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Application of quality improvement approaches in healthcare settings to reduce missed opportunities for childhood vaccination: a scoping review

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Abstract:	<p>Background Missed opportunities for vaccination (MOV) is a poor reflection of the quality of care for children attending health facilities. It also contributes to a reduction in overall immunization coverage. Although there is a growing interest in the use of quality improvement (QI) in complex health systems to improve health outcomes, the degree to which this approach has been used to address MOV is poorly understood.</p> <p>Methods We conducted a scoping review using Arksey and O'Malley's framework to investigate the extent to which quality improvement has been used in health facilities to reduce missed opportunities for vaccination. The review followed five stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3) selecting the studies, (4) charting data, and (5) collating, summarizing and reporting results. The search strategy included electronic databases and grey literature.</p> <p>Results We identified 12 literature on quality improvement projects focused on addressing missed opportunities for vaccination. 11 were published manuscripts, and one was a conference presentation. All the QI projects published were conducted in the United States and majority were between 2014 - 2018. A total of 45 change ideas targeting providers, clients, and health system were identified.</p> <p>Conclusion This study generated important evidence on the use of QI in health facilities to reduce MOV. In addition, the result suggests that there is a growing interest in the use of this approach to address MOV in recent years. However, no literature was found in low and middle-income countries especially sub-Saharan Africa.</p>
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Application of quality improvement approaches in healthcare settings to reduce missed opportunities for childhood vaccination: a scoping review

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ABSTRACT

Background

Missed opportunities for vaccination (MOV) is a poor reflection of the quality of care for children attending health facilities. It also contributes to a reduction in overall immunization coverage. Although there is a growing interest in the use of quality improvement (QI) in complex health systems to improve health outcomes, the degree to which this approach has been used to address MOV is poorly understood.

Methods

We conducted a scoping review using Arksey and O'Malley's framework to investigate the extent to which quality improvement has been used in health facilities to reduce missed opportunities for vaccination. The review followed five stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3) selecting the studies, (4) charting data, and (5) collating, summarizing and reporting results. The search strategy included electronic databases and grey literature.

Results

We identified 12 literature on quality improvement projects focused on addressing missed opportunities for vaccination. 11 were published manuscripts, and one was a conference presentation. All the QI projects published were conducted in the United States and majority were between 2014 - 2018. A total of 45 change ideas targeting providers, clients, and health system were identified.

Conclusion

This study generated important evidence on the use of QI in health facilities to reduce MOV. In addition, the result suggests that there is a growing interest in the use of this approach to address MOV in recent years. However, no literature was found in low and middle-income countries especially sub-Saharan Africa.

INTRODUCTION

Immunization is one of the most effective and cost-effective public health interventions for preventing morbidity and mortality from common childhood infectious diseases (1-3). In addition to averting deaths, immunization also improves long-term productivity and has positive ecological externalities (4). As a result childhood immunization is considered a priority child health service in health facilities (5). Despite this, many children who are eligible for vaccination often make contact with health services and are still missed by the immunization sub-system thus resulting in missed opportunities for vaccination (MOV) (6). This MOV can occur during health care visits for curative or preventive services (6, 7). Its prevalence in low-and-middle-income (LMIC) countries is estimated to be 32.2% (6). A recent review on MOV among African children from 14 countries found a pooled prevalence of 27.26% (8). In the same study, the complexity of MOV was highlighted (8). Using complex adaptive systems lens, it was shown that interrelated and interdependent factors which originates from multiple stakeholders including caregivers, health workers as well as health systems managers are responsible for MOV (8). According to the World Health Organization, MOV contributes to a further reduction in childhood immunization coverage level at district and national level (9). Its impact on this important public health indicator has reinvigorate WHO's interest in address it across health systems (9).

Quality improvement (QI), which originated from industrial manufacturing has emerged as one of the main approaches for improving health outcomes within complex health systems (10-13). This is because quality improvement methodologies enable the use of multicomponent interventions concurrently to institute change at multiple levels and allows experiential learning (12, 14, 15). Within the context of immunization programmes, QI would differ from general implementation activities designed to improve uptake of immunization. This is because QI process would involve specific activities like baseline data collection, testing iterative cycles of intervention packages to improve immunization uptake, brainstorming on progress, and periodic reflections on the change packages supported by continuous data collection on the outcome of interest which can then be used to inform modifications. Several quality

improvement models exist, however, the most commonly used are Model for Improvement (MFI), lean, and six-sigma (16-20). Model for improvement is a hybrid of two frameworks; Total Quality Management (TQM) and Rapid Cycle Improvement (RCI) (21). It uses Plan-Do-Study-Act (PDSA) cycles to test change ideas (21). Lean and six sigma are somewhat similar, however lean is concerned with reducing wastage, while six sigma focuses on reducing process variation (22). Lean six sigma is an integration of the two models which focuses on defect prevention and is usually used when wastage and process variation coexists (23).

At core, quality improvement entails process change with resultant variation in outcomes (10, 11). It has been used in health facilities in high-income countries to improve neonatal and child health outcomes (24-26). Similarly, there is also evidence of its use to strengthen health systems in low- and middle-income countries (27). Studies conducted in Rwanda, Ghana, and Nigeria have demonstrated the impact of quality improvement on maternal health outcomes (28-30). However, there is scarcity of information on how quality improvement has been applied within the immunization system to reduce MOV.

Therefore, in this study, we explored the extent to which QI has been used to address MOV using a scoping review methodology (31). We adopted Arksey and O'Malley's framework for conducting scoping review (31). The review followed five stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3) selecting the studies, (4) charting data, and (5) collating, summarizing and reporting results (31). For this study, we defined a scoping review as a research synthesis technique for mapping literature on a particular field of study or topic to identify key concepts and gaps so as to inform further research, as well as policy and practice (32).

We chose to use a scoping review method as we intend to explore the degree to which QI has been applied in healthcare setting to reduce MOV, rather than sum up available evidence on the effect of QI on MOV (33). This review methodology is as transparent as a systematic review as it employs rigorous approaches to identify literature that are relevant to a research question (33). It is suitable for broad questions that would likely combine diverse literature (33). Using a scoping review will enable us to identify different types of change ideas for reducing MOV that

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4 109 have been used to broadly target stakeholders such as caregivers, health workers and health
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6 110 systems (33). Our study filled existing knowledge gap by presenting a broad descriptive
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8 111 overview of the application of QI in healthcare setting to reduce MOV. This study is relevant for
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10 112 researchers as it highlighted the nature and characteristics of available literature on the topic. It
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12 113 is also relevant for health practitioners and policy makers that are planning to use quality
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14 114 improvement approach within their setting to address this problem. This scoping review was
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16 115 conducted before embarking on a quality improvement project in primary healthcare facilities
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18 116 in a resource constrained setting.

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20 117 The objectives of this study were as follows:

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23 118 a) To map and describe existing literature on quality improvement projects to reduce
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25 119 missed opportunities for vaccination within the context of routine childhood
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29 121 b) To identify the quality improvement models, change ideas, and study designs used in
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31 122 quality improvement projects to reduce missed opportunities for vaccination within
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33 123 the context of routine childhood immunization.
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RESULTS

A total of 12 publications met the eligibility criteria for this review. The total number of publications that were assessed for eligibility were 19, and 7 were excluded as shown in **Figure 1**. In two of the excluded studies, the focus was on general pediatric care (34, 35). Others focused on immunization coverage (36-40). The electronic databases search yielded nine publications. Manual search of the reference list of eligible publication yielded an additional two publications. While the grey literature search yielded one conference presentation. No publication was obtained from the organizations that were contacted.

Description of the characteristics of included publications

The country affiliation of all the first authors included in this review was the United States of America (USA). Their type of institutional affiliation varies with 50% affiliated with a university. Majority of included literature were published in the last five years (2014 – 2018). Other bibliometric characteristics of the publications are shown on **Table 1**.

