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Review

Assessing strategies for increasing urban routine immunization coverage of childhood vaccines in low and middle-income countries: A systematic review of peer-reviewed literature

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ABSTRACT

Introduction: Immunization programs in developing countries increasingly face challenges to ensure equitable delivery of services within cities where rapid urban growth can result in informal settlements, poor living conditions, and heterogeneous populations. A number of strategies have been utilized in developing countries to ensure high community demand and equitable availability of urban immunization services; however, a synthesis of the literature on these strategies has not previously been undertaken.

Methods: We reviewed articles published in English in peer-reviewed journals between 1990 and 2013 that assessed interventions for improving routine immunization coverage in urban areas in low- and middle-income countries. We categorized the intervention in each study into one of three groups: (1) interventions aiming to increase utilization of immunization services; (2) interventions aiming to improve availability of immunization services by healthcare providers, or (3) combined availability and utilization interventions. We summarized the main quantitative outcomes from each study and effective practices from each intervention category.

Results: Fifteen studies were identified; 87% from the African, Eastern Mediterranean and Southeast Asian regions of the World Health Organization (WHO). Six studies were randomized controlled trials, eight were pre- and post-intervention evaluations, and one was a cross-sectional study. Four described interventions designed to improve availability of routine immunization services, six studies described interventions that aimed to increase utilization, and five studies aiming to improve both availability and utilization of services. All studies reported positive change in their primary outcome indicator, although seven different primary outcomes indicators were used across studies. Studies varied considerably with respect to the type of intervention assessed, study design, and length of intervention assessment.

Conclusion: Few studies have assessed interventions designed explicitly for the unique challenges facing immunization programs in urban areas. Further research on sustainability, scalability, and cost-effectiveness of interventions is needed to fill this gap.

Contents

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1. Introduction

Since 2007, the majority of the global population has resided in urban areas, and by 2050, seven in ten people worldwide are projected to be urban-dwelling [1]. Most urban population growth in the next thirty years is anticipated to occur in developing countries, with 86% of this growth accounted for by Africa and Asia [2]. Urbanization, defined as the increase in the urban-dwelling proportion of a population resulting from migration from rural areas or natural urban demographic growth, creates many opportunities but also presents challenges for human health and well-being. Urbanization is coupled with certain health risks such as increasingly crowded and inadequate living conditions, lack of safe food and water, and inadequate sanitation [1], conditions which are especially apparent in urban slums. The urban environment may also increase the risk of infection from communicable diseases, including vaccine-preventable diseases, particularly since unique barriers to the delivery of routine immunization services are present in urban areas [3–5].

Barriers to receipt of immunization services can be classified into two domains. The first is 'service utilization' (or demand-side) barriers, which involve parental knowledge and awareness of the purpose and importance of vaccines, and the locations and times at which they are provided. In urban settings, barriers to utilization of immunization services manifest in several ways. Transient groups, which can account for a large proportion of urban populations, may utilize few health services [6], and seasonal migration complicates the estimation of target populations for routine immunization services and impedes health workers from tracing immunization defaulters. The challenges placed on both transient and permanent urban families, such as inflexible employment situations, may narrowly restrict opportunities to utilize health services. The structure of urban communities may foster low demand for immunization services: for example, segments of urban African populations have been shown to have lower collective confidence and weaker community organization [7] than in rural areas, with community leaders who may be comparatively difficult to identify and exert little influence over community beliefs and behavior [6].

'Service access' (supply-side) barriers involve availability of immunization services, including appropriate scheduling and spatial placement of vaccination sessions, adapting services to the local cultural context, ensuring adequate vaccine supply and health worker availability, and reducing missed opportunities for providing immunizations during other health service contacts. Health services in fast-growing urban areas may be challenged to keep pace with population growth, creating 'pockets' of poor health service infrastructure, particularly in newly emerging peri-urban areas and slums [6,7]. Urban areas generally have a mix of private and public healthcare providers, which can lead to challenges in coordinating and managing the provision of immunization services [5]. In busy urban health facilities, patients may face long waiting times, which may increase the likelihood of incomplete immunization [6,8]. Low health worker motivation in these communities may stem from the challenges of urban living, including high cost of living, low pay, and lack of identification with the community [6].

