

Immunization, urbanization and slums: A review of evidence



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Immunization, urbanization and slums: A review of evidence

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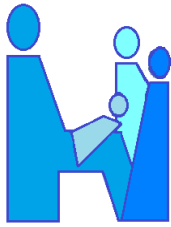
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**MATERNAL, NEWBORN AND CHILD HEALTH
WORKING PAPER
October 2016**

**Immunization, urbanization and slums: *A review of
evidence***

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Abbreviations

DHS	Demographic and Health Survey
DTP3	Diphtheria, Tetanus & Pertussis vaccination, dose 3
DRC	Democratic Republic of the Congo
LMICs	Low and Middle-Income Countries
MDGs	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
NGOs	Non-Governmental Organisations
RCT	Randomized Controlled Trial
SDGs	Sustainable Development Goals
SE	Socio-economic
SMS	Short Message Service (text message)
UN	United Nations
VPD	Vaccine Preventable Disease

Executive Summary

Introduction

Over half (54%) of the world's population lives in urban areas and this proportion is expected to increase to 66 per cent by 2050. About 90% of this projected increase will occur in Asia and, most significantly, in Africa, which is experiencing the highest rates of urbanization globally. This trend towards urbanization is closely linked with an increasing number of people living in urban poor communities, including in slum environments. Since 1990 the absolute number of people living in slums increased from 689 million to 880 million by 2014, with sub-Saharan Africa contributing 56% of this increase. As urbanization trends accelerate the number of people living in urban slums will also increase, especially in Africa.

Methods

We performed a review of literature to identify what factors contribute to the differences in immunization coverage seen among urban communities, especially between poorer and wealthier groups, and identify evidence for effective interventions to increase vaccination uptake. We searched the following databases Medline, Embase, Global Health, Web of Science and CINAHL, with a broad range of search terms from the following categories: vaccine, immunization; urban, peri-urban, slum; and low and middle income countries, restricting our search to articles published since 2000. We included any observational, interventional or ecological study conducted in an urban poor or slum community in a low or middle income country, reporting on factors associated with coverage levels or interventions to increase immunization coverage.

Results

Significant disparities in health outcomes exist in urban areas, with the urban poor most affected. These disparities are driven by demographic, geographic, and socio-economic factors. The coverage of basic health services, including vaccination, is usually lower among urban poor communities, increasing their vulnerability to vaccine preventable diseases. This is related to the socio-economic circumstances in which slum-dwellers live, including: having low levels of income and education; poor provision of public infrastructure such as water and sanitation; insecure legal status resulting in exclusion from public health systems; and reduced or absent provision of basic health services. This situation confers an increased risk of water-borne and vector borne diseases such as diarrhoea, malaria; respiratory tract infections like pneumonia; HIV/AIDS, and other communicable diseases, as well as

malnutrition, injuries, and mental ill health. Recent migrants to slums (resident for <12 months) are even more vulnerable compared with longer settled slum dwellers. However, all slums are different; each with a unique set of social, political and environmental circumstances contributing to the disparities in health outcomes.

Conclusions

To increase immunization coverage, complex interventions, involving different components, designed to meet the specific needs of a local slum community are effective in some contexts. Outreach services may also be useful to reduce geographic distance to health providers. More research is required to evaluate the impact of reminder/recall systems, financial incentives and educational interventions.

Programs should be developed and implemented that improve immunization services in urban poor communities, particularly providing services to children that live in slums, to reduce the disparities in immunization coverage between the urban poor and rich. However, this will require that immunization programs better understand the compositions and dynamics of slum populations, especially the impact of migration, in order to inform policy formulation, strategy development, and intervention planning and evaluation.

1. Introduction

In 2014 over half (54%) of the world's population lived in urban areas,¹ and by 2050 this proportion is expected to increase to 66 per cent, adding approximately 2.5 billion new urban dwellers.² Around 90% of this projected increase will occur in Asia and Africa, which currently have the lowest levels of urban dwelling population (48% and 40% respectively). This increasing trend towards urbanization is closely linked with increasing population living in slum environments, particularly in low- and middle-income countries in Africa and Asia.² Significant disparities exist in health services coverage, including immunization, and health outcomes of people living in urban areas, especially between the richest and poorest residents.³ In this paper we aim to describe the current trends in urbanization and characterise the development of urban poor communities, especially those living in slum environments; identify factors driving inequities in immunization coverage; and identify the evidence base for strategies to provide immunization services to children living in urban slums.

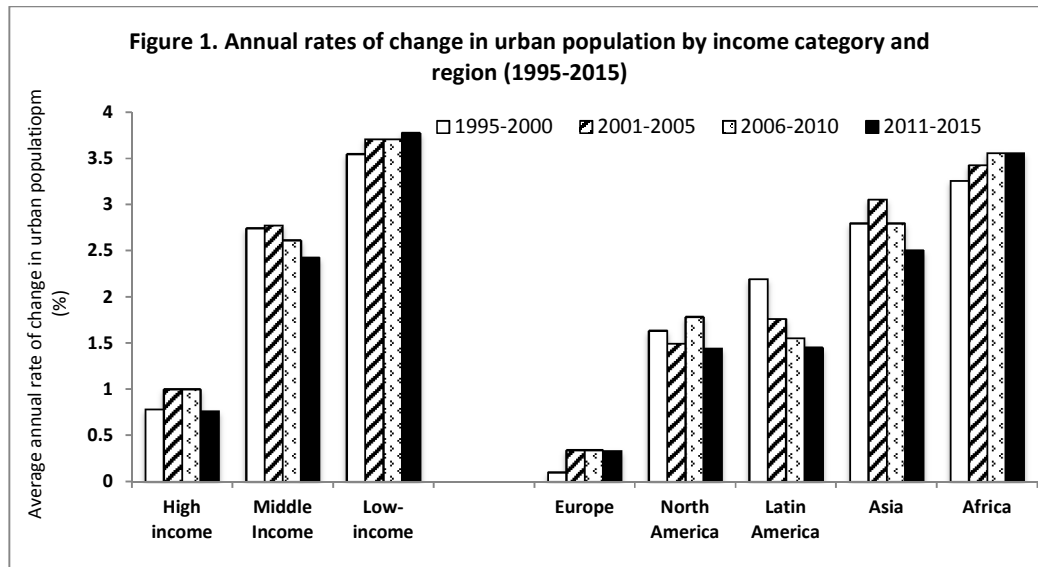
1) Urbanization

Urbanization is the process of people transitioning from dispersed rural settlements, usually where agriculture is the dominant economic force, to high-density environments characterized by industrial and service-based economic activity.² There is currently no universally agreed definition of an urban area, but instead national governments each have their own definition based on the local context.²