Quality improvement interventions

Most of the quality improvement projects that were conducted covered routine childhood immunization, while four focused solely on human papillomavirus virus (HPV) vaccine. In one of the projects, the age group of the target population for HPV vaccine extended till 26 years. This extension to 26 years of age is a function of United States recommendations for catch-up immunization for women who did not receive HPV vaccine as adolescents. In one of the projects, a QI intervention was instituted in a primary care clinic in Denver to reduce MOV among children up to 25 months of age (41). This clinic is in an inner-city teaching hospital that serves low income families (41). Three difference change ideas; chart prompts, provider education and provider reminders were implemented (41). The change ideas targeted nurses and clinicians (41). Details of each literature with the vaccines and target population are presented on **Table 2**. Although all the quality improvement projects were implemented within a health facility the level of healthcare vary across studies (41-51). The context within which these quality improvement projects were implemented also varies from one another (41-51).

One of the quality improvement practices was implemented within a health center in an urban public university (43). In another study, the quality improvement practice was implemented in a clinic that serves mainly low-income families (41).

In all the quality improvement projects conducted, quality improvement teams implemented multiple change ideas (interventions) targeting various levels of stakeholders (41-51). The change ideas were about evenly divided between provider- and patient-focused strategies with few cross-cutting strategies. On **Table 3**, all the compiled change ideas are classified according to their level of influence.

Quality improvement models, methods and study designs

In three of the reviewed publications, continuous quality improvement (CQI) model was used (45, 46, 51). Only one publication reported the use of collaborative quality improvement model (50). The use of Plan-Do-Study-Act (PDSA) as the method for quality improvement was reported in four studies (44-46, 50). In all the publications quality improvement practice was implemented by quality improvement teams (41-51). In the quality improvement projects identified, quasi experimental designs like pre-post design, before and after studies, and time series designs were used to evaluate the effect of the interventions (41, 45-47, 49-51).

DISCUSSION

Summary of results

We embarked on this scoping review to explore the extent to which quality improvement has been used to address missed opportunities for vaccination within the context of routine childhood immunization. Our objective was to map and describe existing literature, and identify the quality improvement models, change ideas, and study designs used in quality improvement projects. Our search for published and grey literature yield 12 publications (11 published literature, and 1 conference presentation). Based on the charted information from these publications, we found that all the quality improvement projects were implemented in the United States and majority of them were conducted between 2014 and 2018. In the quality improvement projects implemented, multicomponent change ideas were used. We identified 45 change ideas across all the projects and classified them into three namely; interventions for providers, interventions for clients, and cross-cutting interventions. It was beyond the ambit of this scoping review to conduct an evaluation of the methodological quality of individual studies included.

Strengths and limitations of the study

A key strength of this review is that we employed a rigorous and transparent search strategy to identify existing literature on the use of quality improvement to address missed opportunities for vaccination. In addition, we did not restrict our search to any language, date of publication or document type. Some limitations of this review should also be considered. Despite the comprehensiveness of our search strategy, we cannot conclude that we found all the publications due to the broad nature of quality improvement as a field of practice. It is still possible that we missed some papers. We were also unable to obtain publications and reports from organizations engaged in quality improvement projects for immunization, as such, it's possible that other non-public literature exist that have not been included in this review.

Quality improvement and missed opportunities for vaccination

Our study confirms the emerging interest in quality improvement as majority of identified literature were published between 2014 - 2018. As practitioners increasingly understand and begin to view MOV from the complexity lens, a further rise in the use of quality improvement to address it might occur. However, the overall volume of quality improvement projects to address missed opportunities for vaccination, which is a healthcare quality issue with substantial population health implications, was low. Furthermore, all the identified publications were for projects conducted in the United States. Although global organizations such as the World Health Organization recognizes the role of QI in health systems, its use in immunization systems in low- and middle-income countries to reduce missed opportunities for vaccination seems low (52). Many factors including paucity of skills to conduct and report QI interventions or failure to publish QI projects might be contributing to this.

Authors of the publications included in this review reported the use of multiple change ideas which is consistent with the science of improvement (10). While some of these change ideas are targeted at providers, others focus on clients and the system, thus enabling a multipronged approach. However, the process of selection of these change ideas were rarely described enough to enable replication in other settings. In a resident-led clinical QI project to improve immunization rate, third year residents engage immunization stakeholders to implement a set of activities (45). These activities include printing daily immunization reports, distributing them to health care providers and discussion about immunization with parents and guardians (45). However, it is unclear how the residents arrived at these choice of change ideas (45).

Most of the quality improvement projects reviewed reported only the quality improvement outcome measure and this practice is inconsistent with current guidance on quality improvement in healthcare (53). It is essential to include and report on process and balancing measures as well (53). Process measures will enable QI practitioners to track whether the system is performing as planned (53). While balancing measure will allow tracking of the influence of the quality improvement project on other parts of the system (53). Balancing measures are particularly important as it will provide information on whether the change ideas

causing improvement in one unit, is decreasing a desirable outcome in others. In addition to these measures, more recent improvement models have also included implementation outcomes (54).

Due to the “real world” context within which quality improvement are implemented, quasi experimental designs are sometimes more feasible (55). As expected, most of the publications reported the use of these study designs. However, it is important to consider additional design features to these quasi-experimental designs or conduct pragmatic or hybrid trials to improve confidence in the effect measure attributed to quality improvement interventions (56-59).

Implications for research

In view of our findings, we recommend more research. Our research recommendations, which follows the EPICOT+ format are presented in **Box 1** (60).

Box 1: Use of EPICOT+ to highlight research recommendations based on gaps identified in a scoping review on the use of quality improvement to address missed opportunities for vaccination

Element	Recommendation(s)
	Core elements
Evidence (State of evidence)	Existing quality improvement projects for addressing missed opportunities for vaccination among children were conducted in the United States.
Population (Population of interest)	Quality improvement projects addressing missed opportunities for vaccination targeting; <ul style="list-style-type: none"> a. Children in low- and middle-income countries especially in sub-Saharan Africa b. HIV exposed infants c. Children in internally displaced persons camps d. Children in hard to reach areas e. Children in urban areas (slums and non-slums)

f. Adolescents including those in LMICs	
Interventions	<p>a. Quality improvement projects with multiple change ideas targeted at different stakeholders that are systematically selected from evidence-based innovation or generated de-novo by healthcare workers in quality improvement teams.</p> <p>b. Collaborative quality improvement projects encompassing the attributes of (a) above.</p>
Comparisons	Control (non-intervention) health facilities
Outcomes	<p>a. Proportion of missed opportunities for vaccination disaggregated by vaccines and vaccine doses.</p> <p>b. Process outcomes to measure how the quality improvement interventions were delivered</p> <p>c. Balancing outcome to assess the effect of quality improvement on other program areas</p> <p>d. Implementation outcomes such as acceptability, adoption, appropriateness, fidelity, feasibility, cost, penetration and sustainability</p>
Time stamp	July 2018
Optional element	
Study type	Quasi experimental design (Interrupted time series design with non-equivalent control groups), pragmatic trials and implementation-effectiveness hybrid trials.

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251 We recommend the use of standardized guidance such as Standards for Quality Improvement
252 Reporting Excellence - SQUIRE 2.0 to report future studies (61). This would greatly enhance the
253 sharing of best practices. Also, researcher and practitioners can place related grey literature on
254 repositories that are accessible to wide range of audience.

METHODOLOGY

A review team was established comprising of the principal investigator and three supervisors with expertise in research synthesis, epidemiology and vaccinology (62). The team deliberated upon and agreed on the broad research question to be addressed as well as the review protocol.

Stage 1: Identify the research question

The scoping review question was, “What is the nature and extent of use of quality improvement approaches in health facilities to reduce missed opportunities for vaccination within the context of routine childhood immunization?” Due to the broad nature of this review question, with its main focus on mapping existing literature, a systematic review would not be appropriate (63). Since emerging consensus on knowledge synthesis methodologies have made clearer the applicability of a broad range of other methods, we used this to inform our choice of scoping review methodology to answer this question (64, 65).

Since routine childhood immunization for children extend to those in the adolescent age group, they were included as part of the population of interest (66). The detailed Population Intervention Comparator and Outcome (PICO) elements for the review question is shown in **Box 2**.