Addressing the challenges facing utilization and availability of routine immunization services may help alleviate the health inequities identified across rapidly growing urban areas of developing countries [1]. In 2014, the World Health Organization (WHO) and partners identified children in deprived urban settings as a priority group for targeted interventions to improve immunization coverage [4,9]. National immunization programs are increasingly refocusing efforts to address these health inequities and can benefit from the lessons of experiences addressing access and utilization of urban immunization services. To this end, we systematically reviewed research on the types and effectiveness of interventions designed to improve routine immunization coverage in urban settings of low- and middle-income countries (LMICs).

Table 1
Literature search strategy.

Keywords used or in combination	Literature databases searched
Immunization, immunization, vaccination	Medline (PubMed and OVID search engines)
Urban	EMBASE
Peri-urban	Web of Science
Slum(s)	Sociological Abstracts
Maternal and child health	Soc Serv Abs
Intervention(s)	CINALH
Strategy/strategies	Cochrane Central Register of Controlled Trials
Challenge(s)	
Coverage	
Dropout	
Uptake	
Compliance	
Determinant(s)	
Health service(s)	
Primary health service(s)	

2. Methods

We searched seven databases (Medline, CINALH, EMBASE, Web of Science, Sociological Abstracts, Soc Serv Abstracts, and Cochrane) that index literature published in the health and social sciences to identify articles for review, using different combinations of search terms related to routine immunization systems, urban health and populations, and immunization uptake, dropout, and schedule compliance (Table 1). We restricted searches to articles published in English from January 1990 to May 2013.

We included studies if they were peer-reviewed; assessed an intervention implemented to improve routine immunization coverage of childhood vaccines; set in an LMIC; and either explicitly focused on an area described by the authors as urban, peri-urban, or slum, or drew comparisons between these areas and rural areas. We excluded studies focusing on adult or adolescent vaccines, vaccine efficacy trials, assessments of supplemental or outbreak response immunization activities (campaigns), or that did not include primary data collection (e.g., systematic reviews, expert opinions). We identified additional articles by searching the references of included articles and applying the same inclusion and exclusion criteria.

We developed a data extraction tool based on recommendations from the Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [10] and used the PICO (Population, Intervention, Control/Comparator, and Outcome) format to frame

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our question and guide our extraction of information from articles. The PICO format has recently been recommended by WHO to guide the development of evidence-based recommendations on vaccine-related issues [11]. We extracted the following information from each included article: study design and research methods, study subject characteristics, and reported measures of immunization uptake.

We analyzed each study by qualitatively summarizing the main themes regarding lessons learned and best practices for the intervention as documented by authors. We also summarized the reported vaccination outcomes; if 'fully immunized' or a similar outcome was reported, this outcome was reported in place of coverage or vaccination status of individuals for specific vaccines. If vaccination status or coverage with individual vaccines was reported, these were reported in place of risk ratios reported by the authors, in order to standardize the information collected on each study and directly compare changes in vaccination status or coverage across studies. In several reviewed studies for which the study design was a hybrid between a pre- and post-intervention trial and a randomized controlled trial (RCT), we reported the RCT-based outcomes. The intervention described by each study was classified into one of three categories, based on whether the intervention primarily addressed: (1) utilization (demand) of immunization services by beneficiaries (caretakers on behalf of children), (2) availability (supply) of immunization services by healthcare providers; or (3) both availability and utilization.

We assessed study quality and the risk of bias according to Agency for Healthcare Research and Quality (AHRQ) guidelines which categorize bias into five domains: (1) recruitment and selection procedures for participants and methods for control of confounding, (2) likelihood of concurrent interventions and fidelity to the intervention protocol, (3) methods for handling missing data, (4) procedures for exposure, outcome, and confounder ascertainment, and (5) full reporting of all pre-specified outcomes [12]. The potential for bias in each domain was expressed using a "low" or "high" risk of bias score. Studies which provided insufficient information to assess bias were assigned an "unclear" risk of bias for one or more domains. Assessment of bias was design-specific; the strength or weakness of the general study design was not considered.

Table 2
Characteristics of studies which evaluated interventions to strengthen routine immunization services in an urban setting.