The process of urbanization is driven by multiple factors, including: 1) natural increase i.e., a larger number of births than deaths in urban areas; 2) migration from rural areas to urban areas driven by the desire of people to improve their economic circumstances by accessing employment, economic, and educational opportunities; 3) disasters and conflicts, resulting in acute or sudden rural-urban or urban-urban migration; and 4) spatial expansion and re-classification: rural areas being designated as urban areas resulting from local development or city expansion, annexing communities in urban fringes. The relative contribution of each of these factors is different in each urban area. The UN Habitat *World Urbanization Prospects Report (2014 revision)* estimates that globally around 60% of urbanization is attributable to natural increases; however, in some areas this is declining, such as in Asia where rural-urban migration has become relatively significant.²

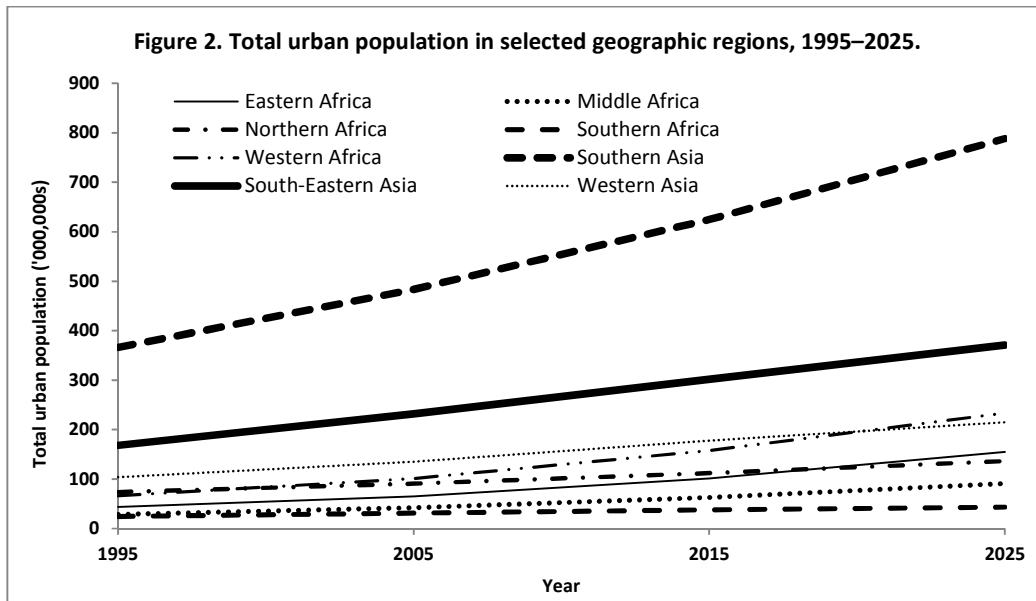
II) Urbanization trends

Africa has experienced the highest rate of urbanization over the last 20 years (figure 1; table B, appendix 1). During this period the rate of change in urban population in Africa averaged 3.55% annually, which was 1.73 times the global average. All other regions had slowing rates of urbanization (figure 1, a list of constituent countries for each region is presented in appendix 2). When categorized by country income levels, only the low-income countries experienced increasing rates of urbanization between 1995 and 2015, and at higher annual rate levels when compared to middle- and high-income countries.



Data source: UN Habitat, World Cities Report, 2016 (1)

However, the absolute number of people living in urban areas is highest in Asian countries with particularly large urban populations in China, India, Indonesia, Pakistan, and the Philippines (table A: appendix 1). In figure 2, we show the historical and projected increase in the number of urban dwellers in African and Asian regions (excluding eastern Asia, which is on a different scale, dominated by population growth in China; appendix 2).



Data sourced from World Cities Report 2016, UN Habitat (1)

As a result of the combined factors of population size and rate of urbanization, 37% of the total projected new urban-dwelling population will be concentrated in China, India, and Nigeria by 2050.²

III) Slum development

Unplanned or poorly managed urbanization results in the development of communities with low quality of living environments, lack of essential services, and low-incomes, i.e., the development of slums. These living environments pose complex risks to child health and are challenging areas in which to implement effective immunization programs. However, the concept of a slum is complex, involving physical characteristics, such as access to clean water and sanitation facilities; environmental characteristics, such as access to health services; and social characteristics, including the legal status of both the buildings and their residents. Given such a broad definition, the term ‘slum’ can apply to a wide variety of urban settlements in different contexts. To better classify slum areas, an operational definition was provided in the 2003 UN Habitat Report *The Challenge of Slums* to try and capture their multi-dimensional nature.⁴ Slums were defined as having one or more of the following characteristics:

- Inadequate access to safe water
- Inadequate access to sanitation and other infrastructure
- Poor structural quality of the housing
- Overcrowding (3 or more people sharing the same room)

