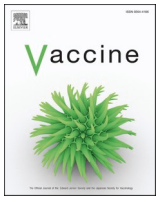
Vaccine 42 (2024) 126458

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine



Review

Exploring the delivery of adult vaccination outside of primary care settings: A mixed methods scoping review

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ARTICLE INFO

Keywords:
Vaccines
Vaccination
Secondary care
Tertiary care
Workplace

ABSTRACT

Background: There are several identified barriers to immunisation delivery and uptake in adults, including governance issues, provider limitations, and patient access. While primary care settings have traditionally been responsible for vaccine delivery, there is a growing need to look to other settings to expand the equitable uptake of vaccinations in adults.
Objectives: This scoping review aims to identify and explore the role of non-primary care settings in delivering adult vaccinations, operational barriers and facilitators to immunisation delivery in these settings, and interventions delivered to improve uptake.
Methods: This scoping review was conducted following the Joanna Briggs Institute (JBI) guidance for scoping reviews and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). Peer-reviewed studies published from 01/01/2010 to 31/12/2022 that focused on the delivery of influenza, COVID-19, pneumococcal and herpes zoster vaccines in adult populations outside of primary care settings were included. Studies were also included if they explored barriers and facilitators to delivery, and interventions to improve uptake.
Results: 75 studies were identified for inclusion. Most were quasi-experimental studies, and 58/75 were from the US. Studies were most frequently conducted in in-patient settings, outpatient clinics, nursing homes, and workplaces. Operational planning and logistics, and provider-level issues, such as poor documentation and workflow interruption were commonly identified barriers to delivery. Government funding, continuity of care, and patient convenience were frequently reported facilitators. Interventions shown to improve uptake were operational planning and clinical improvement systems (Plan-Do-Study-Act [PDSA] cycles), provider education and reminders, on-site vaccination, patient education, and financial incentives.
Conclusions: Mapping of the evidence indicates that adult immunisation delivery may be achievable across tertiary and secondary care settings, as well as non-clinical settings, such as workplaces. There are several identified barriers to delivery, predominantly at the provider-level in tertiary-care settings. Intervention such as operational planning, clinical reminders, and on-site vaccination, may facilitate uptake.

1. Introduction

The World Health Organisation (WHO) and U.S. Center for Disease Control and Prevention (CDC) provide guidelines for routine immunisationof adults against diseases such as COVID-19, influenza, pneumococcal, and herpes zoster [1,2]. Recommendations for adult immunisation are given according to age and risk factors and have been adapted by most countries [1,2]. For healthy adults, the CDC recommends influenza and COVID-19 vaccinations seasonally, and herpes zoster and pneumococcal vaccination series for adults aged 50- and 65-years of age or older respectively [1]. Yet, despite these recommendations and the availability of vaccines in most countries, global adult immunisation coverage continues to fall short [3,4].

While 194 countries reported adult immunisation programs to WHO in 2018, policies, implementation and uptake varied [3]. Between 2018 and 2022 rates of immunisation against influenza of adults older than 65 years ranged from 86 % to as low as 6 % among reporting countries [4]. Among people with chronic disease, influenza vaccination coverage

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https://doi.org/10.1016/j.vaccine.2024.126458
Received 22 April 2024; Received in revised form 12 October 2024; Accepted 12 October 2024
Available online 29 October 2024

in most countries is shown to be lower than 42 % [5]. There is likely to be significant under-reporting of global adult immunisation rates, compared to childhood vaccinations, due to the lack of immunisation information systems for adults [3]. Adult, like childhood vaccinations, are predominantly delivered through primary care and several barriers to the uptake and maintenance of adult immunisation include lack of knowledge of recommended vaccines, lack of provider recommendation for vaccination, poor access to health care, cost, and racial and ethnic disparities [6]. Furthermore, there are several operational challenges to the delivery of immunisation programs, such as supply consistency, cold chain logistics, cost of program delivery, stock control, ensuring appropriate clinical infrastructure equipped for safe vaccine practices, and minimising wasted doses of multidose vial vaccines [7,8].

Given the ongoing challenges with vaccine coverage among adults, there is growing evidence for the need to look beyond primary care settings such as general practice and community pharmacy to expand access and equitable uptake of vaccinations in adult populations [6]. A 2019 review by Bach et.al, addressing barriers to adult immunisation, highlighted the potential benefits of utilising non-primary care vaccination settings, such as workplaces and drive-through clinics, in improving adult access to vaccines [6]. Their review noted that outside of physicians' offices, the workplace was a common site for adult vaccination, with studies reporting up to one-third of 18- to 49-year-old patients received their influenza vaccine at work [6]. While there are existing reviews exploring the delivery of adult vaccinations in specific non-traditional settings, such as hospitals [9], or in improving the uptake of certain vaccines such as the influenza [10], there remains a lack of evidence synthesis of adult vaccination outside of primary care settings as a whole. As the number of adulthood immunisation programs and studies in non-primary care settings continue to grow there is a need to map the available evidence, which can be rapidly achieved via a scoping review.

The objectives of this scoping review are to:

1. Identify and explore the roles of non-primary care settings in the delivery of adult immunisation programs, mapping the available evidence according to setting type
2. Map the evidence identifying operational barriers and facilitators to immunisation delivery in these settings, and
3. Scope existing research on interventions delivered in this context to improve vaccine uptake, and map the evidence according to intervention type

2. Methods

This scoping review was conducted in accordance with the Joanna Briggs Institute (JBI) guidance for scoping reviews [11], and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist [12]. The completed checklist for this scoping review is included in the supplementary data as Supplemental Table 1. A protocol for this scoping review (Supplement 2) was not pre-registered.

2.1. Eligibility criteria

The eligibility criteria for this scoping review are summarised in Supplemental Table 3.

2.2. Population

Studies involving adults over 18 years were included in the review. Those primarily reporting on children and adolescents under 18 years were excluded. Due to additional immunisation requirements, studies focusing on pregnant women and healthcare workers receiving vaccination for occupational risk were additionally excluded.

2.3. Context

Although definitions of primary, secondary and tertiary care settings can vary between countries, the current Australian healthcare system model was followed for this review [13]. Primary care settings were defined as general practice clinics, community health centres and community pharmacies; secondary care settings as specialist clinics, outpatient clinics, nursing homes and long-term care facilities; and tertiary care as hospital settings, including emergency departments and day surgery clinics [13]. Studies in non-primary care settings were included in the review and those in primary care settings excluded. Studies in non-clinical settings such as workplaces, homeless shelters, and polling booths were also included. Special immunisation programs undertaken for humanitarian purposes were considered outside of scope of this study.

2.4. Concepts

Three concepts were investigated in this scoping review:

1. Vaccine delivery.

Studies reporting on the delivery of influenza, COVID-19, pneumococcal and herpes zoster vaccinations outside of primary care settings were included in the review. These vaccines were selected for inclusion as they are recommended as part of routine adult vaccination programs for older and immunocompromised adults. Studies with a focus on other vaccines were excluded.

2. Barriers and facilitators.

Studies investigating system and operational barriers and facilitators to adult immunisation delivery outside of primary care settings were included. Operational barriers were defined as organisational, logistical, financial, and physical barriers to immunisation delivery, or as otherwise identified by the literature search. Barriers and facilitators at facility, provider, and patient levels were included. Studies focusing on provider and patient attitudes and perceptions towards immunisation delivery outside of primary care settings were excluded from this scoping review, due to a significant stand-alone body of evidence on the topic, which the authors felt was more appropriate to explore in a second scoping review. Furthermore, data on individual patient characteristics, such as race, age, and medical status, were not extracted.

3. Interventions.

Studies reporting interventions to increase adult immunisation uptake in non-primary care settings were included. Interventions were defined as implementation strategies, governance, financial, and delivery arrangements in accordance with Cochrane Effective Practice and Organisation of Care (EPOC) taxonomy [14]. Interventions delivered at facility, provider, and patient levels were included in the review.

2.5. Study characteristics

Published, peer-reviewed primary studies were included in this scoping review, including randomised control trials, non-randomised trials, observational studies (cohort studies, cross-sectional studies), quasi-experimental studies (quality improvement projects, uncontrolled pre- and post- test designs, experimental designs), chart reviews, case studies, and modelling studies. Review articles, editorials, opinion pieces, non-full text articles (abstracts, conference posters) and grey literature were excluded.

Studies published in English from 1/1/2010 to 31/12/2022 were included.

2.5.1. Information sources and search strategy

Systematic searches of PubMed (MEDLINE), Embase (Ovid), CINAHL (EBSCO), ProQuest, Web of Science (Scopus), and Cochrane Central Register of Controlled Trials (CENTRAL) were conducted from August to September 2023. The primary search was completed by EL and was peer-reviewed by a librarian, HJ. The primary search was supplemented

by hand searching, scanning the reference list of retrieved articles, and a secondary search by a librarian, CD. Supplemental Table 4 maps the keywords and subject headings used according to the PCC criteria of this scoping review, presented in PubMed format. The full search strategy for each database is further provided in Supplemental Table 5.

