafuri, S., Cozza, V., Martinelli, D., & Prato, R. (2015). Low vaccination coverage among italian healthcare workers in 2013. *Human Vaccines & Immunotherapeutics*, *11*(1), 133–139. https://doi.org/10.4161/hv.34415

Gabutti, G., Conforti, G., Tomasi, A., Kuhdari, P., Castiglia, P., Prato, R., Memmini, S., Azzari, C., Rosati, G. V., & Bonanni, P. (2016). Why, when and for what diseases pregnant and new mothers "should" be vaccinated. *Human Vaccines & Immunotherapeutics*, *13*(2), 283–290. https://doi.org/10.1080/21645515.2017.1264773

Greenhalgh, T., Thorne, S., & Malterud, K. (2018). Time to challenge the spurious hierarchy of systematic over narrative reviews? *European Journal of Clinical Investigation*, *48*(6), e12931. https://doi.org/10.1111/eci.12931

Healthcare workers are recommended to receive pertussis-containing vaccine every 10 years | The Australian Immunisation Handbook. (2023, June 30). https://immunisationhandbook.health.gov.au/recommendations/healthcare-workers-are-recommended-to-receive-pertussis-containing-vaccine-every-10-years

Higa, F., Haranaga, S., Tateyama, M., Hibiya, K., Yamashiro, T., Nakamatsu, M., Tomoyose, T., Nagahama, M., Okamura, T., Owan, T., Kuda, T., Kinjo, F., & Fujita, J. (2008). Assessment of serum anti-Bordetella pertussis antibody titers among medical staff members. *Japanese Journal of Infectious Diseases*, *61*(5), 371–374. https://www.jstage.jst.go.jp/article/yoken/61/5/61_JJID.2008.371/_pdf

Kardos, P., Correia de Sousa, J., Heininger, U., Konstantopoulos, A., MacIntyre, C. R., Middleton, D., Nolan, T., Papi, A., Rendon, A., Rizzo, A., Sampson, K., Sette, A., Sobczyk, E., Tan, T., Weil-Olivier, C., Weinberger, B., Wilkinson, T., & Wirsing von König, C. H. (2024). Understanding the impact of adult pertussis and current approaches to vaccination: A narrative review and expert panel recommendations. *Human Vaccines & Immunotherapeutics*, *20*(1), 2324547. https://doi.org/10.1080/21645515.2024.2324547

Koh, M. T., Liu, C.-S., Chiu, C.-H., Boonsawat, W., Watanaveeradej, V., Abdullah, N., Zhang, X. H., Devadiga, R., & Chen, J. (2016). Under-recognized pertussis in adults from Asian countries: A cross-sectional seroprevalence study in Malaysia, Taiwan and Thailand. *Epidemiology and Infection*, *144*(6), 1192–1200. https://doi.org/10.1017/S0950268815002393

Kretsinger, K., Broder, K. R., Cortese, M. M., Joyce, M. P., Ortega-Sanchez, I., Lee, G. M., Tiwari, T., Cohn, A. C., Slade, B. A., Iskander, J. K., Mijalski, C. M., Brown, K. H., Murphy, T. V., Centers for Disease Control and Prevention, Advisory Committee on Immunization Practices, & Healthcare Infection Control Practices Advisory Committee. (2006). Preventing tetanus, diphtheria, and pertussis among adults: Use of tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine recommendations of the Advisory Committee on Immunization Practices (ACIP) and recommendation of ACIP, supported by the Healthcare Infection Control Practices Advisory Committee (HICPAC), for use of Tdap among health-care personnel. *MMWR. Recommendations and Reports: Morbidity and Mortality Weekly Report. Recommendations and Reports*, *55*(RR-17), 1–37. https://www.cdc.gov/mmwr/pdf/rr/rr5503.pdf

Leekha, S., Thompson, R. L., & Sampathkumar, P. (2009). Epidemiology and control of pertussis outbreaks in a tertiary care center and the resource consumption associated with these outbreaks. *Infection Control and Hospital Epidemiology*, *30*(5), 467–473. https://doi.org/10.1086/596774