WHO Region of study	Number of studies	% of total studies
African	5	33
Americas	1	7
Eastern Mediterranean	4	27
European	0	0
Southeast Asian	4	27
Western Pacific	1	7
Study design		
Randomized controlled trial	6	40
Cross-sectional	1	7
Pre and post-intervention	8	53
Primary outcome indicator(s)		
Fully immunized status	7	47
Measles, DTP3, OPV3 and BCG immunization status[a]	2	13
Measles, DTP3 and BCG immunization status[a]	1	7
DTP3, OPV3 and BCG immunization status[a]	1	7
Measles and DTP3 immunization status[a]	1	7
DTP3 immunization status	2	13
Child attended vaccination session	1	7
Primary objective of study		
Increase availability of vaccination services	4	27
Increase utilization of vaccination services	6	40
Increase availability & utilization of vaccination services	5	33
Setting[a]		
Urban	9	60
Peri-urban	3	20
Urban slum	3	20

[a] As defined in the article.

3. Results

3.1. Populations: study characteristics

We identified 15 articles examining 14 interventions to improve routine immunization coverage in urban areas (Sasaki et al. and Igarashi et al. evaluate the same intervention in Lusaka, Zambia). Studies represented five of the six WHO regions; 13 (87%) were based in the African, Eastern Mediterranean or Southeast Asian regions (Table 2). All studies focused on areas identified by authors as "urban" (nine studies), "peri-urban" (three studies), or "slum" (three studies). The majority (93%) of studies utilized a pre/post data collection approach, either via an experimental study design (40%) or an observational study design (53%). In seven (47%) of all studies, the primary outcome of interest was fully-immunized status. In an additional seven, a range of individual vaccination outcomes were used to assess the intervention effect (Table 2).

Almost half of the studies reported insufficient methodological information to assess extent of bias: seven out of the 15 studies reviewed were assigned an 'unclear' risk of bias score for one or more domains of bias. Of the 15 studies, two (13%) studies scored a 'high' or 'unclear' risk of bias on more than two domains [13,14], three (20%) studies scored a 'high' or 'unclear' risk of bias on two domains [15–17], five (33%) studies scored a 'high' or 'unclear' risk of bias on one domain, [18–22] and five (33%) studies scored a 'low' risk of bias on all domains; [23–27] these studies (three RCTs and two pre/post studies) were the most methodologically sound.

3.2. Interventions, control groups, outcomes: increasing utilization of services

Six studies examined interventions designed to increase utilization of immunization services among caregivers of children [13,15,16,20,23,24]. The interventions included health facility referrals combined with home visits, home-based vaccination education, targeted vaccination messages using visual images, redesigned vaccination cards and mass media campaigns. One study reported a 19% increase in the proportion of children fully vaccinated before versus after the intervention [15], another reported a range between a 4% decrease in coverage and 33% increase across four districts [16], and a third reported an 11% increase in the proportion of fully immunized children [20] (Table 3). Two other studies reported a 20% increase [23] and a 19% increase [24] in the proportion of children vaccinated with DTP3 after the assessed intervention (Table 3).

In the lessons documented by these six studies, authors noted that home visit strategies were well-suited to urban areas where travel time between households was minimal [15], and that home-to-home social mobilizers could improve planning and monitoring by conducting a 'census' of children eligible for immunization, identifying areas with many unvaccinated children and referring people to health facilities for other basic health services [16]. Further, home visits were considered a useful strategy for reaching minority or ethnic groups that typically underutilize

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Table 3
Interventions and selected immunization outcomes among studies which evaluated interventions to increase routine immunization coverage in an urban setting.