2.5.2. Selection of sources of evidence

EL was primarily responsible for screening the titles and abstracts of studies identified through the database search, with clarification and oversight provided by HS. The web-based software Rayyan (https://www.rayyan.ai/) was used to screen articles according to the eligibility criteria. Discrepancies were resolved at regular meetings between EL and HS. The full text of potentially included articles was assessed by EL and reasons for exclusion documented (Fig. 1).

2.5.3. Data extraction and charting

EL extracted the data for the included articles according to the data extraction chart and accompanying guidance form in Supplemental Table 6, with review provided by HS.

2.5.4. Data synthesis

After data extraction, each study was assigned tags according to setting, vaccination type, barriers, facilitators, and intervention type. Interventions were further categorised as successful or unsuccessful, according to study results. Statistical significance was noted. Interventions, barriers, and facilitators were organised depending on their relevance level (facility, provider, or patient), and the settings in which they were reported (tertiary care, secondary care, other setting). This iterative process was continually adapted as information was extracted from included articles.

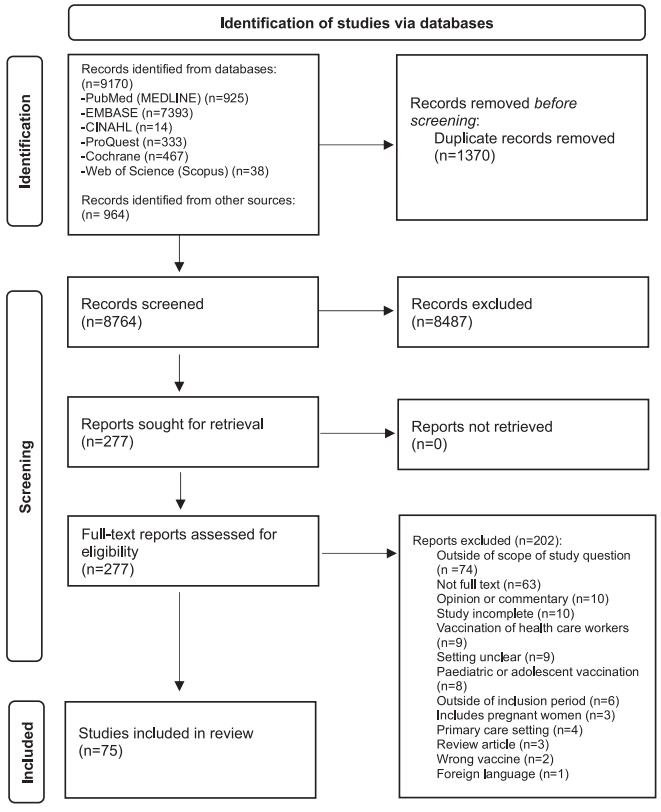

Fig. 1. Flowchart of study identification, screening, and inclusion (PRISMA 2020 V1).

3. Results

The database search results are shown in Fig. 1. 9170 studies were retrieved from the primary database search, and 964 studies were retrieved from supplementary searching (hand search, reference list scanning, secondary librarian search). 1370 duplicate records were removed before screening. The title and abstract of 8764 studies were screened, and 8487 studies were excluded in accordance with the predefined eligibility criteria. 277 studies were sought for full text retrieval and reviewed for eligibility. Of these, a further 202 studies were excluded. Reasons for exclusion included the study focus being outside of scope of research question (such as focus on immunogenicity of vaccine, or comparing different vaccine types, $n = 74$), not full text paper (conference poster or abstract, $n = 63$), opinion or commentary piece ($n = 10$), study or trial incomplete (n = 10), vaccination setting unclear ($n = 9$), primary focus on vaccination of health-care workers (n = 9) or paediatric and adolescent vaccination ($n = 8$), outside of inclusion period (n = 6), primary care setting ($n = 4$), include pregnant women ($n = 3$), review article (n = 3), wrong vaccine of focus ($n = 2$), and foreign language ($n = 1$). 75 studies were eligible for final inclusion in the review. Supplemental Table 7 lists the articles included after full text assessment, including study characteristics, relevance to review, and findings.

3.1. Study characteristics

The characteristics of the included studies are summarised by frequency in Supplemental Table 8. Of the 75 studies, 29 were quasi-experimental studies [15–43], 13 were retrospective cohort studies [44–56], nine were prospective cohort studies [57–65], five were retrospective chart reviews [66–70], five were cross-sectional studies [71–75], four were cost-modelling studies [76–79], four were experience reports [80–83], two were randomised control trials [84,85], and there was one of each longitudinal cohort study [86], case study [87], retrospective observational study [88], and prospective observational trial [89].

58 studies were published in the United States [15–18, 20–31,33–39,41,43–52,54,56,57,59,62,63,66,67,69,71, 72,74–77,79,80,82–85,87–89], there were two studies published in each the United Kingdom [40,65], Canada [55,70], Singapore [19,58], and France [61,73], and one study published in each Italy [64], India [53], Mexico [86], Turkey [42], Belgium [78], Japan [60], Brazil [81], and Australia [68]. There was one study published across multiple countries [32].

The primary focus of 44 studies was interventions to increase immunisation uptake [15–30,32–39,42–44,47,52,53,56–59,61,62,66, 72,75,84–89], nine described the delivery of programs [54,55,67,68,70,71,80,82,83], nine assessed or described barriers and facilitators to delivery [46,48–51,60,63,73,74], six covered both program delivery and interventions [31,40,41,45,65], four were feasibility studies [76–79], two assessed delivery and barriers and facilitators together [69,81], and one assessed intervention and feasibility (cost analysis) simultaneously [64]. Table 1 summarises settings of vaccine delivery and study vaccination program by frequency.

3.2. Barriers and facilitators to delivery

Reported barriers and facilitators to adult vaccination delivery outside of primary care settings are shown in Table 2, and are identified at the level of facility, provider, and patient. Barriers and facilitators are further classified according to the setting in which they were reported. Although assessment of barriers and facilitators was the primary focus of only nine studies in the review [46,48–51,60,63,73,74], they were frequently reported on in other studies (such as intervention studies), and these findings were extracted and included in results analysis. In some studies, barriers and facilitators were assessed using outcome

Table 1
Summary of non-primary care vaccine delivery settings and study vaccination program by frequency.

Setting	n (%)
Tertiary care setting	
Hospital	20 (26·67 %) [15,16,18,19,22,25,26,29,39,40,42–44,53,56,62,65,69,70,87]
Emergency department or urgent care centre	8 (10·67 %) [21,23,37,45,55,72,77,89]
In-patient psychiatric facility	2 (2·7 %) [27,54]
Total	30 (40·0 %)
Secondary care setting	
Outpatient/specialist clinic	12 (16·0 %) [17,20,24,30,34,41,47,58,59,61,63,66]
Nursing home/LTCF	12 (16·0 %) [28,46,48–52,73–75,85,88]
Total	24 (32·0 %)
Other settings	
Workplace	11 (14·7 %) [32,33,36,38,57,60,64,76,78,79,84]
Homeless shelter	2 (2·7 %) [31,35]
Drive-through clinic	2 (2·7 %) [71,81]
Polling booth	1 (1·3 %) [80]
University campus	1 (1·3 %) [83]
Pop-up street clinic	1 (1·3 %) [86]
Student clinic	1 (1·3 %) [67]
Mobile van	1 (1·3 %) [82]
Welfare office	1 (1·3 %) [68]
Total	21 (28·0 %)
Study vaccination program	**n (%)**
Influenza	32 (42·7 %) [15,19,20,23,27,31,33,36,38,41,42,45,49,51,52,57,58,63,64,66,70–72,74–80,84,89]
Pneumococcal	15 (20·0 %) [21,24–26,32,37,43,44,46,55,62,67,69,87,88]
Influenza and pneumococcal	13 (17·3 %) [18,22,28–30,39,48,50,56,59,61,68,73]
COVID-19	11 (14·7 %) [16,40,53,54,60,65,81–83,85,86]
Herpes zoster	3 (4·0 %) [17,34,35]
Herpes zoster, influenza, and pneumococcal	1 (1·3 %) [47]

measures, while in others they were described as part of experience reports, as listed in Supplemental Table 7.

3.3. Barriers

Studies in tertiary care settings [15,16,21,26,27,54,69,70,72,77] reported the largest number of barriers to immunisation delivery, followed by secondary care settings [28,46,48–51,63,73] and other settings including workplaces [33,60], homeless shelters [31,35], a drive-through clinic [81], a student clinic [67], and a polling booth [80]. In tertiary care settings, the most common barriers were provider-level barriers, whereas in secondary care and other settings, facility-level barriers were more common.