Box 2: PICO Elements for scoping review question

Population	Children and adolescents
Intervention	Quality improvement
Comparator	Usual practice
Outcome	Proportion, frequency or percentage of missed opportunities for vaccination
Study setting	Health facilities

For this study, we adopted the Cochrane Effectiveness Practice and Organization of Care (EPOC) group’s definition of quality improvement (QI) as “an iterative process to review and improve care that includes the involvement of healthcare teams, analysis of a process or system, a

structured process improvement method or problem-solving approach, and use of data analysis to assess change” (67). Since our interest is in routine childhood immunization, the following antigens were considered: Bacillus Calmette-Guerin (BCG), hepatitis B, Polio, Diphtheria-Tetanus-Pertussis containing vaccine, *Haemophilus influenzae type b*, pneumococcal (conjugate), rotavirus, measles, rubella and human papilloma virus (66). Other antigens such as: yellow fever, Japanese encephalitis, tick-borne encephalitis, typhoid, cholera, meningococcal, hepatitis A, rabies, dengue, mumps, seasonal influenza, and varicella, that are indicated for children under certain conditions like place of residence, type of population, and immunization programme were also considered (66).

Stage 2: Identifying relevant studies

To identify literature (published and unpublished) appropriate for answering the research question, we employed a search strategy involving:

1. Three (3) electronic databases and manual search of reference lists of relevant studies
2. Google search
3. Contacting networks and organizations involved in quality improvement

Electronic databases

Three (3) electronic databases: PubMed, Scopus, and Web of Science were searched on 4th July 2018 on the internet. These databases were selected to ensure a comprehensive inclusion of all published literature. To ensure that all possible publications were found, date, language, or document type restrictions were not specified during database search. Using the research question, we developed the following search terms: “quality improvement”, “implementation strategy” “implementation process”, “Plan do study act”, “define measure analyze improve control”, “define measure analyse improve control”, “define measure analyse design verify”, “define measure analyze design verify”, “lean six sigma”, “immunization”, “missed opportunities”, “infant”, “childhood”, “teenager” and “adolescent” among others. These search terms are keywords that combines quality improvement with missed opportunities for vaccination in children and adolescent. The search terms were tailored to each database. Detailed search strategy developed with input from an information specialist is attached as

Appendix 1. All citations exported from databases were imported to Endnote X7.7.1. While on the reference manager, duplicate of citations were removed. The reference list of the selected manuscripts was also manually searched to identify any relevant paper that reported the use of quality improvement approach to address missed opportunities for vaccination.

Grey literature

Advanced Google search using the following url: https://www.google.com/advanced_search was implemented to identify grey literature that are relevant to the review question (68). The keywords that were used for electronic database search were also applied. The search filters were left at their default setting so as to include results in any language, from any geographical region, and without data limits among others. Since Google search has the tendency to produce high search volume, we limited our search to the first fifty (50) results (69).

Networks and organizations

Experts at the American Academy of Pediatrics were contacted by email with a request for any published or unpublished report on the use of quality improvement approaches to address missed opportunities for vaccination among children. The use of quality improvement practices is part of the academy's mission of ensuring high standards of health for children (70).

Stage 3: Study selection

A set of eligibility criteria with inclusion and exclusion criteria were developed while preparing the protocol to help in removing studies that did not answer the review question. It was agreed that these eligibility criteria can be modified post-hoc as the authors become more familiar with the studies.

Inclusion criteria were as follows:

- a. All literature reporting a quality improvement approach aimed at reducing missed opportunities for vaccination for children and adolescents.
- b. Vaccines that are used for routine immunization
- c. QI approaches implemented in a health facility setting

Exclusion criteria were as follows:

- a. Quality improvement aimed at improving immunization rate in high-risk children with deficient immune system
- b. QI approaches implemented within a community setting

After identifying relevant literature, two authors independently screened the titles and abstracts of all publications obtained from the electronic databases. If the studies broadly described the use of quality improvement in a health facility setting to reduce missed opportunities for vaccination, its full text was retrieved. There was no masking of reviewers involved in the screening to author name or journal. It was agreed *apriori* that the full text of publications without abstracts will automatically be considered. The prespecified inclusion and exclusion criteria were applied to the full text of the publications to identify the “best fit”. The assistance of librarians at the medicine and health sciences library of Stellenbosch University, South Africa, was sought to help retrieve articles that were published in journals that the university did not subscribe to. It was also agreed that if full text could not be retrieved, then abstract can used. During the study selection, the two reviewers resolved any disagreements through discussion. **Figure 1** is a four-phased flow diagram from identification through inclusion (71). The Google search results were also screened by the two authors.

Stage 4: Charting the data

Two authors independently charted key information from the included publications. An Excel spreadsheet was used for this purpose. The charting approach used was similar to that of a narrative review as we obtained information about the QI projects (72). The recorded information is presented on **Table 4**.

Stage 5: Collating, summarizing and reporting the results

Charted information was collated using Microsoft Excel 2016. Same software was used for coding the data. Analysis was done using Microsoft Excel as well. Number of published literatures over the study periods were calculated. Descriptive statistics (frequency and percentage) of country affiliation, language of publication, publication type, and institutional

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373 affiliation of authors was also calculated. Vaccines targeted in each quality improvement
374 interventions were presented.

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CONCLUSION

This scoping review identified and described the extent of current publications on use of quality improvement approach to address MOV. There is a growing interest in the use of quality improvement to improve health outcomes, and this was also observed for MOV. Given that only few publications were found, all of which were conducted in the United States, buttresses the need for this systematic appraisal of currently available literature. No published or grey literature was found in low and middle-income countries especially sub-Saharan Africa.

COMPETING INTERESTS

None declared

CONTRIBUTORS

AAA conceptualized the study, drafted the review protocol, conducted the literature search, screened publications and charted data, conducted the data analysis and interpretation, and wrote the first draft of the manuscript. CSW, OAU, MAG reviewed and approved the protocol, contributed to data analysis and interpretation, manuscript development and approved the final manuscript. EOW screened publication and charted of data and contributed to manuscript development.

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4 **419 ETHICS APPROVAL**

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**Application of quality improvement approaches in healthcare settings
to reduce missed opportunities for childhood vaccination: ~~a~~ —A
scoping review**

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29 **ABSTRACT**

30 **Background**

31 Missed opportunities for vaccination (MOV) ~~is a complex problem that is a poor reflection~~
32 ~~of impact on the the overall~~ quality of care for children ~~attending in~~ health facilities. ~~It also~~
33 ~~contributes to a reduction in immunization coverage level at district and national level. -~~

34 Although there is a growing interest in the use of quality improvement (QI) in complex health
35 systems to improve health outcomes, the degree to which ~~this approach~~ has been used to
36 address MOV is poorly understood.

37 **Methods**

38 We conducted a scoping review using Arksey and O'Malley's framework to investigate the
39 extent to which quality improvement has been used in health facilities to reduce missed
40 opportunities for vaccination. The review followed five stages as follows: (1) identifying the
41 research question, (2) identifying the relevant studies, (3) selecting the studies, (4) charting
42 data, and (5) collating, summarizing and reporting results. The search strategy included
43 electronic databases and grey literature.

44 **Results**

45 We identified 12 ~~literature publications~~ on quality improvement projects focused on addressing
46 missed opportunities for vaccination. 11 were published ~~manuscripts literatures~~, and one ~~(1)~~
47 was a conference presentation. All the QI projects published were conducted in the United
48 States and majority were between 2014 - 2018. A total of 4~~52~~ change ideas targeting providers,
49 clients, and health system were identified.

50 **Conclusion**

This study generated important evidence on the use of QI in health facilities to reduce MOV. In addition, the result suggests that there is a growing interest in the use of this approach to address MOV in recent years. However, no literature was found in low and middle-income countries especially sub-Saharan Africa. study found evidence of the use of QI approaches to address MOV in health facilities.