Author, Year published	Reference No.	Population: City, Country (urban, Peri-urban, or slum)[a]	Study design	Date of intervention	Length of intervention	Intervention description	Number of study subjects in control/comparator groups	Outcome(s)			
								Indicator	Pre[b]/control[c]	Post[b]/ intervention[c]	Change
Anjum (2004)	17	Karachi, Pakistan (slum)	RCT[d] and pre-post	1998–2002	4 yr	Undergraduate medical students visited families, identified health knowledge gaps, delivered pre-tested health education messages twice in six months to mothers with children less than 5 years of age and vaccinated children present in the household	Control, BCG: 149 Intervention, BCG: 201 Control, OPV3: 126 Intervention, OPV3: 156 Control, DPT3: 46 Intervention, DPT3: 51 Control, Measles: 99 Intervention, Measles: 125	BCG immunization status among children under 5[k]	81%[c]	93%[c]	+24%
								OPV3 immunization status among children under 5[k]	65%[c]	84%[c]	+38%
								DTP3 immunization status among children under 5[k]	56%[c]	77%[c]	+31%[*]
								Measles immunization status among children under 5[k]	58%[c]	74%[c]	+23%[*]
Brugha (1996)	15	Nkawkaw, Kwahu Praso, Akwasiho, Ghana (urban)	RCT[d]	1991–1992	6 mo	Children who failed to report to a clinic following referral were visited up to 3 times over the following 6 months to give repeated messages about returning to the clinic for immunization	Control: 200 Intervention: 219	Fully immunized[e,n]	67%[c]	86%[c]	+19%[*]
Cutts (1990)	16	Inhambane, Beira, Tete, and Quelimane, Mozambique (urban)	Pre/post	1986	12 mo	Twice a year, community representatives visited homes of target groups, checked the immunization status of children and referred eligible children to the nearest health center using referral cards for a 'pulse' immunization session. Health workers collected referral cards upon vaccination at the health center	210 children per district selected for EPI cluster surveys at baseline and follow-up	Fully immunized children 12–23 months of age, Beira district[e,g]	55%[b]	51%[b]	−4%
								Fully immunized children 12–23 months of age, Tete district[e,g]	23%[b]	55%[b]	+22%
								Fully immunized children 12–23 months of age, Quelimane district[e,g]	27%[b]	60%[b]	+33%
								Fully immunized children 12–23 months of age, Inhamabane district[e,g]	39%[b]	53%[b]	+14%
Emond (2002)	18	Natal, Brazil (urban)	Pre/post	1994–1997	30 mo	As part of the 'ProNatal' project, maternity facilities were improved, antenatal and family planning clinics were established, community health agents (CHAs) were introduced, and public health education was provided to medicine and nursing students at local universities	Baseline: 1195 Follow-up: 1210	BCG immunization status[h]	76%[b]	93%[b]	+17%[*]
								OPV3 immunization status[h]	48%[b]	54%[b]	+6%[*]
								DTP3 immunization status[h]	62%[b]	65%[b]	3%
								Measles immunization status[h]	52%[b]	72%[b]	+20%[*]
Hughart (1991)	13	Dhaka, Bangladesh (slum)	Cross-sectional	1987–1988	13 mo	Illiterate/semi-literate women volunteers provided immunization education, referred women and children to clinics for immunization, accompanied women and children to the clinic, and followed up with mothers that did not return to the clinic using a simple record-keeping booklet	789 referrals of children > 2 mo overdue for any immunization	Percent of fully immunized (BCG, DTPx2, OPVx3, measles) children <24 months of age, among those who received referrals[j]	No control	87%	N/A[**]
Igarashi (2010)	19	Lusaka, Zambia (peri-urban)	Pre/post	2002–2005	9 mo (primary), 33 mo (lagged, intervention started 2 years after primary area)	Growth Monitoring Plus (GMP+) sessions, at which medical personnel provided immunization and community volunteers provided other health services (growth monitoring, nutrition counseling, health education, and Vitamin A supplementation), were held monthly	Primary (baseline): 192 Primary (final): 174 Lagged (baseline): 183 Lagged (final): 187	Fully immunized at 12mo, primary area[e,g]	53%[b]	69%[b]	+16%[*]
								Fully immunized at 12mo, lagged area[e,g]	48%[b]	57%[b]	+9%

Table 3 (*continued*)