3.4. Facility-level barriers

The most frequently reported facility-level barriers were operational planning and logistics of program delivery as reported by four studies [16,28,63,80]. Staffing retention and shortage issues were reported as barriers by three studies [28,46,81]. Three studies conducted in nursing homes found that facilities in metropolitan areas (population size >50,000) failed to deliver programs as effectively as those in non-metropolitan areas, due to varying factors such as staffing intensity, geographic location, and facility ownership type [48,50,73]. Less frequently reported facility-level barriers were funding and resources [63,67], liability concerns [63,80], program sustainability [15,21], space demands [33,72], stock control [16], governance and regulation compliance [80], and being a large facility or independent private facility [46] A study of multiple workplaces found that being a smaller company (1–49 employees) was a barrier to immunisation delivery, with results suggesting cultural and socioeconomic factors had the most significant influence on uptake in this setting [60].

3.5. Provider-level barriers

Provider documentation errors, such as unclear or incomplete medication orders, was the most reported barrier to effective immunisation programs delivery, as found by five studies [15,27,70,72,81], four of which were conducted in tertiary care settings [15,27,70,72]. Workflow interruption [15,70,77,80] and time constraints [21,27,33,72] were reported each by four studies. Lack of provider knowledge on vaccine schedules [15,26,27] and compliance issues [46,54,69] were reported in three studies, two studies reported routine vaccination being considered a low medical priority [21,77], and one study reported provider difficulty with identifying eligible patients [16].

3.6. Patient-level barriers

Being a short-term stay patient (<100 days) was found to be a barrier to receiving immunisation in three studies conducted in nursing homes [48,49,51]. Contraindications [46,51], being a longer-term stay resident [46], cost [35], language barriers [72], poor health literacy [31], poor recall of prior vaccination [72], cognitive impairment [46], and mental illness [27] were less frequently reported patient-level barriers.

3.7. Facilitators

Facilitators of immunisation program delivery were most frequently identified outside of clinical settings, such as in workplaces [36,38,57], a student clinic [67], a drive-through clinic [81], a polling booth [80], a university campus [83], mobile health van [82], and homeless shelters [31,35]. Patient convenience and government funding were noted as dominant themes in both non-clinical settings [31,35,36,38,57,67,80,82] and secondary care [34,47,50,58,59,66,74]. Studies in tertiary care settings reported a smaller number of facilitators to immunisation delivery including pre-existing infrastructure [54], on-site vaccine storage [54], standing order programs (SOPs) [72], and integrated clinical workflow [21].

3.8. Facility-level facilitators

Government funding was the most frequently reported facilitator to immunisation program delivery at the facility level, as found by five studies [31,50,67,74,82]. On-site storage facilities [54,67,81],

Table 2
Barriers and facilitators to immunisation delivery reported by relevance level and setting*

Barriers		Setting		
Facility level	Number of studies reporting	Tertiary	Secondary	Other
Operational planning and logistics	4	2 (IP) [16,27]	1 (OP) [63]	1 (poll) [80]
Staffing issues	3		2 (NH) [28,46]	1 (DrTh) [81]
Metropolitan area	3		3 (NH) [48,50,73]	
Funding/ resources	2		1 (OP) [63]	1 (StCl) [67]
Liability concerns	2		1 (OP) [63]	1 (poll) [80]
Sustainability	2	1 (IP) [15] 1 (ED) [21]		
Inadequate space	2	1 (ED) [72]		1 (WP) [33]
Stock control	1	1 (IP) [16]		
Governance/ regulation	1			1 (poll) [80]
Large facility	1		1 (NH) [46]	
Independent for-profit facility	1		1 (NH) [46]	
Small company	1			1 (WP) [60]
Total	23	6	10	7
Provider level				
Documentation errors	5	3 (IP) [15,27,70] 1 (ED) [72]		1 (DrTh) [81]
Workflow interruption	4	2 (IP) [15,70] 1 (ED) [77]		1 (poll) [80]
Time	4	1 (IP) [27] 2 (ED) [21,72]		1 (WP) [33]
Compliance	3	2 (IP) [54,69]	1 (NH) [46]	
Lack of knowledge	3	3 (IP) [15,26,27]		
Low medical priority	2	2 (ED) [21,77]		
Identifying eligible patients	1	1 (IP) [16]		
Total	22	18	1	3
Patient level				
Short-term stay	3		3 (NH) [48,49,51]	
Contraindicated	2		2 (NH) [46,51]	
Long-term stay	1		1 (NH) [46]	
Cost	1			1 (HoSh) [35]
Language barrier	1	1 (ED) [72]		
Poor health literacy	1			1 (HoSh) [31]
Poor recall of prior vaccination	1	1 (ED) [72]		
Cognitive impairment	1		1 (NH) [46]	
Mental illness	1	1 (IP) [27]		
Total	12	3 27	7 18	2 12
Facilitators		**Setting**		
Facility level	Number of studies reporting	Tertiary	Secondary	Other
Government funding	5		2 (NH) [50,74]	1 (HoSh) [31] 1 (StCl) [67] 1 (mob) [82]
On-site storage facilities	3	1 (IP) [54]		1 (StCl) [67] 1 (DrTh) [81]
Operational planning	3			1 (poll) [80] 1 (DrTh) [81] 1 (uni) [83]
Non-metropolitan area	3		3 (NH) [50,73,74]	
Flexible hours	2			1 (StCl) [67] 1 (DrTh) [81]
Community member involvement	2			1 (HoSh) [31] 1 (mob) [82]
Increased staffing	2		2 (NH) [51,73]	
Pre-existing infrastructure	1	1 (IP) [54]		
For-profit facility	1		1 (NH) [73]	
Large company	1			1 (WP) [60]
Higher quality facility	1		1 (NH) [50]	
Smaller facility	1		1 (NH) [74]	
Independent facility	1		1 (NH) [74]	
Total	26	2	11	13
Provider level				
Continuity of care	3		2 (NH) [49,73]	1 (StCl) [67]
Integrated workflow	2	1 (ED) [21]		1 (DrTh) [81]
Standing order programs	1	1 (ED) [72]		
Physician training level	1		1 (NH) [73]	
Total	7	2	3	2
Patient level				
Convenience	11		5 (OP) [34,47,58,59,66]	3 (WP) [36,38,57] 2 (HoSh) [31,35] 1 (poll) [80]
No cost	4			2 (WP) [38,60] 1 (HoSh) [54] 1 (StCl) [67]
Long-term stay	1		1 (NH) [49]	
Total	16	1 5	5 19	10 25

* Abbreviations list: IP = in patient hospital setting, ED = emergency department, OP = outpatient setting, NH = nursing home or long-term care facility, poll = polling booth, DrTh = drive through, StCl = student clinic, WP = workplace, HoSh = homeless shelter, mob = mobile clinic, uni = university campus.

operational planning [80,81,83], and facilities in non-metropolitan areas [50,73,74] were found to be facilitators in each three studies. Less frequently reported facilitators were offering flexible hours of operation [67,81], involving community members in the organisation of programs [31,82], increased staffing [51,73], pre-existing infrastructure [54], being employed in a larger company for workplace vaccination [60], higher quality facility [50], smaller facility [74], independent facility [74], and delivering programs in for-profit facilities [73].

3.9. Provider-level facilitators

As reported by three studies, continuity of care, including increased practitioner-patient interactions, was the most reported provider level-facility-level facilitator [49,67,73]. Integrated workflow and pre-existing SOPs were reported facilitators in two [21,81] and one [72] studies respectively. Higher level of physician training was reported as facilitator in one study [73].

3.10. Patient-level facilitators

Convenience was reported as a key facilitator to receiving immunisation in 11 studies [31,34–36,38,47,57–59,66,80], six of which were conducted in non-clinical settings (workplace, homeless shelters, and a polling booth) [31,35,36,38,57,80,] and five in outpatient secondary care facilities [34,47,58,59,66]. Free vaccination was reported as a facilitator in four studies [31,38,59,67]. One study reported being a long-term stay resident in a nursing home was strongly correlated with vaccine administration [49].

4. Interventions

Interventions delivered to improve vaccination uptake in the included studies are shown in Tables 3 and 4.

Table 3 lists the findings by intervention type, study characteristics and statistical significance.