Keywords

Missed opportunities for vaccination, quality improvement, scoping review, quality of care

INTRODUCTION

Immunization is one of the most effective and cost-effective public health interventions for preventing morbidity and mortality from common childhood infectious diseases (1-3). In addition to averting deaths, immunization also improves long-term productivity and has positive ecological externalities (4). As a result childhood immunization is backed by existing evidence, immunization is considered regarded as a priority child health service in health facilities (5). In fact, checking immunization status and providing appropriate vaccination is a component of the World Health Organization's (WHO) recommended standards for quality of care in children (5). Despite this, many children who are eligible for vaccination often many eligible children who make contact with health services and are still missed by the immunization sub-system thus resulting in missed opportunities for vaccination (MOV) for immunization (6). This MOV This is referred to as missed opportunities for vaccination (MOV), and it can occur during health care visits for curative or preventive services (6, 7). Its prevalence in low-and-middle-income (LMIC) countries The prevalence is of MOV- estimated to be vary across settings, however, a pooled prevalence of 32.2% was found for low and middle income (LMIC) countries (6). A recent review on MOV among African children from 14 countries found a pooled prevalence of 27.26% (8). In the same study, the complexity of MOV was highlighted (8). Using complex adaptive systems lens, it was shown that interrelated and interdependent factors which originates from

~~multiple stakeholders including caregivers, health workers as well as health systems managers are responsible for MOV (8). According to the World Health Organization, MOV contributes to a further reduction in childhood immunization coverage level at district and national level (9). Its impact on this important public health indicator has reinvigorate WHO's interest in address it across health systems (9). The factors that are responsible for MOV are complex and involve multiple stakeholders (9-11). As such, quality improvement, might be a potential approach to addressing it.~~

Quality improvement (QI), which originated from industrial manufacturing has emerged as one of the main approaches for improving health outcomes within complex health systems (10-13). This is because quality improvement methodologies enable the use of multicomponent interventions concurrently to institute change at multiple levels and allows experiential learning (12, 14, 15). Within the context of immunization programmes, QI would differ from general implementation activities designed to improve uptake of immunization. This is because QI process would involve specific activities like baseline data collection, testing iterative cycles of intervention packages to improve immunization uptake, brainstorming on progress, and periodic reflections on the change packages supported by continuous data collection on the outcome of interest which can then be used to inform modifications. Several quality improvement models exist, however, the most commonly used are Model for Improvement (MFI), lean, and six-sigma (16-20). Model for improvement is a hybrid of two frameworks; Total Quality Management (TQM) and Rapid Cycle Improvement (RCI) (21). It uses Plan-Do-Study-Act (PDSA) cycles to test change ideas (21). Lean and six sigma are somewhat similar, however lean is concerned with reducing wastage, while six sigma focuses on reducing process variation (22). Lean six sigma is an integration of the two models which focuses on defect prevention and is usually used when wastage and process variation coexists (23).

At core, quality improvement entails process change with resultant variation in outcomes (10, 11). It has been used in health facilities in high-income countries to improve neonatal and child health outcomes (24-26). Similarly, there is also evidence of its use to strengthen health systems in low- and middle-income countries (27). Studies conducted in Rwanda, Ghana, and Nigeria have demonstrated the impact of quality improvement on maternal health outcomes

(28-30). However, there is scarcity of information on how quality improvement has been applied within the immunization system to reduce MOV.

Therefore, in this study, we explored the extent to which QI quality improvement has been used to address MOV using a scoping review methodology (31). We adopted Arksey and O'Malley's framework for conducting scoping review (31). The review followed five stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3) selecting the studies, (4) charting data, and (5) collating, summarizing and reporting results (31). For this study, we defined a scoping review as a research synthesis technique for mapping literature on a particular field of study or topic to identify key concepts and gaps so as to inform further research, as well as policy and practice (32).

We chose to use a scoping review method as we intend to explore the degree to which QI has been applied in healthcare setting to reduce MOV, rather than sum up available evidence on the effect of QI on MOV (33). This review methodology is as transparent as a systematic review as it employs rigorous approaches to identify literature that are relevant to a research question (33). It is suitable for broad questions that would likely combine diverse literature (33). Using a scoping review will enable us to identify different types of change ideas for reducing MOV that have been used to broadly target stakeholders such as caregivers, health workers and health systems (33). Our study This will fill existing knowledge gap by presenting a broad descriptive overview of the application its application of QI in healthcare setting to reduce MOV. This study is relevant for researchers as it highlighted the nature and characteristics of available literature primary research on the topic. It is also relevant for health practitioners and policy makers that are planning to use quality improvement approach within their setting to address this problem. This scoping review was conducted before embarking on a quality improvement project in primary healthcare facilities in a resource constrained setting.

The objectives of this study ~~were~~is as follows:

- a) To map and describe existing literature on quality improvement projects to reduce missed opportunities for vaccination within the context of routine childhood immunization.

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~~b) publications To, and~~ identify the quality improvement models, change ideas, and study designs used in quality improvement projects to reduce missed opportunities for vaccination within the context of routine childhood immunization.

~~R~~RESULTS

A total of 12 publications met the eligibility criteria for this review. The total number of publications that were assessed for eligibility were 19, and 7 were excluded as shown in Figure 1. In two of the excluded studies, the focus was on general pediatric care (34, 35). Others focused on immunization coverage (36-40). The electronic databases search yielded nine publications. Manual search of the reference list of eligible publication yielded an additional two publications. While the grey literature search yielded one conference presentation. No publication was obtained from the organizations that were contacted.

Description of the characteristics of included publications

The country affiliation of all the first authors included in this review was the United States of America (USA). Their type of institutional affiliation varies with 50% affiliated with a university. Majority of included literature were published in the last five years (2014 – 2018). Other bibliometric characteristics of the publications are shown on **Table 1**.

Quality improvement interventions

Most of the quality improvement projects that were conducted covered routine childhood immunization, while four focused solely on human papillomavirus virus (HPV) vaccine. In one of the projects, the age group of the target population for human papillomavirus-HPV vaccine extended till 26 years. This extension to 26 years of age is a function of United States recommendations for catch-up immunization for women who did not receive HPV vaccine as adolescents. In one of the projects, a QI intervention was instituted in a primary care clinic in Denver to reduce MOV among children up to 25 months of age (41). This clinic is in an inner-city teaching hospital that serves low income families (41). Three difference change ideas; chart prompts, provider education and provider reminders were implemented (41). The change ideas targeted nurses and clinicians (41). Details of each literature publication with the vaccines and target population are presented on **Table 2**. Although all the quality improvement projects were implemented within a health facility the level of healthcare vary across studies (41-51). The context within which these quality improvement projects were implemented also varies from one another (41-51). One of the quality improvement practices was implemented within

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182 a health center in an urban public university (43). In another study, the quality improvement
183 practice was implemented in a clinic that serves mainly low-income families (41).
184 In all the quality improvement projects conducted, quality improvement teams implemented
185 multiple change ideas (interventions) targeting various levels of stakeholders (41-51). ~~IMajority~~
186 ~~of the change ideas were about evenly divided between provider- and patient-focused~~
187 ~~strategies with few cross-cutting strategies. implemented were provider targeted.~~ On **Table 3**,
188 all the compiled change ideas are classified according to their level of influence.

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190 ***Quality improvement models, methods and study designs***

191 In three of the reviewed publications, continuous quality improvement (CQI) model was used
192 (45, 46, 51). Only one publication reported the use of collaborative quality improvement model
193 (50). The use of Plan-Do-Study-Act (PDSA) as the method for quality improvement was reported
194 in four studies (44-46, 50). In all the publications quality improvement practice was
195 implemented by quality improvement teams (41-51). In the quality improvement projects
196 identified, quasi experimental designs like pre-post design, before and after studies, and time
197 series designs were used to evaluate the effect of the interventions (41, 45-47, 49-51).