Author, Year published	Reference No.	Population: City, Country (urban, Peri-urban, or slum)[a]	Study design	Date of intervention	Length of intervention	Intervention description	Number of study subjects in control/comparator groups	Outcome(s)			
								Indicator	Pre[b]/control[c]	Post[b]/ intervention[c]	Change
Loevinsohn (1992)	26	Khartoum, El Obeid, Sudan (urban)	RCT[d] (crossover)	NR	1 day for each intervention (A and B) at 12 health centers	Two interventions aimed to increase the likelihood of vaccination among eligible children that had not attended the clinic specifically for immunization: Intervention A. The immunization table and vaccinator was moved from a side room to the front of the consultation room (an accessible and visible location) Intervention B. Mothers were given a referral to the regular immunization room by the clinician	Intervention A: 79 Intervention B: 93	Percentage of eligible children <12 months of age immunized on day of the intervention[i]	No control	Intervention A: 61% Intervention B: 66%	N/A
Owais (2011)	23	Karachi, Pakistan (urban, peri-urban)	RCT[d]	2008–2009	4 mo	In the intervention arm, community health workers visited mothers at home and used pictorial cards to educate mothers about vaccination, conveying 3 messages: 1) vaccines save lives; 2) logistic information (time and location of immunization sessions); 3) importance of retaining immunization cards; the control group received a general health promotion message	Control: 178 Intervention: 179	DTP3 immunization status 4 months post-enrollment (4–5 months of age)[g]	52%	72%	+20%*
Pradhan (2012)	21	Patna, India (urban)	Pre/post	2008–2010	12 mo	The number of immunization sites was increased, logistical planning for routine immunization sessions was improved, community mobilization activities were undertaken, supportive supervision of health workers was improved, data flow was strengthened and immunization drives implemented	Target population (using census data: ~24,000 Note: Coverage calculated using administrative reports of doses administered and target population estimation using census data	BCG coverage[h] DTP3 coverage[h] Measles coverage[h]	29%[b] 21%[b] 23%[b]	64%[b] 49%[b] 51%[b]	+35%** +28%** +28%**
Ryman (2012)	25	Homa Bay, Kenya (urban)	Pre/post	2009–2010	12 mo	At routine immunization visits, education about hand hygiene/drinking water treatment and storage was provided by nurses and hand hygiene kits were distributed	*2–20 months* 769 *2–13 months* 440 *4–13 months* 440	Percentage of doses received for which child due, 2–20 months of age[g] Child up-to-date, 2–13 months of age[f,g] DTP1-3 dropout, 4–13 months of age[g]	68% (61–74%)[b] 69% (59–78%)[b] 21% (13–32%)[b]	84% (80–86%)[b] 82% (78–85%)[b] 9% (6–13%)[b]	+16%* +13%* −12%*
Sasaki (2011)	22	George Proper, Zambia (Peri-urban)	Pre/post	2003–2006	3 yr	Growth Monitoring Plus (GMP+) sessions, at which medical personnel provided immunization and community volunteers provided other health services (growth monitoring, nutrition counseling, health education, and Vitamin A supplementation), were held monthly	Baseline: 247 Follow-up: 268	DTP3 immunization status of children under age 5[g] Measles immunization status of children under age 5[g]	76%[b] 67%[b]	87%[b] 76%[b]	+11%** +9%**
Tandon (2012)	14	India (urban)	RCT[d]	1983–1988	>5 yr	The Integrated Child Development Services program used community volunteers to provide nutrition and health education and services to children and pregnant/lactating mothers. Volunteers listed infants to be vaccinated, motivated acceptance of vaccination, assisted health teams in performing vaccination, and managed adverse events	Control: 126 Intervention: 1715	BCG coverage[k] DTP3 coverage[k] OPV3 coverage[k]	7%[c] 1%[c] 2%[c]	81%[c] 75%[c] 75%[c]	+74%** +74%** +73%**

(*continued on next page*)

Table 3 (*continued*)