4.1. Plan-Do-Study-Act (PDSA) cycles

The PDSA model, as developed by Shewart and Deming [90] is an improvement methodology, frequently used in clinical settings [91]. It involves front-end planning and small cycle testing of changes to monitor and adapt outcomes [91]. Six of the included studies [15,16,23–25,30] employed PDSA cycles as interventions, across hospital [15,16,25], emergency department [23], and outpatient settings [24,30]. Within-cycle interventions included varying combinations of operational planning, improving logistics, patient education, staff education, staff collaboration, on-site vaccination, clinical reminders, and standing order programs, [15,16,23–25,30] as listed in Table 3. All six studies reported an increase in vaccination rates with use of PDSA cycles, although only the study by Parker [30] reported statistical significance.

4.2. Pharmacist intervention

Four of the included studies [39,43,44,88] utilised pharmacist intervention to improve vaccination rates and ensure correct vaccination choice and dosage. This was achieved via clinical reminders [44], pharmacist-driven immunisation screenings [88], pharmacist intervention on vaccine choice [43], and patient education delivered by pharmacists [39], Three of the included studies took place in hospital in-patient settings [39,43,44], and one in a nursing home [88]. The studies by Baucom [44] and Dauz [88] reported statistically significant improvements in vaccination rates.

4.3. Provider reminders

Two studies [21,45] used provider reminders as interventions, both taking place in emergency departments and employing computer-based reminder systems. Both studies reported improvement in vaccination rates although neither reported statistical significance.

4.4. Patient education

The studies by Dalton [65] and Ferro [64] employed patient education interventions to improve vaccination rates. The study by Dalton [65] took place in a hospital rehabilitation ward and utilised physicians to deliver education, reporting an improvement in vaccination rates. The study by Ferro [64] was a workplace study, using promotional material to deliver education. Vaccination rates were low at the completion of the study and this intervention was deemed unsuccessful [64]. Neither study reported statistical significance in their findings for vaccination rate.

4.5. Other

There were several interventions employed in single studies including public reporting of facility immunisation rates [52], patient prizes and financial incentives [53], facility recognition incentives [56], on-site vaccination offered to patients in existing specialist appointments [47], motivational messaging delivered to patients [42], provider education [28], and operational planning for workflow optimisation [89]. The studies utilising patient financial incentives [53], on-site vaccination [47], and operational planning [89] interventions, reported statistically significant improvements in vaccination rates. The study by Heidenreich [56] showed that a facility recognition incentive failed to improve vaccination rates, as did the study by Isler [42] utilising motivational messaging.

4.6. Multicomponent strategies

The remaining studies included in the review used multicomponent strategies to increase vaccination rates. Strategies involved varying combinations of the above interventions, as well as standing order programs [22,75], increased funding [85], offering free vaccinations [33], establishing vaccination screening practices [37,59], offering patients a choice of vaccines [84], and specialist consultation [62]. These studies took place across a variety of settings and with varying levels of statistical significance. The studies by Bardenheier [75], Clark [26], Cooper-White [41], Cotugno [27], Hebert [59], Hill [22], Lehman [37], Li [19], Nowalk [84], Ofstead [57], Peterson [29], Sheth [17], and Smith [62], reported statistically significant improvements in vaccination rates. Interventions employed in these studies included varying combinations of standing order programs [22,75], provider education [17,26,29], patient education [17,19,26,37], on-site vaccinations offered in workplaces [57] and specialist clinics [41,59], free vaccination [41,57], motivational messaging [41], pharmacist intervention [27], operational planning via workflow optimisation [27,29], patient screening practices [37,59], provider reminders [17,22], physician intervention [19], patient choice of vaccine [84], and patient financial incentive [57].

Table 4 further maps interventions according to their reported success, the setting (tertiary, secondary, or other) and level at which they were delivered (facility, practitioner, or patient). Overall, there was a significantly higher number of successful interventions than unsuccessful interventions reported in the included studies, although statistical significance varied, as outlined in Table 3.

Table 3
Characteristics of intervention studies by intervention type.

Study (ref)	Location and setting	Study design	Target population	Vaccination type	Intervention	Findings	Statistical significance
Plan-Do-Study-Act (PDSA) cycles							
Cohen [15]	Veteran hospital; US	Quasi-experimental study	Hospitalised older adults at high-risk of influenza	Influenza	8× PDSA cycles (2007–2013) involving staff and patient education, clinical reminders, audits, and SOP	% of veterans discharged with an up-to-date influenza vaccination increased from 60 % in 2007 to 80 % in 2009 Vaccination coverage rate decreased to 75 % when SOPs were implemented in 2012	Not reported
De Guzman [16]	Hospital; US	Quasi-experimental study	Hospitalised adults	COVID-19	4× PDSA cycles (2021−2022) involving clinical reminders (int 1), staff (int 2,3) and patient education (int 4)	Vaccination rates increased from baseline across all cycles, but more significantly in interventions 1 and 4 Baseline (prior) = 10·7 % After intervention 1 = 19·7 % Int 2 and 3 = 11·4 % and 11·8 % Int 4 = 19·0 % Mean at conclusion = 15·4 %	Not reported
Farrell [23]	Emergency department; US	Quasi-experimental study	Unvaccinated adults attending emergency departments	Influenza	5× PDSA cycles (2018–2021) involving operational planning (int 1), improved logistics (int 2,3,5), patient education (int 2), staff education (int 4)	Vaccination rates increased from baseline and with each cycle Baseline = 0 18–19 season (PDSA1–3) = 61 patients vaccinated 19–20 (PDSA4) = 134 20–21 (PDSA5) = 142	Not reported
Parker [30]	Outpatient clinic; US	Quasi-experimental study	Immuno-suppressed adults with inflammatory bowel disease	Influenza Pneumococcal	2× PDSA cycles including operational planning, patient education, and on-site vaccinations	Influenza vaccination rate increased from 54·0 % to 81·0 % after intervention Pneumococcal vaccination rate increased from 31·0 % to 54·0 % after intervention	$P < 0{\cdot}001$ $P < 0{\cdot}001$
Wilson [24]	Outpatient clinic; US	Quasi-experimental study	Adults with rheumatoid arthritis attending a specialist clinic	Pneumococcal	3× PDSA cycles ('Lean Six Sigma') involving provider education and workflow improvement	The baseline vaccination rate was 0–11·0 % PDSA 1: rates increased from 0 % to 25 %. However, by the end of this cycle, rates returned to 0 %. PDSA 2–3: rates improved from 0 % to 18 %. After PDSA cycles: rates improved to 23 % Overall the vaccination rate increased to 14·2 %	Not reported
Yancey [25]	Hospital; US	Quasi-experimental study	Hospitalised adults	Pneumococcal	PDSA model with changes made to assessment, ordering, obtaining and administering vaccines, staff education	Vaccination rate increased from 34·7 % at baseline to 90·0 % two years after intervention implemented	Not reported
Pharmacist intervention							
Baucom [44]	Hospital; US	Retrospective cohort study	Hospitalised adults	Pneumococcal	Implementation of a pharmacy-to-dose protocol involving nursing clinical reminder and collaborative workflow	Correct vaccine ordering rates increased from 26·9 % pre-protocol to 83·1 % post-protocol	$P < 0{\cdot}001$
Dauz [88]	Nursing home (LTCF); US	Retrospective observational study	Older adults in long-term care facilities	Pneumococcal	Pharmacist-driven immunisation screening on admission	20·2 % of residents were up to date in the exposure group, compared to 1·9 % in the control group	$P < 0{\cdot}05$

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Table 3 (*continued*)