- Insecure residential status

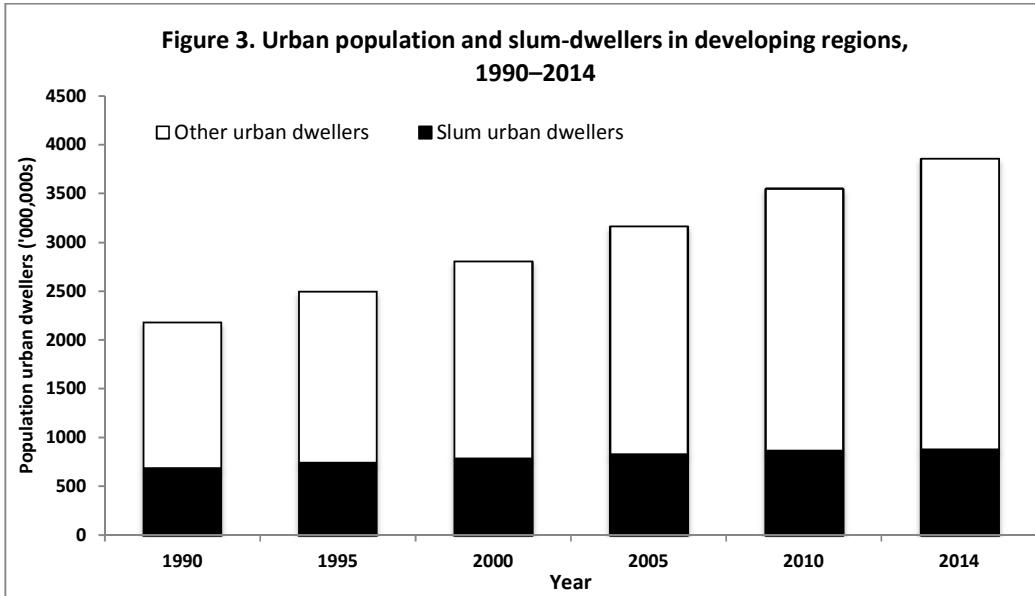
The report further underscored the complexity of slums, which often exist as relative entities in local contexts, and highlighted that slums change and develop faster than other urban areas making them difficult to quantify reliably. Overall, the idea of a slum is fluid, but generally applies to an urban area with characteristics of vulnerability for the resident population.

While some of these characteristics of vulnerability can be identified from routinely collected information such as the Demographic and Health Surveys (DHS), accurate slum identification often also requires good local knowledge to supplement this information. A recent review and analysis describes a more detailed set of factors that characterise slums and how they impact on the people who live in them for use in models to predict and evaluate slum development.⁵ These include:

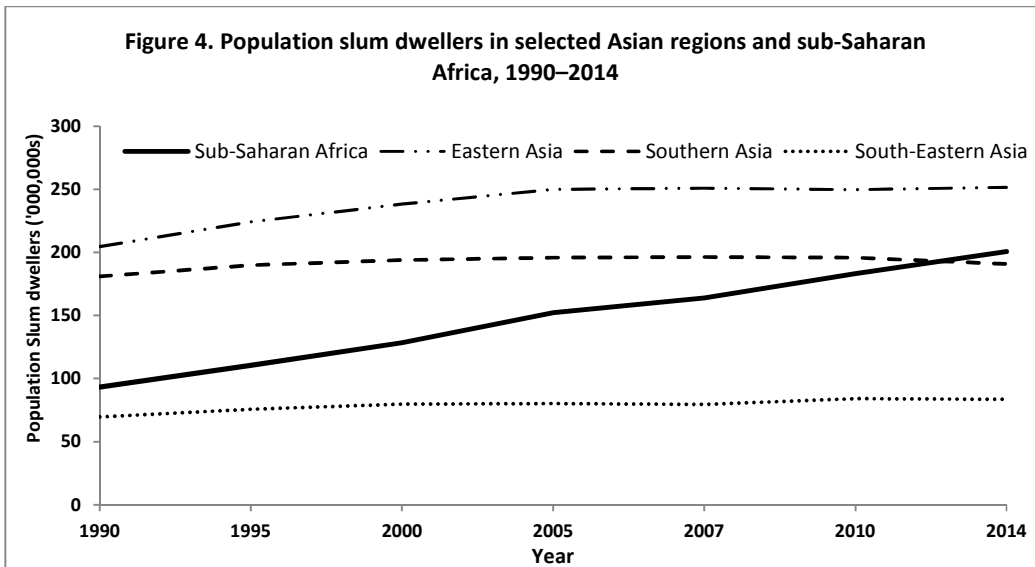
- Being entry points for the poor: slums often provide the first place of residence for many people arriving in a city, including rural-urban migrants.
- Being hubs of rising income and asset ownership: with houses often doubling as businesses, and households with higher possession of television and other technology than in rural areas.
- Creating safety concerns for women, with high levels of violence.
- Having negative impacts on health and child mortality, resulting from lack of access to basic water, sanitation, and health services.
- Lack of education, often due to child labour.
- Exclusion of residents from the formal financial system.
- Political and social exclusion: as slums are often considered to be illegal settlements and not recognised by governments.
- Being prone to disasters and climate change.

Despite declining global proportion of urban residents who are living in slums, from 46.2% in 1990 to 29.7% in 2014,¹ the absolute number of people living in slums has increased substantially in the same time period, from 689 million in 1990 to 880 million in 2014 (figure 3). In southern and eastern Asia the number of slum dwellers has remained relatively static since 2005; however, sub-Saharan Africa has recorded substantial increases, contributing 56% of the total increase in slum-dwellers since 1990 (figure 4).¹ Current demographic

evidence suggests that Africa will continue to be the main contributor to the growth of the global slum population for years to come.¹



Data source: UN Habitat, World Cities Report, 2016 (1)



Data source: UN Habitat, World Cities Report, 2016(1)

In table 1 we show the top 10 countries with the largest absolute number of slum-dwelling population. China dominates with over 190 million people; however, >160 million people live in slums in a collection of south and east Asian countries (India, Bangladesh and Pakistan) and a further 46 million in Indonesia and the Philippines.