Author, Year published	Reference No.	Population: City, Country (urban, Peri-urban, or slum)[a]	Study design	Date of intervention	Length of intervention	Intervention description	Number of study subjects in control/comparator groups	Outcome(s)			
								Indicator	Pre[b]/control[c]	Post[b]/ intervention[c]	Change
Uddin (2009)	27	Dhaka, Bangladesh (slum)	Pre/post	2006–2007	12 mo	EPI service schedules were extended, training for service providers in valid/invalid doses and side effect management was offered, screening tools were used in non-EPI centers to refer to EPI centers, an EPI 'support group' of community members was created to advocate for immunization	Baseline: 529 Follow-up: 526	Fully immunized at 12mo, among children aged 12–23 months[l]	43%[b]	99%[b]	+56%[*]
								Fully immunized at 12mo, among children aged 12–23 months (working mothers only)[l]	14%[b] (n = 227)	99%[b] (n = 242)	85%[*]
								DTP1-3 dropout, among children aged 12–23 months[l]	33%[b]	1%[b]	−32%[*]
Usman (2009)	24	Karachi, Pakistan (urban)	RCT[d]	2003	3 mo	Redesigned immunization cards with the next scheduled vaccination date in large print were given to caretakers, either alone or in combination with a 2–3 min education session given by a study personnel member emphasizing importance of immunization schedule completion	Redesigned card arm: 375 Education arm: 375	Received DTP3 during 90 days follow-up (education only vs. standard care)[m]	55%[c]	74%[c]	+19%[*]
							Card + education arm: 375	Received DTP3 during 90 days follow-up (education and redesigned card vs. standard care)[m]	55%[c]	65%[c]	+10%[*]
							Standard care only arm: 375				
Zimicki (1994)	20	Manila, Philippines (urban)	Pre/post	1990	5 mo	A media campaign focused on measles immunization, emphasizing a particular day of the week that measles immunization was provided	Baseline: 446 Follow-up: 461	Fully immunized, children aged 12–23 months[l]	54%[b]	65%[b]	+11% (3–19%)[*]

NR = not reported.
Mo = month.
Yr = year.
[*] Significant change (no * indicates a non-significant result). In Anjum et al., represents a significant change in the intervention but not the control area in the survey after compared to the survey before the intervention.
[**] Did not report measures of statistical significance for this outcome.
[a] based on the author's designation of the study area.
[b] Percentages refer to pre-intervention and post-intervention values.
[c] Percentages refer to control group and intervention group values.
[d] RCT: Randomized controlled trial.
[e] Fully immunized: immunized with BCG, DTP1-3, OPV1-3, and measles-containing vaccine (unless otherwise noted).
[f] Up-to-date: child has received all recommended vaccinations for their age.
[g] Vaccination status determined by card only (no recall).
[h] Coverage determined by administrative estimates.
[i] Vaccination status determined by health clinic vaccination records.
[j] Vaccination status determined by health worker's collection of referral slip at vaccination visit.
[k] Method of vaccination status determination not reported.
[l] Vaccination status determined by card or recall.
[m] Vaccination status determined by records of study personnel stationed at health facility.
[n] Vaccination status determined by card or clinic vaccination records.

health services [15]. However, authors noted that home visit programs need to be considered within the context of the human and financial resources required, should incorporate a supervisory component, be customized to the targeted community, and may not be suitable in areas with unreliable provision of immunization services [15,16]. To reduce the health worker resources needed for home visit programs, authors recommended using non-medical personnel closely linked with the community [13].

Recommendations for designing and implementing parental education interventions included the provision of specific, directed messages that focused on logistical information, such as the time and location of immunization sessions, rather than general health promotion messages [23,24]. To improve effectiveness, Usman et al. and Owais et al. recommended parental education be targeted towards pre-identified high-risk communities [23,24]. Usman noted that interventions similar to the redesigned vaccination card, which required few resources and could be implemented within the existing structure of the routine immunization system, have the potential to achieve substantial cost benefits, since the card is inexpensive to implement but could substantially improve immunization rates. Owais et al. noted that the cost of scaling up the home-based education intervention to a national level had the potential to be highly cost-effective. With respect to mass media campaigns, Zimicki et al. noted that they require extensive planning and stakeholder support, and that the target population should have sufficient access to mass media. Moreover, the health system must be prepared to serve the increased demand resulting from an effective health communication campaign. Although the Filipino mass media campaign focused on communicating times and locations of measles immunizations, such messages can also increase other vaccination coverage rates through increasing awareness of immunization services generally [20].

3.3. Interventions, control groups, outcomes: increasing availability (supply) of services

Approaches such as the integration of child health services, providing or increasing the availability of outreach services, and enhancing availability of immunization services within a health facility were evaluated as strategies for increasing availability of urban immunization services. Four studies in this review described interventions designed to improve availability of routine immunization services [19,22,25,26]. Across these four studies, the proportion of children fully vaccinated increased by 11–16% over the intervention period (Table 3).