Study (ref)	Location and setting	Study design	Target population	Vaccination type	Intervention	Findings	Statistical significance
King [43]	Hospital; US	Quasi-experimental study	Hospitalised adults	Pneumococcal	Pharmacist intervention on vaccine choice	Correct vaccine rates improved from 40·0 % during the historical period to 95·6 % during the post policy period	Not reported
Queeno [39]	Hospital; US	Quasi-experimental study	Hospitalised adults who previously declined vaccination	Influenza Pneumococcal	Patient education delivered by pharmacist	23·4 % of in-patients accepted and received the influenza vaccine after intervention. 26·5 % of in-patients accepted and received the pneumococcal vaccine after intervention.	P = 0·6 *P* = 0·18
Provider reminders							
Dexheimer [21]	Emergency department; US	Quasi-experimental study	Physicians working in emergency departments who saw older adult patients (>65 years)	Pneumococcal	Computer-based pneumococcal vaccination reminder system with multiple prompt points for vaccine assessment and ordering	The vaccination rate increased from 38·8 % at baseline to 45·4 % after intervention.	Not reported for vaccination rate
Parrish [45]	Emergency department; US	Retrospective cohort study	Physicians and nurses working in medical wards and their patients	Influenza	Vaccination reminder added to task list in electronic health record for nurse initiation	43·7 % of eligible patients were vaccinated during the study period	Not reported for vaccination rate
Patient education							
Dalton [65]	Hospital; UK	Prospective cohort study	Hospitalised adults in rehabilitation settings	COVID-19	Patient education via physician discussion	Vaccination rate increased from 68·75 % pre-intervention to 80·0 % 3 weeks after intervention	Not reported
Ferro [64]	Manufacturing company; Italy	Prospective cohort study	Employed adults	Influenza	Promotional workplace campaign for flu immunisation	14·7 % of employees accepted the influenza vaccine	Not reported for vaccination rates
Public reporting of facility immunisation rates							
Cai [52]	Nursing home; US	Retrospective cohort study	Older adults in nursing homes	Influenza	The facility's vaccination rates would be publicly reported	The increase in vaccination rates after the intervention was no greater than the vaccination rate among community-dwelling elderly	Not reported
Prize/financial incentive (patient)							
Gupta [53]	Hospital; India	Retrospective cohort study	Adults attending hospitals	COVID-19	Incentive of 'lucky draw' entry for 15 prizes for participants who recevied vaccination	2705 vaccines were administered at the incentivised camp, compared to 1406 vaccines at the non-incentivised camp	P < 0·001
Facility recognition incentive							
Heidenreich [56]	Hospital; US	Retrospective cohort study	Hospital facilities with adult in-patients	Influenza Pneumococcal	Facility offered additional public recognition for improving vaccination rates	For influenza vaccination: adjusted rates of increase pre-program were OR = 2·832, 95 % CI [1·445 to 5·550].... per quarter and during program OR = 0·988, 95 % CI [0·928 to 1·052].... per quarter For pneumococcal vaccination: adjusted rates of increase pre-intervention were OR = 2·473, 95 % CI [1·521 to 4·019].... per quarter and post intervention 1·040, 95 % CI [0·928 to 1·116].... per quarter	P = 0·003 *P* < 0·001
On-site vaccination							
Hussain [47]	Outpatient clinic; US	Retrospective cohort study	Adults with inflammatory bowel disease seeking specialist consultation	Herpes zoster Influenza Pneumococcal	Clinic A offered on-site vaccination services for patients attending specialist appointment Clinic B did not	Influenza vaccination rates were higher in clinic A (67·8 %) than clinic B (47·8 %) A higher percentage of patients received pneumococcal and herpes	P < 0·001

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Table 3 (*continued*)

Study (ref)	Location and setting	Study design	Target population	Vaccination type	Intervention	Findings	Statistical significance
						zoster vaccinations in clinic A however the difference was not statistically significant	
Motivational messaging							
Isler [42]	Hospital; Turkey	Quasi-experimental study	High-risk hospitalised adults	Influenza	Two motivational messages: 1. Self-benefit frame 2. Social-benefit frame	The vaccination rate in group 1 was 42 % and in group 2 was 34 % aOR = 1·63, 95 % CI [0·90 to 2·95]....	Difference not statistically significant *P* = 0·108
Provider education							
Nace [28]	Nursing home; US	Quasi-experimental study	Adult residents of nursing homes	Influenza Pneumococcal	Provider education given to intervention group in the form of a single half-day collaborative training program. The control group received no training.	In the intervention group resident influenza vaccination rate increased by 4·0 % and pneumococcal vaccination rate increased by 29·9 %. In the control group resident influenza vaccination rate decreased by 20·8 % and pneumococcal vaccination rate decreased by 13·9 %	Not reported
Operational planning and improvements (logistics, workflow)							
Venkat [89]	Emergency department; US	Prospective observational trial	Adults attending emergency departments	Influenza	Workflow optimisation via a clinical decision support tool embedded into existing computerised physician order entry system	Influenza vaccination rate rose by 17·5 % (95 % CI [16·0 % to 19·0 %].... after intervention	P < 0·001
Multicomponent interventions							
Bardenheier [75]	Nursing home; US	Cross-sectional study	Nursing home staff and their patients	Influenza	1. Standing order program 2. Other programs (pre-printed admissions order, advanced physicians order, personal physicians order) 3. No program	Influenza vaccination coverage among residents in facilities with SOP = 68·0 % Influenza vaccination coverage among residents in facilities with other programs = 59·0 %-63·0 %	P < 0·01
Bawa [40]	Hospital; UK	Quasi-experimental study	Hospitalised adults	COVID-19	1. Workflow improvement to promote vaccination screening 2. Offering on-site vaccinations to inpatients	34 patients vaccinated in <2 months after intervention introduced, compared to 20 patients in 4 months prior to intervention	Not reported
Beers [31]	Homeless shelter and meal site; US	Quasi-experimental study	People attending homeless shelters and meal sites	Influenza	1. Patient education via population-tailored information sheet 2. Shelter staff education 3. Offered on-site vaccination	The influenza vaccination rate at the homeless shelter decreased from 24·77 % pre-intervention to 23·85 % post-intervention. The influenza vaccination rate at the non-traditional meal site improved.	Not reported
Berry [85]	Nursing home; US	Cluster-RCT	Staff and residents of nursing homes	COVID-19	1. Education material and electronic messaging for staff 2. Townhall meetings with frontline staff 3. Messaging from community leaders 4. Gifts with socially concerned messaging (e.g. t-shirts) 5. Use of specialist to facilitate consent practices 6. Funding	The vaccination rate was 82·5 % (95 % CI [81·2 % to 83·7 %]....) in the intervention arm and 79·8 % (95 % CI [78·5 % to 81·0 %]....) in the control arm. There was an average marginal effect of 0·8 % (95 % CI [1·9 % to 3·7 %]....).	Effect of intervention OR 0·06, 95 % CI (−0·24 to 0·36)

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Table 3 (*continued*)

Study (ref)	Location and setting	Study design	Target population	Vaccination type	Intervention	Findings	Statistical significance
Clark [26]	Hospital; US	Quasi-experimental study	At-risk adults undergoing presurgical screening	Pneumococcal	1. Staff education, audit, and performance incentives 2. Patient education flyer	Intervention 1: the vaccination rate was 24 % pre-intervention and 44 % post-intervention Intervention 2: little impact on the rate of immunisation	P < 0·0001
Cohen [72]	Emergency department; US	Cross-sectional study	Adult patients attending the emergency department	Influenza	1.Nurse screening 2. Electronic clinical reminder system 3. Pharmacist vaccination	41 % of patients agreed to receive the vaccine 74 % were willing to receive the vaccine from the pharmacist and 78 % in the ED	Not reported
Cooper-White [41]	Outpatient clinic; US	Quasi-experimental study	Parents accompanying at-risk children to paediatric appointments	Influenza	1. Offering on-site vaccination (during patient's paediatric appointment) 2. Free vaccination 3. Motivational messaging (protecting children)	The vaccination rate increased from 23·7 % in the previous year to 85·6 % after the intervention was implemented	P < 0·001
Cotugno [27]	Psychiatric hospital; US	Quasi-experimental study	Adults hospitalised in psychiatric facilities	Influenza	1. Pharmacist intervention via staff education, training, and audit 2. Logistics and workflow improvement	The vaccine screening and administration (if required) compliance rate improved from 55·0 % pre-intervention to 99·0 % post-intervention	P < 0·0001
Donoghue [32]	Workplaces; multinational	Quasi-experimental study	Welders	Pneumococcal	1. Patient education via webinar 2. Vaccinations offered on-site in workplaces 3. Free vaccination	31 % of welders were vaccinated 12 months after the intervention was implemented	Not reported
Graves [33]	Restaurants; US	Quasi-experimental study	Employed adults working in hospitality	Influenza	1. Vaccination promotion materials and patient education 2. On-site vaccination offered 3. Free vaccination	Vaccination rates increased from 26·0 % pre-intervention to 46·0 % post-intervention	Adjusted OR = 2·33, 95 % CI [1·69 to 3·22]....
Grivas [20]	Outpatient clinic; US	Quasi-experimental study	Adult patients attending cancer care	Influenza	1. Provider reminders 2. Patient reminders and education	There was a 37·6 % increase in vaccination rate during 2011–2012, and a 56·1 % increase in 2012–2013	95 % CI [35·0 % to 40·3 %].... 95 % CI [40·9 % to 73·0 %]....
Harvey-Vera [86]	Pop-up clinic; Mexico	Longitudinal cohort study	People who inject drugs	COVID-19	1. Financial incentive 2. Free vaccination	83·1 % of participants who attended the pop-up clinic were vaccinated	Adjusted OR = 9·15, 95 % CI [5·68 to 14·74]....
Hebert [59]	Outpatient clinic; US	Prospective cohort study	Adults with systolic heart failure	Influenza Pneumococcal	1. Screening practices implemented in clinical protocol 2. Vaccination offered during appointment	For influenza vaccination, prevalence of being vaccinated was 28·3 % at baseline and 50·4 % after intervention For pneumococcal vaccination, prevalence of being vaccinated was 30·7 % at baseline and 65·5 % after intervention	P < 0·0001 *P* < 0·0001
Hill [22]	Hospital; US	Quasi-experimental study	Hospitalised adults	Influenza Pneumococcal	Intervention group: 1.Clinician reminder delivered by pharmacy 2. Nurse-driven SOP Control group: 1. Nurse-driven SOP	Influenza vaccination: 92·9 % of patients in the intervention group were vaccinated, compared to 72·2 % in the control group Pneumococcal vaccination: 84·3 % of patients in the intervention group were	P = 0·001 *P* = 0·638