Table 1. Top 10 countries with the largest absolute number of slum-dwelling population in 2014.*			
Country	Total country population ('000s)	Slum-dwelling population ('000s)	Proportion of urban population living in slums (%)
China	1,376,049	191,107	25.2
India	1,311,051	98,449	24.0
Nigeria	182,202	42,067	50.2
Brazil	207,848	38,491	22.3
Pakistan	188,295	32,365	45.5
Bangladesh	160,996	29,272	55.1
Indonesia	257,564	29,212	21.8
DRC	77,267	21,778	74.8
Philippines	100,699	17,055	38.3
Ethiopia	99,391	13,570	73.9

**Adapted from UN Habitat Report, 2016 (1)*

Table 2 shows the top 10 countries with the highest proportion of their total urban population who live in slums. In contrast to the previous table, all of the countries with high proportions of the urban population living in slums are in sub-Saharan Africa.

Table 2: Top 10 countries with the highest proportion of urban population who are slum-dwelling in 2014.*			
Country	Total country population ('000s)	Slum-dwelling population ('000s)	Proportion of urban population in slums (%)
South Sudan	12,340	2,086	95.6
CAR	4,900	1,747	93.3
Sudan	40,235	11,939	91.6
Chad	14,037	2,603	88.2
Sao Tome & Principe	190	111	86.6
Guinea-Bissau	1,844	698	82.3
Mozambique	27,978	6,789	80.3
Mauritania	4,068	1,886	79.9
Madagascar	24,235	6,273	77.2
Sierra Leone	6,453	1,857	75.6

**Adapted from UN Habitat Report, 2016 (1)*

IV) Health inequities

Given the rapid rate of urbanization, having access to high quality, reliable data on health outcomes is essential to understand and analyze the drivers and disparities in health among children in urban areas. However, there are specific challenges facing data collection in urban areas,⁶ which include:

- The poorest communities are often under-sampled in cross-sectional surveys, including DHS and MICS.
- Sample sizes resulting from cluster or purposive representative methods may not be large enough to capture intra-urban disparities.
- Routine population level surveys, including DHS and national censuses, are carried out too infrequently to accurately represent rapid urbanization.
- All surveys may actively exclude informal settlements, including slums, for political or legal reasons.
- Neither 'rural' nor 'urban' have specified, agreed definitions.

Despite these limitations, there are sufficient data that highlight issues relating to disparities in health service coverage and outcomes between rural and urban populations and between different groups within an urban population.

A) Rural-urban disparities

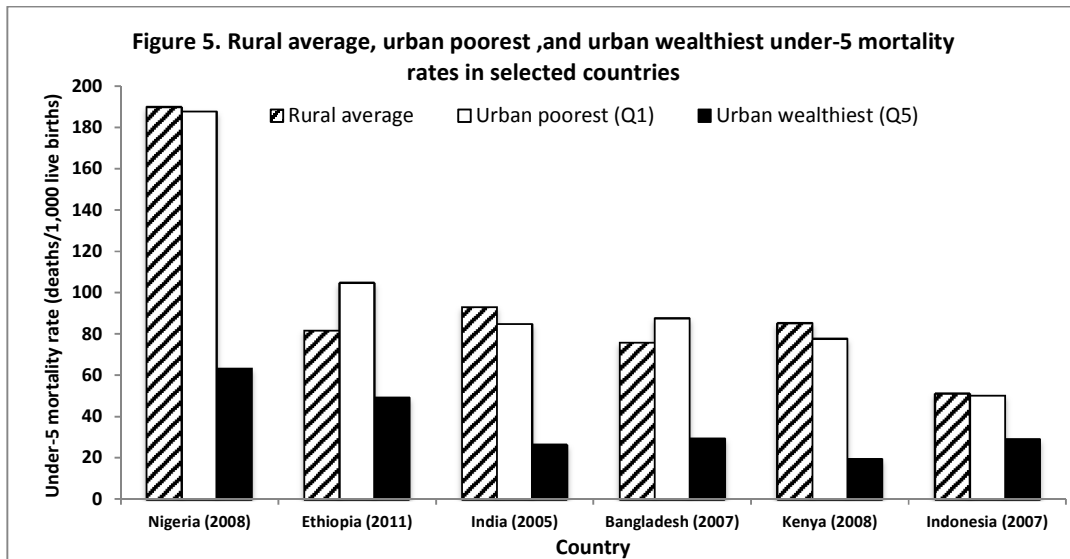
On average health outcomes in urban areas are generally better than those in rural areas, however child mortality has declined dramatically in both urban and rural settings in low- and middle-income countries (LMICs) over the last 30 years. More recently this decline has continued in rural areas, but begun to stagnate in urban areas, particularly those with large slum-dwelling populations, such as countries in sub-Saharan African.⁷

Globally, immunization coverage is higher in urban areas than in rural areas,⁸ however, evidence is mixed at national and sub-national level. For example, in India overall immunization coverage is higher in urban areas than in rural areas, and in Bangladesh coverage is almost equal in urban and rural areas.^{9,10} In the publically available DHS data the picture looks similar in sub-Saharan Africa, with higher coverage in rural areas. However, a detailed analysis of DHS survey data using advanced statistical techniques showed that children in urban areas are 12% more likely to be un-immunized when other socio-economic characteristics were taken into account.¹¹

B) Disparities in health outcome by wealth within urban areas

While urban settings are home to the wealthiest and healthiest people in a country, they are also home to some of the poorest and most marginalized communities.¹² The urban rich-poor gap is widening as urbanization increases.¹ Latin America and the Caribbean, the world's most urbanized region, also has the highest levels of wealth inequality; wealth inequality has also been increasing steadily in Asian cities, including in China, India and Indonesia.¹ Despite poor quality data, wealth inequality also appears to be on the increase in urban Africa.