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212 DISCUSSION

213 Summary of results

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214 We embarked on this scoping review to explore the extent to which quality improvement has
215 been used to address missed opportunities for vaccination within the context of routine
216 childhood immunization. Our objective was to map and describe existing literature publications,
217 and identify the quality improvement models, change ideas, and study designs used in quality
218 improvement projects. Our search for published and grey literature yield 12 publications (11
219 published literature, and 1 conference presentation). Based on the charted information from
220 these publications, we found that all the quality improvement projects were implemented in
221 the United States and majority of them were conducted between 2014 and 2018. ~~The first~~
222 ~~authors had diverse institutional affiliations such as universities, hospitals and government~~
223 ~~agencies were reported.~~ In the quality improvement projects implemented, multicomponent
224 change ideas were used. We identified ~~45~~ 2 change ideas across all the projects and classified
225 them into three namely; interventions for providers, interventions for clients, and cross-cutting
226 interventions. ~~Continuous quality improvement model and collaborative quality improvement~~
227 ~~were reported by some authors. Also, plan-do-study-act (PDSA) was used as the quality~~
228 ~~improvement method in some of the projects. Quasi-experimental designs such as time series~~
229 ~~designs, pre-post design and before and after studies were employed in evaluating the quality~~

~~improvement interventions.~~ It was beyond the ambit of this scoping review to conduct an evaluation of the methodological quality of individual studies included.

Strengths and limitations of the study

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A key strength of this review is that we employed a rigorous and transparent search strategy to identify existing literature on the use of quality improvement to address missed opportunities for vaccination. In addition, we did not restrict our search to any language, date of publication or document type. Some limitations of this review should also be considered. Despite the comprehensiveness of our search strategy, we cannot conclude that we found all the publications due to the broad nature of quality improvement as a field of practice. It is still possible that we missed some papers. We were also unable to obtain publications and reports from organizations engaged in quality improvement projects for immunization, as such, it's possible that other non-public literature exist that have not been included in this review.

Quality improvement and missed opportunities for vaccination

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Our study confirms the emerging interest in quality improvement as majority of identified literature were published between 2014 - 2018. As practitioners increasingly understand and begin to view MOV from the complexity lens, a further rise in the use of quality improvement to address it might occur. However, the overall volume of quality improvement projects to address missed opportunities for vaccination, which is a healthcare quality issue with substantial population health implications, was low. Furthermore, all the identified publications were for projects conducted in the United States. Although global organizations such as the World Health Organization recognizes the role of ~~QI~~quality improvement in health systems, its use in immunization systems in low- and middle-income countries to reduce missed opportunities for vaccination seems low (52). Many factors including paucity of skills to conduct and report QI interventions or failure to publish ~~QI~~quality improvement projects ~~and lack of skills might be contributing to this.~~ ~~-could have accounted for this.~~

257 Authors of the publications included in this review reported the use of multiple change ideas
258 which is consistent with the science of improvement (10). While some of these change ideas
259 are targeted at providers, others focus on clients and the system, thus enabling a multipronged
260 approach. However, the process of selection of these change ideas were rarely described
261 enough to enable replication in other settings. In a resident-led clinical QI project to improve
262 immunization rate, third year residents engage immunization stakeholders to implement a set
263 of activities (45). These activities include printing daily immunization reports, distributing them
264 to health care providers and discussion about immunization with parents and guardians (45).
265 However, it is unclear how the residents arrived at these choice of change ideas (45).

266 Most of the quality improvement projects reviewed reported only the quality improvement
267 outcome measure and this practice is inconsistent with current guidance on quality
268 improvement in healthcare (53). It is essential to include and report on process and balancing
269 measures as well (53). Process measures will enable QI practitioners to track whether the
270 system is performing as planned (53). While balancing measure will allow tracking of the
271 influence of the quality improvement project on other parts of the system (53). Balancing
272 measures are particularly important as it will provide information on whether the change ideas
273 causing improvement in one unit, is decreasing a desirable outcome in others. In addition to
274 these measures, more recent improvement models have also included implementation
275 outcomes (54).

276 Due to the “real world” context within which quality improvement are implemented, quasi
277 experimental designs are sometimes more feasible (55). As expected, most of the publications
278 reported the use of these study designs. However, it is important to consider additional design
279 features to these quasi-experimental designs or conduct pragmatic or hybrid trials to improve
280 confidence in the effect measure attributed to quality improvement interventions (56-59).

281 Implications for research

282 In view of our findings, we recommend more research. Our research recommendations, which
283 follows the EPICOT+ format are presented in **Box 12** (60).

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Box **12**: Use of EPICOT+ to highlight research recommendations based on gaps identified in a scoping review on the use of quality improvement to address missed opportunities for vaccination

Element	Recommendation(s)
	Core elements
Evidence (State of evidence)	Existing quality improvement projects for addressing missed opportunities for vaccination among children were conducted in the United States.
Population (Population of interest)	<p>Quality improvement projects addressing missed opportunities for vaccination targeting;</p> <ul style="list-style-type: none"> a. Children in low- and middle-income countries especially in sub-Saharan Africa b. a. Children aged 0–23 months c. b. HIV exposed infants d. c. Children in internally displaced persons camps e. d. Children in hard to reach areas f. e. Children in urban areas (slums and non-slums) g. f. Adolescents including those in LMICs
Interventions	<ul style="list-style-type: none"> a. Quality improvement projects with multiple change ideas targeted at different stakeholders that are systematically selected from evidence-based innovation or generated de-novo by healthcare workers in quality improvement teams. b. Collaborative quality improvement projects encompassing the attributes of (a) above.
Comparisons	Control (non-intervention) health facilities

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Outcomes	<ul style="list-style-type: none"> a. Proportion of missed opportunities for vaccination disaggregated by vaccines and vaccine doses. b. Process outcomes to measure how the quality improvement interventions were delivered c. Balancing outcome to assess the effect of quality improvement on other program areas d. Implementation outcomes such as acceptability, adoption, appropriateness, fidelity, feasibility, cost, penetration and sustainability
Time stamp	July 2018
Study type	<p>Optional element</p> <p><u>Quasi experimental design</u> (Interrupted time series design with non-equivalent control groups), <u>pragmatic trials and implementation-effectiveness hybrid trials.</u></p>

We recommend the use of standardized guidance such as Standards for QQuality Improvement Reporting Excellence - SQUIRE 2.0 to report future studies (61). This would greatly enhance the sharing of best practices. Also, researcher and practitioners can place related grey literature on repositories that are accessible to wide range of audience.

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305 **METHODOLOGY**

306 ~~This scoping review was conducted before embarking on a quality improvement project with~~
307 ~~health workers in primary healthcare facilities in a resource constrained setting.~~ A review team
308 was established comprising of the principal investigator and three supervisors with expertise in
309 research synthesis, epidemiology and vaccinology (62). The team deliberated upon and agreed
310 on the broad research question to be addressed as well as the review protocol. ~~We adopted~~
311 ~~Arksey and O'Malley's framework for conducting scoping review (33). The review followed five~~
312 ~~stages as follows: (1) identifying the research question, (2) identifying the relevant studies, (3)~~
313 ~~selecting the studies, (4) charting data, and (5) collating, summarizing and reporting results~~
314 ~~(33). For this study, we defined a scoping review as a research synthesis technique for mapping~~

315 literature on a particular field of study or topic to identify key concepts and gaps so as to inform
316 further research, as well as policy and practice (34).

317 Stage 1: Identify the research question

318 The scoping review question was, “What is the nature and extent of use of quality
319 improvement approaches in health facilities to reduce missed opportunities for vaccination
320 within the context of routine childhood immunization?” Due to the broad nature of this review
321 question, with its main focus on mapping existing literature, a systematic review would not be
322 appropriate (63). Since emerging consensus on knowledge synthesis methodologies have made
323 clearer the applicability of a broad range of other methods, we used this to inform our choice of
324 scoping review methodology to answer this question (64, 65).

325 Since routine childhood immunization for children extend to those in the adolescent age group,
326 they were included as part of the population of interest (66). The detailed Population
327 Intervention Comparator and Outcome (PICO) elements for the review question is shown in **Box**
328 **1**.