Authors noted several lessons learned from implementing the interventions studied. The approach of the Growth Monitoring Plus (GMP+) intervention described by Igarashi and Sasaki et al. shows the benefits of optimizing placement and outreach of health services in potentially low-coverage neighborhoods. Although increased service provision locations could be expensive, Igarashi suggested introduction of income-generating ventures to mitigate costs (although no other details were offered). In Sudan, Loevinsohn et al. note that programs redirecting patients within the health facility often had a substantial health worker supervision component, and sustainability of this component needed to be prioritized and understood in further research. Ryman et al. and Igarashi et al. advocated for the use of non-health personnel to deliver integrated interventions as it could reduce the burden on nurses and strengthen the links between health facilities and communities. In these studies, community volunteers anecdotally spent more time educating mothers, were perceived as more dedicated and were more able to effectively relate with mothers [19,25]. Additionally, Ryman et al. note that those providing health education should be well-linked to the target communities and that provision of health education could be task-shifted to non-medical personnel rather than delivered by overburdened health workers, particularly since mothers appeared to prefer health education from lay persons [25]. Lastly, Ryman noted that since integrated interventions could not overcome long distances to health facilities, their use may be more sustainable and effective in urban areas than in rural areas [25].

3.4. Interventions, control groups, outcomes: increasing availability (supply) and utilization (demand) of services

Interventions in five studies were aimed at simultaneously increasing utilization and availability of immunization services [14,17,18,21,27]. Interventions included home-based education coupled with on-site vaccine administration, promotion of health education, and general improvement of immunization programs that involved assisting patients to understand and utilize health services as well as improving the services offered. One study reported a 56% increase in the proportion of children fully vaccinated during intervention period [27]. The remaining four studies reported on change in the proportion of children who received DTP3 vaccination during the intervention period; these values ranged from 3% to 74% (Table 3).

The authors noted that integrated interventions were successful when combined with community-based service delivery [18]. Uddin et al. point out the need to ensure consistent service provision before increasing service demand via referrals and suggested that, in certain settings, extending the referral service to pharmacists may be a useful avenue for reaching more children [27]. In addition, they recommended cost-benefit analyses to help program managers determine the value of investing resources in referral programs. Uddin also noted that one of the strengths of training interventions is that while refresher trainings need to be offered at regular intervals after the initial session is given, these often require only a re-focusing of existing training materials rather than labor-intensive re-development of curricula. In addition, qualitative interviews confirmed that modifications to service delivery that were designed specifically for urban caregivers, including extended EPI center service hours, were popular with mothers and service providers in addition to significantly improving coverage in these groups [27].

4. Discussion

This is the first systematic review of the impact of strategies to improve routine immunization coverage in urban settings of LMICs. Although all studies reported a positive effect of the assessed intervention on reported immunization outcomes, our cross-study comparisons were limited by the heterogeneity of primary vaccination outcomes used and characteristics of the interventions. Despite these constraints, we identified multiple promising interventions and lessons learned that can provide guidance on future areas of research and intervention design. Researchers mainly used two approaches to intervention design, either explicitly focusing on unique characteristics of the urban setting to develop the intervention, or by using existing, non-geographically-specific strategies to strengthen urban immunization services. Lessons learned from both approaches provide useful information for future research directions.

Several interventions were either explicitly designed for urban areas or were effective in urban areas for specific reasons. Interventions promoting simple, strategic changes aimed at adapting immunization services to special characteristics of urban populations had measurable impacts on immunization uptake. For example, accommodating urban working mothers' schedules by extending health facility hours to nights and weekends improved

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access to, and utilization of, immunization services. Home visit strategies that aimed to increase utilization of vaccination services leveraged the density of communities in urban areas to rapidly reach a large number of immunization defaulters and immunization-eligible children. This finding is consistent with another review that indicated the use of a patient recall and reminder systems (including home visits and referrals) can positively affect coverage rates [28].