A general trend of health inequities is seen within urban areas when outcomes are disaggregated by wealth quintile. The socio-economic environment in which people live is known to have a profound effect on health throughout their life course.¹³ Evidence from India, Nepal, and Pakistan show that child-mortality in urban areas on average is lower than rural areas, except in the poorest 2 urban socio-economic quintiles, which have higher mortality than the rural population average.¹⁴⁻¹⁶ This has resulted in a growing proportion of child deaths occurring in urban areas and the majority of these preventable deaths are concentrated among urban poor populations, especially communities in slum environments.¹⁷ In figure 5 we show under-5 mortality in urban areas disaggregated by wealth quintile, separating the richest and the poorest urban residents, as compared to the average under-5 mortality for all wealth quintiles in rural areas. All countries show substantially lower mortality in the wealthiest urban quintile when compared to both the poorest urban quintile and rural average. In Nigeria and Indonesia, mortality in the poorest urban quintile is similar to the rural average; in Ethiopia and Bangladesh it is higher; and in Kenya and India it is slightly lower.

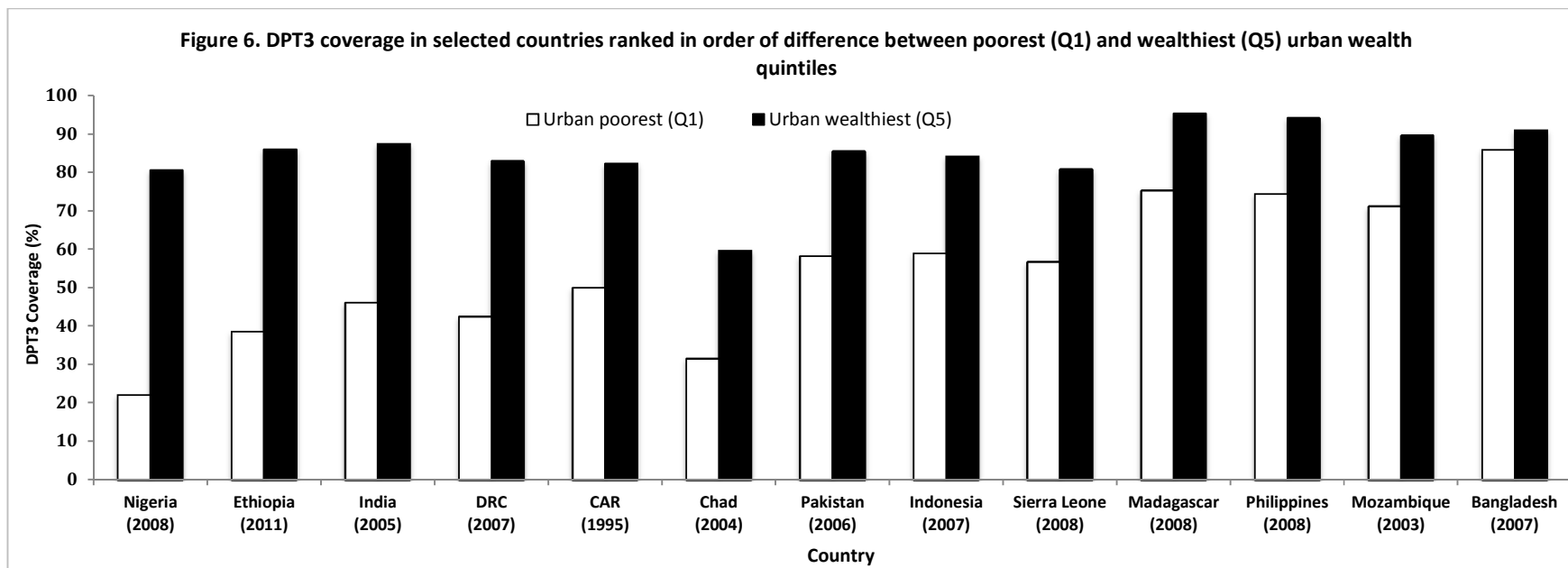


Data source: World Health Organization, Global Health Observatory (3)

One of the main contributing factors to these disparities is that the people in the lowest income quintiles in urban areas are likely to be living in urban slums, which confer an increased risk of water-borne and vector borne diseases, such as malaria, diarrhoea; respiratory tract infections, such as pneumonia; HIV/AIDS and other communicable diseases, as well as malnutrition, injuries and mental ill health.¹⁸ While children living in urban slums may have better health outcomes than their rural counterparts, in some circumstances, compared with their wealthier urban peers, their health outcomes are worse. The most important socio-economic determinants of health outcomes in slums appear to be maternal education, household wealth, and access to health services.¹⁹ A recent review of health outcomes in slums found that child mortality in slum areas of Nairobi is now higher than it was 20 years ago, and 2.5 times higher than other areas of the city; similar trends have also been noted in Bangladesh and Nigerian cities.¹⁸

C) Disparities in immunization coverage by socio-economic status in urban areas

An important disparity in health outcomes seen between the wealthiest and poorest within an urban area is lower levels of vaccination coverage and increased risk of vaccine preventable diseases (VPDs) among urban poor communities. Data from DHS surveys are presented in figure 6 for DTP3 vaccination coverage by richest and poorest wealth quintile in urban areas.



Data sourced from World Health Organization, Global Health Observatory (3)

The absolute difference in vaccination coverage between the wealthiest and poorest urban dwellers within each country varies markedly, from 5.1% in Bangladesh to 58.4% in Nigeria. However, there is relatively little variation in coverage among the wealthiest urban quintile, which is above 80% in all selected countries except for Chad; but a wide range in coverage for the poorest urban quintile, ranging from 22% to 86%.

DHS questionnaires do not classify or adequately sample slum communities, so many studies have been conducted to investigate differential coverage of immunization in specific slum areas. Tables 3 and 4 show studies that have collected data on immunization coverage in slums in India and in sub-Saharan African countries respectively, published since 2000. Articles are ranked in order of countries with the highest reported levels of complete immunization in the study population. Immunization status was broadly categorized either as being complete (having had all recommended vaccinations for age), partial (having had some, but not all vaccinations) or unvaccinated (having had no vaccines); or using a dichotomous variable of complete or incomplete (including both partial and unvaccinated populations). The second classification was more common in sub-Saharan African studies.