329 Box 1: PICO Elements for scoping review question

Population	Children and adolescents
Intervention	Quality improvement
Comparator	Usual practice
Outcome	Proportion, frequency or percentage of missed opportunities for vaccination
Study setting	Health facilities

330 For this study, we adopted the Cochrane Effectiveness Practice and Organization of Care (EPOC)
331 group’s definition of quality improvement (QI) as “an iterative process to review and improve
332 care that includes the involvement of healthcare teams, analysis of a process or system, a
333 structured process improvement method or problem-solving approach, and use of data analysis
334 to assess change” (67). Since our interest is in routine childhood immunization, the following
335 antigens were considered: Bacillus Calmette-Guerin (BCG), hepatitis B, Polio, Diphtheria-

336 Tetanus-Pertussis containing vaccine, *Haemophilus influenzae type b*, pneumococcal
337 (conjugate), rotavirus, measles, rubella and human papilloma virus (66). Other antigens such as:
338 yellow fever, Japanese encephalitis, tick-borne encephalitis, typhoid, cholera, meningococcal,
339 hepatitis A, rabies, dengue, mumps, seasonal influenza, and varicella, that are indicated for
340 children under certain conditions like place of residence, type of population, and immunization
341 programme were also considered (66).

342 **Stage 2: Identifying relevant studies**

343 To identify literature (published and unpublished) appropriate for answering the research
344 question, we employed a search strategy involving:

- 345 1. Three (3) electronic databases and manual search of reference lists of relevant studies
- 346 2. Google search
- 347 3. Contacting networks and organizations involved in quality improvement

348 *Electronic databases*

349 Three (3) electronic databases: PubMed, Scopus, and Web of Science were searched on 4th July
350 2018 on the internet. These databases were selected to ensure a comprehensive inclusion of all
351 published literature. To ensure that all possible publications were found, date, language, or
352 document type restrictions were not specified during database search. Using the research
353 question, we developed the following search terms: “quality improvement”, “implementation
354 strategy” “implementation process”, “Plan do study act”, ~~“plan do check act”~~, “define measure
355 analyze improve control”, “define measure analyse improve control”, “define measure analyse
356 design verify”, “define measure analyze design verify”, “lean six sigma”, “immunization”,
357 ~~“vaccination”~~, “missed opportunities”, “infant”, ~~“newborn”~~, ~~“child”~~, “childhood”, “teenager”
358 and “adolescent” among others. These search terms are keywords that combines quality
359 improvement with missed opportunities for vaccination in children and adolescent. The search
360 terms were tailored to each database. Detailed search strategy developed with input from an
361 information specialist is attached as **Appendix 1**. All citations exported from databases were
362 imported to Endnote X7.7.1. While on the reference manager, duplicate of citations were
363 removed. The reference list of the selected manuscripts was also manually searched to identify

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any relevant paper that reported the use of quality improvement approach to address missed opportunities for vaccination.

Grey literature

Advanced Google search using the following url: https://www.google.com/advanced_search was implemented to identify grey literature that are relevant to the review question (68). The keywords that were used for electronic database search were also applied. The search filters were left at their default setting so as to include results in any language, from any geographical region, and without data limits among others. Since Google search has the tendency to produce high search volume, we limited our search to the first fifty (50) results (69).

Networks and organizations

Experts at the American Academy of Pediatrics were contacted by email with a request for any published or unpublished report on the use of quality improvement approaches to address missed opportunities for vaccination among children. The use of quality improvement practices is part of the academy's mission of ensuring high standards of health for children (70).

Stage 3: Study selection

A set of eligibility criteria with inclusion and exclusion criteria were developed while preparing the protocol to help in removing studies that did not answer the review question. It was agreed that these eligibility criteria can be modified post-hoc as the authors become more familiar with the studies.

Inclusion criteria were as follows:

- a. All literature reporting a quality improvement approach aimed at reducing missed opportunities for vaccination for children and adolescents.
- b. Vaccines that are used for routine immunization
- c. QI approaches implemented in a health facility setting

Exclusion criteria were as follows:

- a. Quality improvement aimed at improving immunization rate in high-risk children with deficient immune system
- b. QI approaches implemented within a community setting

After identifying relevant literature, two authors independently screened the titles and abstracts of all publications obtained from the electronic databases. If the studies broadly described the use of quality improvement in a health facility setting to reduce missed opportunities for vaccination, its full text was retrieved. There was no masking of reviewers involved in the screening to author name or journal. It was agreed *apriori* that the full text of publications without abstracts will automatically be considered. The prespecified inclusion and exclusion criteria were applied to the full text of the publications to identify the “best fit”. The assistance of librarians at the medicine and health sciences library of Stellenbosch University, South Africa, was sought to help retrieve articles that were published in journals that the university did not subscribe to. It was also agreed that if full text could not be retrieved, then abstract can used. During the study selection, the two reviewers resolved any disagreements through discussion. **Figure 1** is a four-phased flow diagram from identification through inclusion (71). The Google search results were also screened by the two authors.

Stage 4: Charting the data

Two authors independently charted key information from the included publications. An Excel spreadsheet was used for this purpose. The charting approach used was similar to that of a narrative review as we obtained information about the QI quality improvement projects published (72). The recorded information is presented on **Table 4**.

Stage 5: Collating, summarizing and reporting the results

Charted information was collated using Microsoft Excel 2016. Same software was used for coding the data. Analysis was done using Microsoft Excel as well. Number of published literatures over the study periods were calculated. Descriptive statistics (frequency and percentage) of country affiliation, language of publication, publication type, and institutional

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417 affiliation of authors was also calculated. Vaccines targeted in each quality improvement
418 interventions were presented.

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438 CONCLUSION

439 This scoping review identified and described the extent of current publications on use of quality
440 improvement approach to address MOV. There is a growing interest in the use of quality
441 improvement to improve health outcomes, and this was also observed for MOV. Given that
442 only few publications were found, all of which were conducted in the United States, buttresses
443 the need for this systematic appraisal of currently available literature. No published or grey
444 literature was found in low and middle-income countries especially sub-Saharan Africa.

445 COMPETING INTERESTS

446 None declared

447 CONTRIBUTORS

448 AAA conceptualized the study, drafted the review protocol, conducted the literature search,
449 screened publications and charted data, conducted the data analysis and interpretation, and
450 wrote the first draft of the manuscript. CSW, OAU, MAG reviewed and approved the protocol,
451 contributed to data analysis and interpretation, manuscript development and approved the
452 final manuscript. EOW screened publication and charted of data and contributed to manuscript
453 development.

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465 **ETHICS APPROVAL**

466 Not applicable

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Table 1: General features of publications on use of quality improvement to address missed opportunities for vaccination

Characteristics	Frequency	Percentage
Year of publication		
1999–2003	2	16.67
2004–2008	1	8.33
2009–2013	0	
2014–2018	9	75.00
Country affiliation		
United States of America	12	100
Others	0	
Publication type		
Published literature	11	91.67
Conference proceedings	1	8.33
Type of institutional affiliations		

Characteristics	Frequency	Percentage
University	5	41.67
Hospital	4	33.33
Government agency	3	25.00

Table 2: Target population and vaccine(s) targeted in quality improvement practices to address missed opportunities for vaccination

Authors	Study title	Target population	Vaccine(s)
Published literature			
Daley, M. F., et al.	Quality improvement in immunization delivery following an unsuccessful immunization recall(41)	children aged 3–35 months	All routine immunization
Daly, K. L., et al.	A University Health Initiative to Increase Human Papillomavirus Vaccination Rates(43)	Young adults aged 18–26 years	Human papillomavirus (HPV) vaccine
Fiks, A. G., et al.	Improving HPV Vaccination Rates Using Maintenance of Certification Requirements(44)	Adolescents aged 11–17 years	Human papillomavirus (HPV) vaccine
Jones, K. B., et al.	Improving Immunizations in Children: A Clinical Break-even Analysis(46)	children aged three years and below	All routine immunization