MacIntyre, C. R., de Sousa, J. C., Heininger, U., Kardos, P., Konstantopoulos, A., Middleton, D., Nolan, T., Papi, A., Rendon, A., Rizzo, A., Sampson, K., Sette, A., Sobczyk, E., Tan, T., Weil-Olivier, C., Weinberger, B., Wilkinson, T., & von König, C. H. W. (2024). Public health management of pertussis in adults: Practical challenges and future strategies. *Human Vaccines & Immunotherapeutics*, *20*(1), 2377904. https://doi.org/10.1080/21645515.2024.2377904

Maltezou, H. C., & Poland, G. A. (2014). Vaccination policies for healthcare workers in Europe. *Vaccine*, *32*(38), 4876-4880. https://doi.org/10.1016/j.vaccine.2013.10.046

Michal, C. S., & Stephen, J. (2021). Risk perceptions and acceptance towards the uptake of pertussis vaccine amongst the healthcare workers in Sabah and Sarawak. *Malaysian Journal of Medicine and Health Sciences*, *17*(1), 124-132. https://medic.upm.edu.my/upload/dokumen/2020123014462518_MJMHS_0449.pdf

Mohamed, T. J., Fong, S. M., Nadarajaw, T., Choo, C. M., Yusoff, N. K. N., Nachiappan, J. P., Chan, K. C., Koh, M. T., Amran, F., Hashim, R., Jabar, K. A., Teh, C. S. J., Macina, D., & Ibrahim, H. M. (2022). Burden of pertussis among young infants in Malaysia: A hospital-based surveillance study. *Vaccine*, *40*(35), 5241–5247. https://doi.org/10.1016/j.vaccine.2022.07.019

Mohan, A., Tan, Y.-Y., Hashim, R., Ng, D. C.-E., Wong, V. H.-S., Liew, D.-W., Chien, S.-L., Tan, L.-S., Lau, P. S.-T., Rajandran, T., Podin, Y., & Ooi, M.-H. (2024). Incidence and severity of pertussis among hospitalized infants, Sarawak, Malaysia, 2015-2021. *Journal of Infection in Developing Countries*, *18*(9), 1394–1403. https://doi.org/10.3855/jidc.18837

Nguyen, P. N. T., Heininger, U., Muloiwa, R., von König, C. H. W., Hozbor, D., Ong-Lim, A., Tan, T. Q., & Forsyth, K. (2025). Pertussis in Southeast Asia: Country-level burden and recommendations from the Global Pertussis Initiative. *IJID Regions*, *14*, 100559. https://doi.org/10.1016/j.ijregi.2024.100559

Paez, A. (2017). Gray literature: An important resource in systematic reviews. *Journal of Evidence-Based Medicine*, *10*(3), 233–240. https://doi.org/10.1111/jebm.12266

Pascual, F. B., McCall, C. L., McMurtray, A., Payton, T., Smith, F., & Bisgard, K. M. (2006). Outbreak of pertussis among healthcare workers in a hospital surgical unit. *Infection Control and Hospital Epidemiology*, *27*(6), 546–552. https://doi.org/10.1086/506232

Pertussis: Occupational vaccination of healthcare workers. (2024, August 15). GOV.UK. https://www.gov.uk/government/publications/pertussis-occupational-vaccination-of-health-care-workers

Pertussis (whooping cough) | The Australian Immunisation Handbook. (2025, October 24). https://immunisationhandbook.health.gov.au/contents/vaccine-preventable-diseases/pertussis-whooping-cough

Public Health Agency of Canada. (2025). Immunization of workers: Canadian Immunization Guide. Government of Canada. https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-immunization-guide-part-3-vaccination-specific-populations/page-11-immunization-workers.html

Regan, A. K. (2025). Challenges associated with pertussis detection, monitoring, and vaccination in adults. *Expert Review of Anti-Infective Therapy*, *23*(8), 639–650. https://doi.org/10.1080/14787210.2025.2516556