Table 3. Studies conducted in slum populations in India reporting immunization status of children since 2000.

City in India	Year of study	Population	Sample size	Immunization Status (%)			Notes	Ref
				Complete	Partial	Unimmunized		
Mumbai	2013	Children 12-23 months	352	88.7	11.9		Complete or incomplete	(20)
Jamnagar	2013	Children 1-5 years	450	75.0	13.3	11.6		(21)
Mumbai	2016	Children 12-23 months	336	75.0	22.3	2.7		(22)
Rewa	2014	Children 12-23 months	210	72.4	21.9	5.7		(23)
South Delhi	2001	Children 12-23 months	166	69.3	15.7	15.1		(24)
Solapur	2012	Children <5 years	420	64.3	25.6	9.8		(25)
Delhi [†]	2010	Rural-urban migrant children up to 2 years	746	60.2	34.9	4.9	Settled migrants	(26)
Varanasi	2015	Children 12-23 months	384	57.0	43.0		Complete or incomplete	(27)
Jagdapur	2015	Children 12-23 months	225	55.1	30.7	14.2		(28)
Surat	2003	Children 9-59 months	3035	49.3	51.7		Measles only	(29)
New Delhi	2012	Children 12-23 months	210	47.8	17.2	35.2	Hepatitis B only	(30)
Hyderabad	2014	Children 12-23 months	510	44.1	32.0	23.9		(31)
Lucknow	2007	Children 12-23 months	510	44.1	32.0	23.9		(32)
Kanpur	2014	Children <5 years	390	41.4	44.8	13.8		(33)
Delhi [†]	2010	Rural-urban migrant children up to 2 years	746	39.7	54.8	5.5	Recent migrants	(26)
Bhopal	2012	Children < 5 years	790	35.2	48.2	n/a	16.4% status unknown	(34)
Bijapur	2013	Children 12-23 months	155	34.8	62.6	2.6		(35)
Meerut	2010	Children 12-23 months	216	31.0	17.1	51.9		(36)
Surat	2009	Children 12-23 months	300	25.1	51.7	23.1		(37)
Delhi	2002	Children <5 years	500	25.0	44.4	30.6		(38)
Chandigarh [‡]	2015	Children 12-23 months	310	23.0	73.0	3.0	Non-migrants	(39)
Agra	2010	Children 10-23 months	1728	14.0	45.0	41.0		(40)
Chandigarh [‡]	2015	Children 12-23 months	310	3.0	91.0	6.0	Migrants	(39)

† and ‡ denote results from the same study disaggregated by migration status.

Table 4: Studies conducted in slum populations in sub-Saharan Africa reporting immunization status of children since 2000.

Country	City	Year	Population	Sample size	Immunization Status (%)			Notes	Ref
					Complete	Partial	Unimmunized		
Burkina Faso [€]	Ouagadougou	2015	Children 12-59 months	3103	93.3	6.7		(41)	
Kenya	Kaptembwo	2013	Children 12-23 months	380	76.6	23.4		(42)	
Kenya	Nairobi	2015	Children 12-23 months	382	70.0	30.0		(43)	
CAR	Bangui	2014	Children <11 months	400	67.0	33.0		(44)	
Kenya	Nairobi	2011	Children 12-23 months	1848	58.0	42.0		(45)	
Kenya [€]	Nairobi	2015	Children 12-59 months	1369	55.0	45.0		(41)	
Ethiopia	Jijiga	2014	Children 12-23 months	582	47.6	32.7	19.7	Low-income urban (not slum specifically)	(46)
Nigeria	Ibadan	2013	Children 12-23 months	588	38.8	45.6	15.7	Low-income urban (not slum specifically)	(47)
Nigeria [¥]	Multiple cities	2012	Children >12 months	604	24.3	75.7		Rural	(48)
Nigeria [¥]		2012	Children >12 months	593	15.2	84.8		Urban	
Nigeria [¥]		2012	Children >12 months	1303	8.5	91.5		Rural-Urban migrant	

€ and ¥ denote results from the same study disaggregated by urban, rural or migration status.

The most striking feature of this evidence is the wide range of coverage reported in different slum contexts. In India, complete coverage reported ranged from 3.0% in rural-urban migrant children in a slum in Chandigarh to 88.7% in Cheetah Camp in Mumbai, while the highest levels of unimmunized children were found in Meerut (51%) and Agra (41%). Similarly, across 8 studies conducted in 5 sub-Saharan countries complete immunization coverage ranged from 8.5% in a representative sample of rural-urban migrant children in Nigeria to 93.3% in the slums of Ouagadougou, Burkina Faso.

As a result of lower vaccination coverage, VPDs contribute to worse health outcomes in low-income urban populations, particularly in slum areas. Increased morbidity and mortality has been observed for a variety of diseases, including measles,^{49,50} mumps,⁵¹ diphtheria,⁵² influenza,⁵³ and typhoid^{54–57} in countries including: South Africa,⁴⁹ India,^{50,51,55,57} Bangladesh^{53,56} and Kenya.⁵⁴ Outbreaks of VPDs are more common in urban slums owing to high population density and continuous influx of a new pool of infective agents with immigrating population and have a larger number of cases and potential for greater morbidity and mortality.^{49–52,57}

D) Rural-urban migration

One of the factors contributing to disparities in health outcomes and immunization coverage in urban poor communities is rural-urban migration, which is known to have a negative impact on immunization coverage in migrant children. Children in migrant communities in China, India, and Nigeria have been found less likely to be fully immunized than urban non-migrants; and more recent migrants have lower coverage than settled migrants (generally classified as being resident for 12 months or more)⁵⁸ partly explained by the legal status of migrants, which can impact on uptake of services and health outcomes. An example of this is the *hukou* system of registration for public services in China, which determines entitlement to healthcare. Migrant workers are most often registered in their rural home district and not in their urban location and thus are known to under-use health services in general and immunization services specifically, resulting in lower childhood immunization coverage than among their urban or rural counterparts.⁵⁹

Slum communities are often the entry point for recent rural-urban migrants, who are more likely to have worse health outcomes than settled slum residents. For example, a study comparing the morbidity among children who migrated with their parents from a rural to an

urban area in Nairobi found significantly greater morbidity among the new urban arrivals than would be expected if they had remained in their rural environment.⁶⁰ Immunization coverage is also lower in the new-arrival population than in both the rural community that the migrants left and the urban community which they have joined.⁵⁸ The difference in immunization uptake can be stark, as evidenced in tables 3 and 4 that disaggregate a range of study populations by migration status.