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Table 3 (*continued*)

Study (ref)	Location and setting	Study design	Target population	Vaccination type	Intervention	Findings	Statistical significance
						vaccinated, compared to 81·3 % in the control group	
Jacobs [66]	Outpatient clinic; US	Retrospective chart review	Adults accompanying children to paediatrician appointment	Influenza	1. Offered a prescheduled parent vaccination appointment 2. Offered vaccination on day of child's visit 3. Patient education	84 % of participants accepted vaccination on the day of their child's appointment 16 % of participants accepted a prescheduled appointment to be vaccinated	Not reported
Jung [34]	Outpatient clinic; US	Quasi-experimental study	Adults attending ophthalmology appointments	Herpes zoster	1. Patient screening 2. Patient education	100 vaccinations were given of 177 eligible patients	Not reported for vaccination rate
Kaplan-Weisman [35]	Homeless shelter; US	Quasi-experimental study	Adults attending homeless shelters	Herpes zoster	1. Patient education via 30 min talk at shelter 2. On-site vaccination 3. Collaboration between homeless shelter staff, local medical clinic and pharmacy	The vaccination rate was 39·8 %	Not reported for vaccination rate
Landwehr [36]	Workplace; US	Quasi-experimental study	Employed adults	Influenza	1. Patient education via flyer 2. Patient surveys 3. On-site vaccination offered 4.Free vaccines	The vaccination rate was 54 % post-intervention, compared to 37 % pre-intervention	Not reported for vaccination rate
Lehman [37]	Emergency department; US	Quasi-experimental study	Adult patients attending emergency departments	Pneumococcal	1. Screening practice implemented 2. Patient education delivered by pharmacy students 3.Collaboration between pharmacy and ED staff	96 (10·7 %) patients in the intervention group were vaccinated compared to 2 in the control group	$P < 0·0001$
Li [19]	Hospital; Singapore	Quasi-experimental study	Hospitalised adults with COPD	Influenza	1. Patient education via poster 2. Direct intervention by physician 3. Nurse intervention	The vaccination rate was 80·7 % post-intervention compared with 47·7 % pre-intervention 87·8 % of vaccinations were attributed to the physician intervention, 12·1 % to the nurse intervention and 0 % to patient education	$P < 0·001$
Montejo [38]	Workplace; US	Quasi-experimental study	Employed adults	Influenza	1. Financial incentive 2. Patient education via an information session 3.Promotional stickers 4.On-site vaccination	The vaccination rate in the intervention group was 45 %, compared to 32 % in the control group	Not reported
Nowalk [84]	Workplace; US	Stratified randomised control trial	Working adults	Influenza	Control sites: 1. advertised and offered vaccine clinics as normal. Choice sites: 1. offered choice of intranasal or injected vaccine Choice Plus sites: 1. increased advertising 2. promoted and offered a choice of vaccines 3. offered a nominal incentive	The overall vaccination rate increased from 39 % pre-intervention to 46 % post-intervention For intranasal injection there was a 6·5 % increase in vaccination rate in the choice site vs control, and a 9·9 % increase in choice plus vs control. For injected vaccination there was a 15·9 % increase in choice vs control for	$P < 0·001$ $P < 0·001$

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Table 3 (*continued*)

Study (ref)	Location and setting	Study design	Target population	Vaccination type	Intervention	Findings	Statistical significance
						workers >50 years, and no change in choice plus.	$P = 0{\cdot}024$
Ofstead [57]	Workplace; US	Prospective cohort study	Working adults	Influenza	1. Financial incentive + free vaccination (insured) 2. Free vaccination alone (uninsured) 3. Patient education 4. Mass vaccination event (on-site vaccination) 5. Advertising	There were 1765 vaccinations delivered post-intervention, compared to 1000 vaccinations delivered in the prior year	$P < 0{\cdot}001$
Peterson [29]	Hospital; US	Quasi-experimental study	Hospitalised adults	Influenza Pneumococcal	1. Staff education via slide show 2. Department audits, competitions, and prizes 3. Process improvement	The vaccination compliance rate increased from 78 % pre-intervention to 96 % post-intervention for pneumococcal, and from 84 % to 97·5 % for influenza.	$P = 0{\cdot}001$
Rees [18]	Hospital; US	Quasi-experimental study	Hospitalised adults	Influenza Pneumococcal	1. Unit-based interventions: a) clinical reminders b) staff education c) reports on vaccination rates 2. Institution wide interventions: a) clinical reminders b) improved logistics c) daily audits	For unit-based reminders the vaccination rate was 84 % in the intervention group compared to 46 % in the control group. Institution wide the vaccination rate improved from 45 % pre-intervention to 78 % post-intervention	$P = 0{\cdot}002$ Not reported
Robke [87]	Hospital; US	Case study	Hospitalised adults with community acquire pneumonia	Pneumococcal	1. Pharmacist intervention (eligibility screening, patient education, vaccine ordering) 2. Improved workflow	Vaccination rate increased from 71·2 % in 2003 to 88·3 % in 2008	Not reported
Sheth [17]	Outpatient clinic; US	Quasi-experimental study	Patients with rheumatoid arthritis attending a specialist clinic	Herpes zoster	1. Physician reminder 2. Physician education 3. Patient education	The vaccination rate increased from 10·1 % pre-intervention to 51·7 % post-intervention	$P < 0{\cdot}0001$
Sitte [61]	Outpatient clinic; France	Prospective cohort study	Patients with gastrointestinal disease attending a specialist clinic	Influenza Pneumococcal	Phase 1: questionnarie Phase 2: infectious disease consultation Phase 3: subsequent questionnaire	87·3 % of patients participating in phase 2 consultation received vaccination	Not reported
Smith [62]	Hospital; US	Prospective cohort study	Hospitalised adults	Pneumococcal	1. Workflow improvement 2. Logistics improvement 3.On-site vaccination	The vaccination rate increased from 19·1 % pre-intervention to 74·2 % post-intervention	$P < 0{\cdot}001$
Yeo [58]	Outpatient clinic; Singapore	Prospective cohort study	Solid organ transplant recipients attending a specialist clinic	Influenza	1. On-site vaccination offered 2. Patient education	The vaccination rate improved from 25 % pre-intervention to 60·6 % post-intervention	Not reported for vaccination rates

4.7. Successful interventions

Provider-level interventions, including education [15,16,18,23,25–27] and clinical reminders [15,16,18,21,22,44,45,72] were the most frequently reported successful interventions delivered in tertiary care settings, alongside operational planning and improvement [18,23,25,27,40,62,87,89]. Educating patients [17,20,30,33,34,36,38,58,66] and offering on-site vaccination [30,33,36,38,41,47,57–59,63,66] were the most successful interventions reported in both secondary care and workplaces.

4.8. Facility-level

Operational planning, including logistics and workflow improvements, and Plan-Do-Study-Act (PDSA) cycles were the most frequently reported successful interventions for improving immunisation rates at

the facility level, as reported by ten [18,23–25,27,30,40,62,87,89] and six [15,16,23–25,30] studies respectively. Ten of these studies took place in tertiary care settings [15,16,18,23,25,27,40,62,87,89]. Advertising of vaccination programs was reported as a successful intervention in three studies [33,38,84].

4.9. Provider-level

Practitioner education [15–18,23–29] and clinical reminders [15–18,20–22,44,45,72] were reported as successful interventions in 11 and ten studies respectively. Pharmacist intervention in the clinical process, via patient and vaccine choice screening, improved immunisation rates in seven studies [22,27,43,44,72,87,88]. Collaboration between staff, such as physicians and administrators, improved immunisation rates in six studies [22,24,35,37,43,44], four of which took place in tertiary care [22,37,43,44]. Screening practices [34,37,59,72], audits [18,26,29], financial incentives [26,29], and SOPs [22,75] were less frequently reported successful interventions.

4.10. Patient-level

Patient education, particularly when delivered in hospital settings or existing medical appointments, was the most frequently reported successful intervention overall, as reported in 18 of the included studies [15–17,20,23,30,33–39,57,58,65,66,87]. On-site vaccination was also advantageous in improving immunisation rates in 14 studies [30,33,35,36,38–41,47,57–59,63,66], seven of which were conducted in outpatient settings [30,41,47,58,59,63,66], and four in workplaces [33,36,38,57]. Free vaccines [33,36,41,57,86], financial incentives [38,53,57,84,86], pharmacist consultation [39,87,88], physician or nurse intervention [19,61], choice of vaccine [84], and motivational messaging [41] were less frequently reported successful interventions.