In urban settings where community cohesion may be lower than in rural settings, utilization studies identified increases in immunization uptake through use of community volunteers to implement interventions such as providing education, writing referrals, and advocating for immunization. High population density made home-based education feasible in urban areas, particularly if immunization program tasks could be shifted to community volunteers. These findings are echoed in a similar review that reported success in using non-medical personnel for community outreach and home visits [29], though this review was not specific to urban settings. It is notable that, although urban health workers are generally assumed to have weaker community ties than health workers in rural areas, the use of community volunteers and health workers for home-based education or clinic referrals was consistently identified as successful by the interventions studied. Another review has cited health education campaigns as one of the most effective methods to increase coverage [30]; in the current review, we also found these strategies were reported to be generally effective in the urban setting. Studies that tested interventions that aimed to increase demand for immunization, however, were careful to note that a functional health system that can reliably provide immunization services is a prerequisite to implementing an intervention of this type.

Many of the recommendations made in the reviewed studies were not specifically tailored to the urban setting. These recommendations included updating health facility catchment maps to include high-risk areas, ensuring that communication messages included location and time of immunization sessions, establishing health facilities at locations convenient for the community and ensuring reliable supply of vaccines, and advocating the use of the Reaching Every District (RED) strategy which was originally developed to improve vaccine outreach, communications, supervision, monitoring and microplanning in rural locations [31]. However, many of these strategies are undoubtedly applicable in urban areas, and consideration should be given to tailoring such strategies to the unique urban context. Interventions that address broad health system challenges, such as ensuring vaccine supply and adequate human resources, coupled with urban-tailored approaches, such as adapting clinic hours to the work hours of urban families, could potentially be successful in improving immunization coverage. Future research should focus on the effectiveness of these multi-pronged approaches.

Although the number of articles identified (15) was small, this in part reflected our search strategy. Although we identified all citations of articles that explicitly identified the study area as 'urban, 'peri-urban' or a 'slum', we may have overlooked studies that did not have 'urban' in the title or as a keyword. Moreover, since definitions of 'urban', 'peri-urban', or 'slum' were not applied consistently across studies, we could not make any conclusions about the differential effectiveness of interventions in each particular setting. In addition, it was difficult to directly compare studies that reported different measures of immunization uptake, and as a result, a more descriptive analysis is presented. We also recognize that excluding grey literature may have contributed to publication bias in our results, as published literature is more likely to describe successful interventions and grey literature may include a wider range of reports on experiences with implementation and evaluation of coverage improvement strategies. Lastly, we did not include studies which assessed interventions using only qualitative research approaches, which may provide more detailed information about why interventions were successful. However, we found that most authors of the included studies discussed the reasons for the success or failure of interventions.

Analyses of the scalability and sustainability of interventions beyond the study settings were identified by several authors as a future research priority. Sustainability was a concern with interventions that included a substantial supervisory component, since supervision may not be able to be continued in the long-term and thus the potential impact of the program was unclear. To better understand the strategies that work best in urban settings, evaluations should document the reasons why they work in certain areas and how to best scale up the strategy, if appropriate. Lastly, consistently incorporating a costing component into these studies can help others understand the resource needs of these interventions.

Certain unique aspects of the urban setting were not covered by the reviewed studies and may also be considered for future research. For instance, since many urban families may be transient residents due to seasonal migration, and even parents who are permanent residents can easily move across multiple health facilities for vaccination visits, methods for sharing of immunization records across urban health facilities, such as through the use of electronic or biometric immunization registries, could be explored. Since urban areas may have reliable electricity and cellular connectivity, improving utilization of services may be feasible through electronic reminder messages, perhaps via SMS, to parents. Further defining the unique characteristics of the urban setting in LMICs may also help identify other research areas.

5. Conclusions

This review describes the promise of strategies that improve availability and utilization of immunization services for improving routine immunization coverage in urban communities. Gaps in our knowledge about certain interventions do exist, including the long-term impact of interventions involving a high level of supervision as well as the potential for scalability of interventions that have only been tested in a single clinic or neighborhood. Answering these questions should be prioritized as countries become increasingly urbanized and country managers grapple with developing effective and sustainable strategies to increase immunization coverage in these communities.

Conflict of interest statement

The authors have no conflicts of interest to report. The findings and conclusions in this report are those of the authors and do not necessarily represent the official positions of the U.S. Centers for Disease Control and Prevention.

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