However, a number of these studies highlight that the difference is partly explained by the socio-economic status of the migrant population, suggesting that factors such as wealth, income, and education play an important role, as well as migratory disruption.^{26,39,48} This effect has also been noted in rural-urban migrant communities in China.⁶¹

2. Methods

We performed a review of literature to identify what factors contribute to the differences in coverage in immunization services seen among urban communities, especially between poorer and wealthier groups, and identify evidence for effective interventions to increase vaccination uptake and utilization. We searched the Medline, Embase, Global Health, Web of Science and CINAHL databases, with a broad range of search terms from the following categories: vaccine, immunization; urban, peri-urban, slum; and low and middle income countries, restricting our search to articles published since 2000. We included any observational, interventional or ecological study conducted in an urban poor or slum community in a low or middle income country, reporting on factors associated with immunization coverage levels or on interventions to increase immunization coverage.

In total, 49 studies reporting on factors associated with immunization coverage were identified and 21 studies reporting on interventions to increase vaccination uptake in urban slum communities. A summary of this evidence is presented below.

3. Factors associated with immunization uptake in urban slums

The evidence relating to what factors are associated with immunization coverage among children living in urban slums is presented below, categorized into 3 groups: socio-economic characteristics; information, beliefs and behavior; and health services.

I) Socio-economic characteristics

The evidence for the effect of different socio-economic (SE) characteristics of slum-dwelling urban population is mixed, with studies conflicting on whether certain factors are associated with immunization uptake and, if they are, the strength of the association. The largest evidence base in the literature is from India, where SE factors have been studied extensively in a variety of slum areas. One study used data from the Indian National Family Health Survey and compared SE factors and outcomes of 1,877 children in less developed Empowered Action Group states with their more developed northern counterparts;⁶² of 9 characteristics studied, contributing factors to SE inequality were having an illiterate mother (31%), poverty (26%), an illiterate father (12%), and being a 3rd born child or greater (11%).

However, studies conducted in individual slums paint a more heterogeneous picture, with a few studies associating mothers' education with lower immunization coverage^{22,25,40} and others not associating mother's education with low immunization coverage.^{23,26} Similarly, female children had lower coverage in some studies,^{22,23,40} but no gender difference was found in others.^{20,25,30} Outside India, a study in a slum in Karachi, Pakistan, found an association between immunization coverage with SE status, with lower coverage in lower SE groups.⁶³ However, the study reported a significant effect of being from a marginalized ethnic group, particularly if this is associated with illegal or insecure residential status in a slum.

The findings in sub-Saharan African countries are similar, with different factors emerging as important in different slum areas. For example, across three different slum populations in Kenya, factors associated with immunization uptake included maternal education, employment and age, child's birth order, number of children in the family, place of birth (home or health facility) and household assets and expenditure.^{42,43,45} In another study, ethnic group was a significant predictor of measles vaccine uptake.⁶⁴ However, a paired study conducted in slums in Nairobi, Kenya, and Ouagadougou, Burkina Faso, found that while the SE factors in each slum were similar, children in Nairobi were 11.5 times more likely to be unvaccinated, suggesting a powerful environmental effect in this case.⁴¹

The findings above are partly as a result of the nature of available studies, which is primarily associated with SE factors and coverage data from routine sources or cross-sectional surveys, and so the outcome is dependent on the data variables collected. However, there is

a probability of variation in the effect of SE factors in different slum areas, depending on specific cultural and demographic conditions.

II) Information, beliefs and behavior

The majority of the studies that collected information on demographic and SE characteristics in urban slums also asked parents (mainly mothers) why their children were not fully vaccinated. A synthesis of the most frequently cited factors in 16 studies undertaken in a variety of Indian slums found a wide range of factors offered by parents. The most common were: parents being unaware of the need for vaccines (14 studies); either the child's mother or both parents being too busy to take their child to be vaccinated (7 studies); parents traveled to home village or place of origin (5 studies); and parents or caretakers unaware of the location or timing of the vaccine clinic (5 studies).^{20,22-27,29-32,38-40,62,65} Additionally, several factors, ranging from having no faith in vaccinations to loss of earnings, were also raised with different factors being important in different slums.

Unfortunately, there are fewer studies available from other countries to make similarly detailed comparisons. In a study conducted in Islamabad, Pakistan, maternal knowledge of immunization was an important factor in predicting immunization coverage;⁶⁶ a study in Ibadan, Nigeria, found fear of side-effects, mothers not aware of services, and parents being too busy to attend clinic to be significant;⁴⁷ and the 3 main reasons for under-vaccination identified in a study from Bangui, Central African Republic, were the mother being too busy, negative attitude of health workers, and lack of access to information on vaccination.⁴⁴

Only one qualitative study, conducted using qualitative analysis of focus group interviews, to investigate access and uptake of health services among urban slum populations in DRC was identified.⁶⁷ Overall the study reports that out-of-pocket expenditure was the main barrier to use of services. Respondents also reported treating free commodities, including vaccines and bed nets, with suspicion. Services were often seen to be beneficial, but were not acceptable due to lack of information and distrust in the government. Participants cited rumors and uncertainty about whether some interventions could be harmful and highlighted lack of health worker knowledge and poor communication in relation to vaccines. This paints a more complex and nuanced picture of health beliefs alongside the need for good information and communication generated by qualitative studies than is captured through cross-sectional studies alone

Similarly with the SE factors, it's likely that there is a combination of research study design and local variation in health beliefs, culture, and environment that contributes to the variation in factors identified in the studies described above. However, the evidence suggests that improving demand-side interventions, such as improving communication, awareness, and knowledge, could increase immunization coverage.