Authors	Study title	Target population	Vaccine(s)
Krantz, L., et al.	Increasing HPV Vaccination Coverage Through Provider-Based Interventions(47)	Adolescents aged 13–17 years	Human papillomavirus (HPV) vaccine
Moore, K. L., et al.	Tennessee's 3-Star Report: Using Available Data Systems to Reduce Missed Opportunities to Vaccinate Preteens(49)	Adolescents aged 11–13 years	Tetanus-diphtheria-pertussis vaccine (Tdap), Quadrivalent meningococcal vaccine (Men-ACWY), and Human papillomavirus (HPV) vaccine
Rand, C. M., et al.	A Learning Collaborative Model to Improve Human Papillomavirus Vaccination Rates in Primary Care(50)	Adolescents aged 11–17 years	Human papillomavirus (HPV) vaccine
Jones, K. B., et al.	Improving pediatric immunization rates: description of a resident-led clinical-continuous quality improvement project(45)	children aged three years and below	All routine immunization
Sinn, J. S., et al.	Improving immunization rates in private pediatric practices through physician leadership(51)	children aged 9 to 30 months	All routine immunization
Melinkovich, P., et al.	Improving pediatric immunization rates in a safety-net delivery system(48)	children aged three years and below	All routine immunization
Carlin, E., et al.	Using Continuous Quality Improvement Tools to Improve Pediatric Immunization Rates(42)	children aged two years and below	All routine immunization
Conference presentation			
Gurov, Heidi	Assessment-Feedback-Incentive-Exchange (AFIX) Overview(73)	Children below 35 months of age, and adolescents aged 13–17 years	All routine immunization

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697 *Table 3: Classification of quality improvement interventions (change ideas) used in quality*
698 *improvement projects to address missed opportunities for vaccination*

Interventions for providers	Interventions for clients	Cross-cutting interventions
Place registry-generated copy of child's immunization data on front of chart at every visit (41)	Providing a strong recommendation for vaccination at every visit (42)	Improve record-keeping by keeping immunization history current (51)
Make notation on clinician encounter form whenever child is due to visit (41)	Using patient reminder systems (43)	record-keeping (42)
Educate providers regarding methods for reducing missed opportunities (41)	Implementing campus-based marketing strategies (43)	Developing an immunization registry to track patients (48)
Place reminder posters prominently in clinic (41)	Use of consistent language to recommend HPV vaccine (44)	

Interventions for providers	Interventions for clients	Cross-cutting interventions
Prevent missed opportunities to vaccinate by increasing provider acknowledgement of vaccine history (43)	Provider emphasizing the vaccine as a tool for cancer prevention (44)	
Distributing immunization records for all scheduled pediatric patients to provider medical assistants teamlets (46)	Provider emphasizing the vaccines at acute visits (44)	
educational seminar on HPV for physicians, residents, nurses, and medical assistants (47)	Mailing letters to caregivers of children under 3 years of age providing information on reasons for immunization and encourage them to make appointment to obtain missing immunizations (46)	
weekly individualized audit to providers who missed an opportunity to vaccinate a patient against HPV (47)	Administering all recommended vaccines at the same visit (49)	
Allowing staffs to schedule their HPV visits (47)	Making strong recommendations for vaccines (49)	
Support staffs indicating to providers when client is HPV vaccine eligible (47)	Discussing the need for immunizations with caregivers at that day's visit (45)	
"Best practice alert" for HPV in EMR (47)	Use all clinical encounter to screening at every visit (51)	
Electronic reminders using Huddle (47)	Administer immunization at some sick visits (51)	
Auditing and feedback (49)	Administer immunization at any opportunity (51)	
Providers were trained on offering a strong recommendation for HPV vaccination (50)	Using only true contraindication to immunization (51)	

Interventions for providers	Interventions for clients	Cross-cutting interventions
Practices implemented provider prompts and/or standing orders and/or reminder/recall if desired (50)	Simultaneous administration of multiple vaccines (51)	
Provide monthly feedback on missed opportunities for vaccination to assess their progress (50)	Administering DTP at 12 or 15 months instead of 18 months (51)	
Teach residents about the principles of FOCUS-PDSA through didactic lecture (45)	Recommendations pertained to missed opportunities (42)	
Printing daily report with the immunization record for that day's pediatric patients (45)	Encourage parents to bring immunization record to all clinic visits (51)	
Algorithms for catch-up of patients not on schedule or with incomplete immunizations (42)		
Conducting regular assessment of immunization levels with provision of clinic-specific feedback (48)		
Holding team-based quality improvement meetings (48)		

*HPV = Human papilloma virus, *EMR = Electronic Medical Record, *FOCUS-PDSA = Find-Organize-Clarify-Understand-Select – Plan-Do-Study-Act

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Table 4: Key information charted and their description

Information	Description
<i>General characteristics</i>	
ID	Identifier of the publication
year of publication	Year of publication of the document
Country	Location of institution of the first author
type of publication	Type of document
Language	Language of publication
<i>Setting and target population</i>	
Level of healthcare	Category of health facility where the quality improvement project was implemented
Context	Setting in which the quality improvement project was conducted
Target population	Individuals whom the quality improvement was meant to have an impact on
Age group of target population	Age category of the individuals targeted in the quality improvement project
<i>Quality improvement process</i>	

Quality Improvement (QI) strategy	The strategies that were used during the quality improvement project
Quality Improvement (QI) team	people responsible for implementing the quality improvement project
Quality Improvement (QI) model	theoretical framework or model of the quality improvement project
Quality Improvement (QI) method	process of iterative implementation of the quality improvement activities
Vaccines	antigens that were targeted

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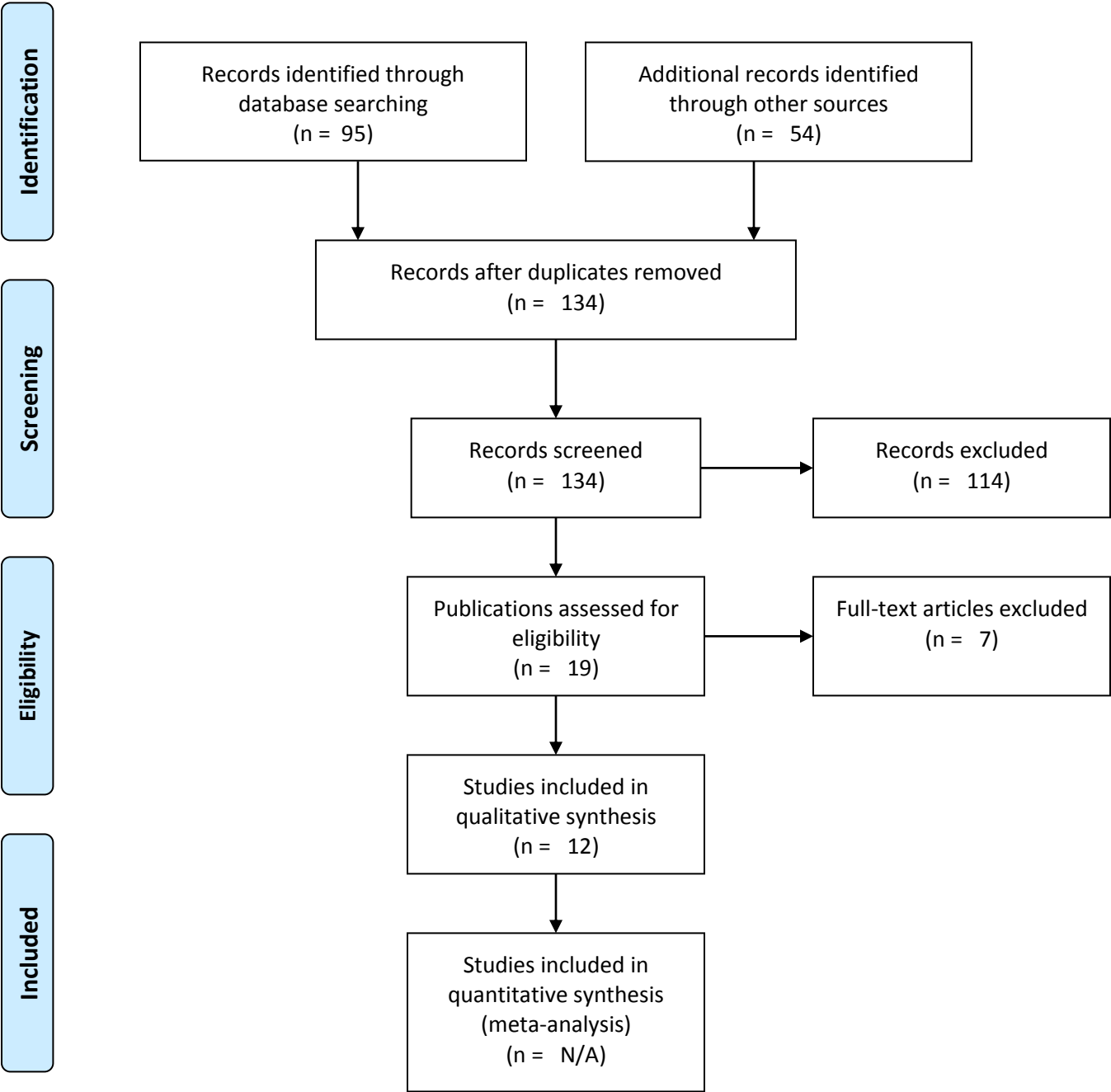