4.11. Unsuccessful interventions

There were more unsuccessful interventions reported in secondary care [52,85] and non-clinical settings [31,32,57,64] than in tertiary care [15,19,26,56]. Education of patients across settings was the most frequently reported unsuccessful intervention [19,26,31,32,64,85], however the number of studies reporting success with this method was higher [15–17,20,23,30,33–39,57,58,65,66,87].

4.12. Facility-level

There were few facility-level interventions shown to be unsuccessful in improving delivery of immunisations, reported in only four of the included studies [52,56,57,85]. These interventions included public reporting of facility immunisation rates [52], advertising of immunisation clinics [57], a facility-recognition incentive [56], and increased funding [85].

4.13. Provider-level

There were only three provider interventions reported as unsuccessful in improving immunisation delivery, being an SOP reported in one hospital study [15], and staff education and financial incentives reported in nursing home settings [85].

4.14. Patient-level

There were more unsuccessful patient-level interventions reported [19,26,31,32,42,64,85] than those at facility- [52,56,57,85] and provider-level [15,85]. Six studies reported failed patient education interventions [19,26,31,32,64,85], three of which took place in non-clinical settings [31,32,64]. Other failed interventions included on-site vaccination [31,32], free vaccines [32], financial incentives [85], motivational messaging [42], and community involvement in program delivery [85], each reported in only one study.

5. Cost analysis

Five studies modelled feasibility of immunisation programs [64,76–79], four in the workplace [64,76,78,79] and one in an emergency department [77]. All four workplace models indicated that immunisation programs were cost-effective for employers [64,76,78,79]. The emergency department study indicated that an immunisation program in this setting would be financially neutral for the organisation [77].

6. Discussion

To the authors' knowledge, this is the first scoping review to provide a comprehensive picture of the existing evidence regarding adult immunisation delivery outside of primary care settings, including mapping of setting types, operational barriers and facilitators to delivery, interventions to improve uptake in these settings, and cost-feasibility analysis. The general findings of this review indicate that a significant proportion of immunisation programs outside of primary care are delivered in tertiary care settings, most frequently in hospital in-patient wards [15,16,18,19,22,25,26,29,39,40,42–44,53,56,62,65,69,70,87].

At the facility level, operational planning [18,23–25,27,30,40,62,87,89] and PDSA cycles [15,16,23–25,30] were the most frequently reported interventions shown to improve immunisation program delivery, particularly in tertiary care settings [15,16,18,23,25,27,40,62,87,89]. Education [15–18,23–29] and clinical reminder [15–18,20–22,44,45,72] interventions were shown to be the most successful at the provider-level, trialled across both tertiary and secondary care settings. Education was also the most frequently reported successful intervention at the patient level [15–17,20,23,30,33–39,57,58,65,66,87], although there were limitations to the success of this intervention in workplaces [32,64] with employees shown to be more financially incentivised. [38,57,84].

Five studies suggest that immunisation programs outside of primary care settings are generally cost effective [64,76–79], and potentially financially beneficial to employers offering workplace vaccination [64,76,78,79].

6.1. Immunisation of hospital in-patients and provider barriers

Immunisation of patients admitted to hospital or presenting to the emergency department is becoming recognised as a useful strategy for identifying patients who are not up to date with routine immunisations, particularly among underserved populations [9]. The findings of this scoping review further highlight the development of in-patient vaccination programs, with a significant proportion of included studies conducted in hospital wards [15,16,18,19,22,25,26,29,39,40,42–44,53,56,62,65,69,70,87]. Operational planning, including logistics and workflow improvements [18,23,25,27,40,62,87,89], provider education, [15,16,18,23,25–27], and clinical reminders [15,16,18,21,22,44,45,72] were shown to be the most successful interventions in this setting. However, the largest proportion of provider-level barriers to immunisation delivery were reported in tertiary care settings, including documentation errors, workflow interruption, time constraint, compliance, and low medical priority [15,27,70,72]. This finding is unsurprising given competing workflow demands that tend to feature in these settings [92] and which may be compounded by the introduction of immunisation programs. This issue was highlighted in the study by Dexheimer [21] who noted several operational challenges in implementing a pneumococcal vaccination initiative in a US emergency department, including resource demands, time constraints, and low medical priority, factors which may have limited the program's success.

Table 4
Interventions delivered at facility-, provider-, and patient-level, reported by success and setting type*

Reported as successful		Settings		
Facility level	Number of studies reporting	Tertiary	Secondary	Other
Operational planning and improvements (logistics, workflow)	10	6 (IP) [18,25,27,40,62,87] 2 (ED) [23,89]	2 (OP) [24,30]	
Plan-Do-Study-Act cycles	6	3 (IP) [15,16,25] 1 (ED) [23]	2 (OP) [24,30]	
Advertising	3			3 (WP) [33,38,84]
Total	19	12	4	3
Provider level				
Education	11	7 (IP) [15,16,18,25–27,29] 1 (ED) [23]	2 (OP) [17,24] 1 (NH) [28]	
Clinical reminders	10	5 (IP) [15,16,18,22,44] 3 (ED) [21,45,72]	2 (OP) [17,20]	
Pharmacist intervention (clinical process)	7	5 (IP) [22,27,43,44,87] 1 (ED) [72]	1 (NH) [88]	
Collaboration with other practitioners	6	3 (IP) [22,43,44] 1 (ED) [37]	1 (OP) [24]	1 (HoSh) [35]
Screening practices	4	2 (ED) [37,72]	2 (OP) [34,59]	
Audits	3	3 (IP) [18,26,29]		
Financial incentive	2	2 (IP) [26,29]		
Standing order programs	2	1 (IP) [22]	1 (NH) [75]	
Total	45	34	10	1
Patient level				
Education	18	5 (IP) [15,16,39,65,87] 2 (ED) [23,37]	6 (OP) [17,20,30,34,58,66]	4 (WP) [33,36,38,57] 1 (HoSh) [35]
On-site vaccination	14	2 (IP) [40,62]	7 (OP) [30,41,47,58,59,63,66]	4 (WP) [33,36,38,57] 1 (HoSh) [35]
Free vaccines	5		1 (OP) [41]	3 (WP) [33,36,57] 1 (pop) [86]
Financial incentive	5	1 (IP) [53]		3 (WP) [57,84] 1 (pop) [86]
Pharmacist consultation	2	2 (IP) [39]		
Physician intervention	2	1 (IP) [19]	1 (OP) [61]	
Motivational messaging	1		1 (OP) [41]	
Choice of vaccine	1			1 (WP) [84]
Total	48	13 59	16 30	19 23
Reported as unsuccessful		**Setting**		
Facility level	Number of studies reporting	Tertiary	Secondary	Other
Public reporting	1		1 (NH) [52]	
Advertising	1			1 (WP) [57]
Recognition incentive	1	1 (IP) [56]		
Increased funding	1		1 (NH) [85]	
Total	4	1	2	1
Provider level				
Standing order programs	1	1 (IP) [15]		
Education	1		1 (NH) [85]	
Financial incentive	1		1 (NH) [85]	
Total	3	1	2	
Patient level				
Education	6	2 (IP) [19,26]	1 (NH) [85]	2 (WP) [32,64] 1 (HoSh) [31]
On-site vaccination	2			1 (HoSh) [31] 1 (WP) [32]
Free vaccines	1			1 (WP) [32]
Financial incentive	1		1 (NH) [85]	
Motivational messaging	1	1 (IP) [42]		
Community involvement	1		1 (NH) [85]	
Total	12	3 5	3 7	6 7

* Abbreviations list: IP = in patient hospital setting, ED = emergency department, OP = outpatient setting, NH = nursing home or long-term care facility, poll = polling booth, DrTh = drive through, StCl = student clinic, WP = workplace, HoSh = homeless shelter, mob = mobile clinic, uni = university campus.

Sustainability is likely a key consideration in the successful implementation of in-patient immunisation programs.

6.2. *Immunisation in outpatient clinics: a more sustainable approach?*

Interventions tended to be similarly successful in studies conducted in outpatient clinics, including rheumatology [17,24], gastroenterology [30,47,61], oncology [20], organ transplant [58], ophthalmology [34], and cardiology [59]. The opportunity for patients to be conveniently vaccinated at their existing specialist appointments was a key facilitator to program success in several of the included studies [30,41,47,58,59,63,66]. There were significantly fewer barriers

reported to immunisation delivery in outpatient clinics [63] which may suggest increased sustainability of programs in this setting.