Sandora, T. J., Gidengil, C. A., & Lee, G. M. (2008). Pertussis Vaccination for Health Care Workers. *Clinical Microbiology Reviews*, *21*(3), 426–434. https://doi.org/10.1128/CMR.00003-08

See, K. C. (2025). Pertussis vaccination for adults: An updated guide for clinicians. Vaccines, 13(1), 60—Google Search. (n.d.). Retrieved December 21, 2025, from https://www.mdpi.com/2076-393X/13/1/60

Urbiztondo, L., Broner, S., Costa, J., Rocamora, L., Bayas, J. M., Campins, M., Esteve, M., Borras, E., Domínguez, A., & For the Study of The Immune Status In Health Care, T. W. G. (2015). Seroprevalence study of B. pertussis infection in health care workers in Catalonia, Spain. *Human Vaccines & Immunotherapeutics*, *11*(1), 293–297. https://doi.org/10.4161/hv.36167

Vaccination policies for healthcare workers in Europe—PubMed. (n.d.). Retrieved December 21, 2025, from https://pubmed.ncbi.nlm.nih.gov/24161573/

Wanlapakorn, N. (2023). *Immunity to pertussis vaccination* [Doctoral dissertation, Chulalongkorn University]. Chulalongkorn University Digital Repository. https://doi.org/10.58837/chula.the.2018.29

Weber, D. J., & Rutala, W. A. (1998). Pertussis: An underappreciated risk for nosocomial outbreaks. *Infection Control and Hospital Epidemiology*, *19*(11), 825-828. https://doi.org/10.1086/647739

Wennekes, M. D., Almási, T., Eilers, R., Mezei, F., Petykó, Z. I., Timen, A., Vokó, Z., & VITAL Consortium. (2024). Effectiveness of educational interventions for healthcare workers on vaccination dialogue with older adults: A systematic review. *Archives of Public Health = Archives Belges De Sante Publique*, *82*(1), 34. https://doi.org/10.1186/s13690-024-01260-1

Whooping cough cases rise to over 10,000. (2024, August 8). GOV.UK. https://www.gov.uk/government/news/whooping-cough-cases-rise-to-over-10000

Wright, S. W., Decker, M. D., & Edwards, K. M. (1999). Incidence of pertussis infection in healthcare workers. *Infection Control and Hospital Epidemiology*, *20*(2), 120–123. https://doi.org/10.1086/501593

Yaqub, O., Castle-Clarke, S., Sevdalis, N., & Chataway, J. (2014). Attitudes to vaccination: A critical review. *Social Science & Medicine (1982)*, *112*, 1–11. https://doi.org/10.1016/j.socscimed.2014.04.018

Yasmin, S., Sunenshine, R., Bisgard, K. M., Wiedeman, C., Carrigan, A., Sylvester, T., Garcia, G., Rose, K., Wright, S., Miller, S., Huerta, R. D. L., Houser, H., D'Souza, A., Anderson, S., Howard, K., Komatsu, K., & Klein, R. (2014). Healthcare-Associated Pertussis Outbreak in Arizona: Challenges and Economic Impact, 2011. *Journal of the Pediatric Infectious Diseases Society*, *3*(1), 81–84. https://doi.org/10.1093/jpids/pis136

Yeung, K. H. T., Duclos, P., Nelson, E. A. S., & Hutubessy, R. C. W. (2017). An update of the global burden of pertussis in children younger than 5 years: A modelling study. *The Lancet. Infectious Diseases*, *17*(9), 974–980. https://doi.org/10.1016/S1473-3099(17)30390-0

Zhang, L., Prietsch, S., Axelsson, I., & Halperin, S. (2011). Acellular vaccines for preventing whooping cough in children. *Cochrane Database of Systematic Reviews (Online)*, *9*, CD001478. https://doi.org/10.1002/14651858.CD001478.pub4