Figure 1: Adapted PRISMA flow chart

Table 1: General features of publications on use of quality improvement to address missed opportunities for childhood vaccination

Characteristics	Frequency	Percentage
Year of publication		
1999 - 2003	2	16.67
2004 - 2008	1	8.33
2009 - 2013	0	
2014 - 2018	9	75.00
Country affiliation		
United States of America	12	100
Others	0	
Publication type		
Published literature	11	91.67
Conference proceedings	1	8.33
Type of institutional affiliation of first author		
University	5	41.67
Hospital	4	33.33
Government agency	3	25.00

Table 2: Target population and vaccine(s) targeted in quality improvement practices to address missed opportunities for vaccination

Authors	Study title	Target population	Vaccine(s)
Published literature			
Daley, M. F., et al.	Quality improvement in immunization delivery following an unsuccessful immunization recall(41)	children aged 3 - 35 months	All routine immunization
Daly, K. L., et al.	A University Health Initiative to Increase Human Papillomavirus Vaccination Rates(43)	Young adults aged 18 - 26 years	Human papillomavirus (HPV) vaccine
Fiks, A. G., et al.	Improving HPV Vaccination Rates Using Maintenance-of-Certification Requirements(44)	Adolescents aged 11 - 17 years	Human papillomavirus (HPV) vaccine
Jones, K. B., et al.	Improving Immunizations in Children: A Clinical Break-even Analysis(46)	children aged three years and below	All routine immunization
Krantz, L., et al.	Increasing HPV Vaccination Coverage Through Provider-Based Interventions(47)	Adolescents aged 13 - 17 years	Human papillomavirus (HPV) vaccine
Moore, K. L., et al.	Tennessee's 3-Star Report: Using Available Data Systems to Reduce Missed Opportunities to Vaccinate Preteens(49)	Adolescents aged 11 - 13 years	Tetanus-diphtheria-pertussis vaccine (Tdap), Quadrivalent meningococcal vaccine (Men-ACWY), and Human papillomavirus (HPV) vaccine
Rand, C. M., et al.	A Learning Collaborative Model to Improve Human Papillomavirus Vaccination Rates in Primary Care(50)	Adolescents aged 11 - 17 years	Human papillomavirus (HPV) vaccine
Jones, K. B., et al.	Improving pediatric immunization rates: description of a resident-led clinical continuous quality improvement project(45)	children aged three years and below	All routine immunization
Sinn, J. S., et al.	Improving immunization rates in private pediatric practices through physician leadership(51)	children aged 9 to 30 months	All routine immunization
Melinkovich, P., et al.	Improving pediatric immunization rates in a safety-net delivery system(48)	children aged three years and below	All routine immunization
Carlin, E., et al.	Using Continuous Quality Improvement Tools to Improve Pediatric Immunization Rates(42)	children aged two years and below	All routine immunization
Conference presentation			

Authors	Study title	Target population	Vaccine(s)
Gurov, Heidi	Assessment-Feedback-Incentive-Exchange (AFIX) Overview(73)	Children below 35 months of age, and adolescents aged 13 - 17 years	All routine immunization

Table 3: Classification of quality improvement interventions (change ideas) used in quality improvement projects to address missed opportunities for vaccination

Interventions for providers	Interventions for clients	Cross-cutting interventions
Place registry-generated copy of child's immunization data on front of chart at every visit (41)	Providing a strong recommendation for vaccination at every visit (43)	Improve record keeping by keeping immunization history current (51)
Make notation on clinician encounter form whenever child is due to visit (41)	Using patient reminder systems (43)	record keeping (42)
Educate providers regarding methods for reducing missed opportunities (41)	Implementing campus-based marketing strategies (43)	Developing an immunization registry to track patients (48)
Place reminder posters prominently in clinic (41)	Use of consistent language to recommend HPV vaccine (44)	
Prevent missed opportunities to vaccinate by increasing provider acknowledgement of vaccine history (43)	Provider emphasizing the vaccine as a tool for cancer prevention (44)	
Distributing immunization records for all scheduled pediatric patients to provider medical-assistants teamlets (46)	Provider emphasizing the vaccines at acute visits (44)	
educational seminar on HPV for physicians, residents, nurses, and medical assistants(47)	Mailing letters to caregivers of children under 3 years of age providing information on reasons for immunization and encourage them to make appointment to obtain missing immunizations (46)	
weekly individualized audit to providers who missed an opportunity to vaccinate a patient against HPV (47)	Administering all recommended vaccines at the same visit (49)	
Allowing staffs to schedule their HPV visits (47)	Making strong recommendations for vaccines (49)	

Interventions for providers	Interventions for clients	Cross-cutting interventions
Support staffs indicating to providers when client is HPV vaccine eligible (47)	Discussing the need for immunizations with caregivers at that day's visit (45)	
"Best practice alert" for HPV in EMR (47)	Use all clinical encounter to screening at every visit (51)	
Electronic reminders using Huddle (47)	Administer immunization at some sick visits (51)	
Auditing and feedback (49)	Administer immunization at any opportunity (51)	
Providers were trained on offering a strong recommendation for HPV vaccination (50)	Using only true contraindication to immunization (51)	
Practices implemented provider prompts and/or standing orders and/or reminder/recall if desired (50)	Simultaneous administration of multiple vaccines (51)	
Provide monthly feedback on missed opportunities for vaccination to assess their progress (50)	Administering DTP at 12 or 15 months instead of 18 months (51)	
Teach residents about the principles of FOCUS-PDSA through didactic lecture (45)	Recommendations pertained to missed opportunities (42)	
Printing daily report with the immunization record for that day's pediatric patients (45)	Encourage parents to bring immunization record to all clinic visits (51)	
Algorithms for catch-up of patients not on schedule or with incomplete immunizations (42)	Educating parents even when refusal occur (73)	
Conducting regular assessment of immunization levels with provision of clinic-specific feedback (48)		

Interventions for providers	Interventions for clients	Cross-cutting interventions
Holding team-based quality improvement meetings (48)		
Use of standing orders on immunization in clinics (73)		
Training of health care providers (73)		

*HPV = Human papilloma virus, *EMR = Electronic Medical Record, *FOCUS-PDSA = Find Organize Clarify Understand Select – Plan Do

Study Act

Table 4: Key information charted and their description

Information	Description
<i>General characteristics</i>	
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Quality Improvement (QI) method	process of iterative implementation of the quality improvement activities
Vaccines	antigens that were targeted

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TITLE-ABS-KEY ("quality improvement" OR "quality system*" OR "quality network*" OR "quality process*" OR "quality improvement*" OR "quality enhancement*" OR "quality strateg*" OR "quality intervention*" OR "quality management" OR "implementation strategy*" OR "implementation process*" OR "Plan do study act" OR "plan do check act" OR "define measure analyze improve control" OR "define measure analyse improve control" OR "define measure analyse design verify" OR "define measure analyze design verify" OR lean OR "six sigma")

TITLE-ABS-KEY (infant OR toddler* OR preterm* OR prematur* OR baby OR babies OR neonat* OR newborn OR preschool* OR pre-school* OR child OR child*OR kindergar* OR pupil* OR schoolchild* OR teen* OR youth OR youths OR youngster* OR young person* OR young people OR minors OR minors OR puberty OR pubescen* OR prepubescen* OR paediatric*] OR pediatric* OR peadiatric* OR kid OR boy* OR girl* OR creche* OR highschool* OR "secondary school" OR juvenil* OR adolescent OR adolescen*)

TITLE-ABS-KEY (Immunization OR immuni* OR vaccin* OR revaccin* OR innoculat* OR inoculat*)