Interestingly, there were several US studies which trialled programs of adult caregiver vaccination in paediatric offices [41,63,66], a process referred to as cocooning [41]. In the studies by both Cooper-White [41] and Jacobs [66] a significant proportion of adult caregivers readily accepted the influenza vaccine when offered at their child's paediatrician appointment. The study by Cooper-White [41] involving free, on-site vaccinations for adult caregivers, and motivational messaging related to their child's health, resulted in 85·6 % of eligible participants receiving the influenza vaccine. Cocooning practices at paediatric offices may represent a unique opportunity to immunise clinically eligible adult caregivers, a population with a historical influenza vaccination rate as low as 17 % [41].

6.3. Workplace immunisation and limitations of patient education

Outside of clinical settings, the findings of this review indicate that workplaces are the predominant setting for adult immunisation programs [32,33,36,38,57,60,64,76,78,79,84]. Included studies took place across various company-types, including welding [32], manufacturing [57,64], hospitality [33], corporate [36], and retail [38]. Convenience [34,47,58,59,66] appeared to be a key facilitator for patients in this setting, although interestingly education was not received as well as in clinical settings [32,64]. The multi-national study of pneumococcal vaccination for welders by Donoghue et al. [32] found that an education webinar, coupled with no-cost on-site vaccinations resulted in only 31 % of welders receiving the vaccine, 6 % lower than the mean influenza vaccination rate across 18 US companies in 2008–2009. This is despite the fact that lobar pneumonia is a known occupational disease of welders [32]. The authors concluded that the interventions may have been insufficient to convince employees to receive vaccination adequately and speculate that use of company 'champions' may have been useful [32]. They also suggest that cultural differences across countries may have played a role [32]. Education was also unsuccessful in a study of an Italian manufacturing company [64], wherein only 14·7 % of employees accepted voluntary influenza vaccination. These findings suggest that interventions in workplaces need to be better tailored to the target population to achieve sufficient immunisation uptake. The randomised control trial of 53 US companies by Nowalk et al. [84], found that a financial incentive and choice of vaccine improved immunisation rates across workplaces. This finding was consistent in the study by Ofstead [57], which showed improved influenza immunisation rates with a financial incentive among employees of a large manufacturing company in the US. They found primary reasons for accepting the vaccine to be economic rather than health related [57]. These findings suggest greater success may be obtained with financial incentives than education campaigns in improving immunisation rates for those clinically eligible in the workplace, although uptake may vary in countries outside of the US.

6.4. Operational planning and Plan-Do-Study-Act (PDSA) cycles

Demands of operational planning was reported as a barrier to immunisation program delivery in each setting type [16,28,63,80] while also functioning as a successful intervention in multiple included studies [18,23,25,27,40,62,87,89]. In considering requirements for successful vaccine provision [7], this finding is not unexpected. Vaccine service providers must consider supply and ordering issues, cold chain management, storage and handling of vaccines, stock control, minimisation of wasted doses, training of clinical staff and patient safety protocols including management of adverse events [7]. Studies included in the review which placed significance on operational planning, including PDSA cycles tended to report more successful immunisation program delivery than those without [15,16,23–25,30]. The study by Yancey et al. aimed to improve pneumococcal vaccination rates in an acute care hospital setting in the US [25]. They implemented a PDSA cycle optimising vaccination assessment, ordering, obtaining and administration processes, improving vaccination rates from 34·7 % to 90 % over a two-year period [25]. Other studies who utilised the PDSA model employed interventions including education campaigns, clinical reminders, workflow improvement, and gifts [15,16,23,24,30]. These studies ranged across settings, such as in-patient wards, emergency departments, a gastroenterology outpatient clinic, a rheumatology clinic, and a skilled nursing facility [15,16,23,24,30], with each reporting an improvement in immunisation rates. These findings indicate that operational planning is likely to facilitate successful delivery of immunisation outside of primary care settings, and that PDSA cycles may help administrators and clinicians to optimise processes. It is worth noting, however, that the majority of these studies were low quality quasi-experimental designs and failed to report size effect and statistical significance of their results. Future high-quality studies examining the effect of PDSA cycles on facility vaccination rates are required to confirm the success of this intervention.

6.5. Provider education and clinical reminders

Provider clinical reminders were given in the form of adapted forms and note templates, secure electronic reminders, electronic health record prompts, and pharmacy interventions [15–18,20–22,44,45,72]. The study by Rees et al., which aimed to improve influenza and pneumococcal vaccination rates for inpatients at a US university hospital, grouped practitioner education and reminders together as interventions [18]. Unit based reminders, education, and reports were combined with improved workflow and clinical audits between 2009 and 2010 [18]. The intervention group increased immunisation rates from 57 % to 84 %, while the control group immunised patients at a 46 % rate [18]. Reminders alone improved compliance from 47 % to 88 % [18]. These findings are supported by a systematic review conducted by Ward et al. assessing strategies to improve vaccination uptake in Australia [93]. Their findings showed that multi-component strategies, including provider reminders were most effective [93]. Another systematic review by Last et al., showed that clinical nudges, especially those that frame information or enable choice show promise in improving clinical decision-making regarding immunisation [94]. These findings suggest that clinical reminders may assist in increasing immunisation rates and program delivery.

6.6. Limitations

There were several limitations to this scoping review. Firstly, critical appraisal of individual studies was not performed, and therefore an indication of the overall quality of evidence is unable to be included. Not all studies assessed barriers, facilitators and interventions using consistent outcome measures, with findings sometimes described as part of experience reports. Furthermore, studies were conducted in different settings, using a variety of population groups and sample sizes, which limits the ability to meaningfully compare results. Although geographical region was not limited in database searches, the majority of studies included were conducted in high income countries, with only one study published in a low-middle income country. Furthermore, most of these studies were conducted within the US health care system, which may limit replicability in other countries. Finally, although a protocol for this scoping review was drafted it was not published or peer-reviewed prior to undertaking the full study.

7. Conclusion

This scoping review maps the available evidence on the delivery of adult immunisation in non-primary care settings, according to study characteristics and setting types. It describes reported barriers and facilitators and scopes the existing research on interventions to improve

uptake of immunisation in these settings. The findings indicate that immunisation delivery shows promise in multiple settings outside of primary care, including outpatient clinics and workplaces that offer new complementary approaches to increase uptake of adult vaccines.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

AI use statement

The web-based software Rayyan (www.rayyan.ai) was used to facilitate detection of article duplicates, and title and abstract screening during the study search. All identified duplicates, and the titles and abstracts of each article were manually reviewed and approved by EL.

Strengths and limitations

- This study is the first review of its kind to map the existing research on the delivery of adult immunisation outside of primary care settings, barriers and facilitators to delivery, and interventions to improve uptake
- The selection of included studies was limited to peer-reviewed articles published in English
- The study is limited by the general nature of scoping reviews, including a lack of critical appraisal of the strength of evidence of individual studies
- A protocol for the study was not pre-registered

CRediT authorship contribution statement

Eleftheria Lentakis: Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Holly Seale:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Rajeka Lazarus:** Writing – review & editing, Supervision. **Sandra Mounier-Jack:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Holly Seale reports a relationship with University of New South Wales that includes: consulting or advisory and funding grants. Rajeka Lazarus reports a relationship with Severn Pathology that includes: board membership, consulting or advisory, and funding grants. Sandra Mounier-Jack reports a relationship with London School of Hygiene & Tropical Medicine that includes: board membership, consulting or advisory, and funding grants. HS receives institutional funding from Moderna for investigator driven research focused on factors impacting COVID-19 vaccine uptake, payment from Sanofi Pasteur for contributing to a review of vaccine reactogenicity, and support from Moderna for attending a COVID-19 expert meeting.

RL receives funding from GSK via an investigator initiated grant to investigate coadministration of the shingles vaccine with influenza and COVID-19 vaccines, funding from the National Institute of Health Research UK for policy grant: National Immunisation Schedule Consortium, payment from Astra Zeneca for conference presentation in non-promotional sessions, support for attending a conference from Astra Zeneca, is part of the Sanofi Pasteur advisory board, and University of Oxford Data Safety Monitoring Board for three phase one vaccine trials (nipah, plague, and non-typhoid salmonella), is vice president of the British Infection Association, and co-founder of the Clinical Vaccine Network UK.

SMJ receives funding from the Bill and Melinda Gates Foundation for zero dose strategies in fragile countries, the National Institute of Health Research UK for health protection research in immunisation, and UNITAID for the evaluation of IPTI, consulting fees from The Global Alliance on Vaccines and Immunisation as part of an independent review committee, is part of the GABI independent review committee, and currently seconded at UNICEF. If there are other authors, they 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

No data was used for the research described in the article.

Acknowledgments

The authors gratefully acknowledge librarians Helen Jones and Caroline De Brun, who assisted with the literature search.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2024.126458.

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