III) Health services

In informal, illegal or swiftly emerging settlements, the provision of health services has been shown to be different when compared to the rest of an urban area, which may also have an effect on immunization coverage and lead to inequities in coverage, particularly among the urban poor in slums.⁶⁸ Access to health services is also an important factor in improving immunization coverage in slum areas. A detailed study that used mapping techniques to evaluate health service access in a slum community in Agra, India, found that the presence of a health center within 2km of the slum doubled the chances of a child being completely vaccinated.⁴⁰ A study conducted in Lusaka, Zambia, using Geographic Information System methods also showed that further distance from service points were associated with a significant reduction in uptake of DTP3 and measles vaccine, but that the effect of this could be reduced by the provision of outreach services into underserved areas.⁶⁹ In addition, health services in slum areas may be provided through different organizations than in other parts of an urban area. For example, a study conducted in Bangladesh highlights that the informal private sector provision of health services by non-medically qualified staff is more common than public provision in slum areas, although this may be supplemented by services provided by NGOs and satellite clinics from public institutions.⁷⁰

Slum-dwelling populations are less likely to access health services, even when they are provided, because of fear of costs, risk of losing income, or not knowing where and when services can be accessed.⁷¹ When people do access healthcare, the quality of the services provided also plays a role: higher patient satisfaction and provision of accurate information leads to increased attendance for repeat vaccine doses, thus increasing coverage.⁷²

When people do access health services, missed vaccination opportunities, which is when health workers interact with a child who is under-immunized and could have been offered a vaccination but for some reason do not, might occur. It is not clear whether there are differences by slum areas, but a study conducted in 6 health facilities in a Nairobi slum found

that coverage of 1st, 2nd, and 3rd doses of oral polio vaccine would have increased by 16%, 18%, and 11% respectively if all missed opportunities for vaccination had been taken. Additionally, increases of 11% for 1st and 2nd doses of DTP, 7% for 3rd dose of DTP, and 19% for measles would have been noted if missed opportunities were addressed, underscoring the significance of addressing missed vaccination opportunities.⁷³

IV) Migration status

Recent migrants appear to have lower immunization coverage than migrants who have been settled in an urban-slum area for more than 12 months,²⁶ suggesting that migrating to a new locale has the most significant effect on immunization coverage, which then resolves to be similar to the slum-area average over time as a result of adaptation to the new environment. A study comparing rural, urban and rural-urban migrant mothers in Nigeria found that children of urban non-migrant mothers had 67% higher chance of being fully immunized than children whose mothers had migrated.⁴⁸ This difference was attributed to the disrupting force of migration, including loss of social networks and changes to economic circumstances, which are unique to migrant populations in slums. However, after applying a statistical model, other characteristics, including children being of higher birth order; being a mother aged <18 years; and having a lower SE status, also played a role in determining immunization status of migrants, independent of migration status. Thus there are elements of similarity of the risks of low immunization coverage as faced by all urban poor communities, but these are exacerbated by the disruptive force of migration itself.

The reasons for low coverage in rural-urban migrants also appear to be different from non-migrants living in slum communities. A study comparing reasons for under-immunization given by migrant and non-migratory parents of children in an Indian slum cited the following reasons for migrant populations: mother or both parents being too busy; parent returned to home village; parent unaware of place or time of immunization; and lack of awareness for the need for immunization as the main reasons for under-immunization among a majority of migrant parents.³⁹ This suggests that health services or other interventions need to be tailored to meet the needs of migrant communities, if uptake and utilization of immunization services is to be improved in this vulnerable population.

4. Interventions to improve immunization coverage in slums

Twenty-one studies were identified that looked at interventions to increase immunizations uptake specifically in a slum area, or have included interventions delivered in an urban

population including a low-income or slum community. A summary of these interventions are presented below, divided into four categories: complex interventions; outreach programs; reminder/recall systems; education; and studies considering incentives.

I) Complex interventions

Interventions involving multiple components designed to meet the specific needs of a slum-dwelling community have evidence of effectiveness in some contexts, especially if they have been designed and delivered with community involvement. Two related studies report on an intervention conducted in urban slums in Dhaka, Bangladesh. The first is a non-controlled before-and-after evaluation of the intervention, which included four components: extended immunization services hours to cater for working parents in slum areas; training for service providers to increase knowledge of vaccines; a screening tool to identify opportunities for vaccination at clinics; and a support group made up of local community members to increase participation.⁷⁴ Analysis of data involving 529 children before and 526 after the intervention showed that during the 12-month intervention period coverage for all vaccinations increased, with complete immunization rising from 43% to 99%. The second paper calculated the cost of the program at \$20.95 per additional fully immunized child.⁷⁵ While this cost is not insignificant, this does provide a potentially effective model to consider when designing programs to meet the needs of urban slum-dwellers.

A similar program in Patna, India, that involved enhanced service delivery, including outreach services, additional nursing staff, task shifting, GPS monitoring of vaccine distribution, community link workers and community mobilization, increased monitoring, supervision and communication components, in low-income urban areas was evaluated using before- and after-analysis of routinely collected data.⁷⁶ The results showed substantial increases in immunization uptake and utilization e.g., DTP3 increased from 21% to 49%, measles from 23% to 51%. However, the low baselines meant that high proportions of children who were under-immunized children were still vulnerable to preventable diseases. A similar study conducted in Indian slums evaluated the implementation of the Urban Health Program (UHP), which included interventions designed to increase awareness and demand of health services, while increasing supply and accessibility across providers and improving links between providers and slum communities.⁷⁷ Interventions included the formation of women's groups, outreach health camps, and political engagement, resulting in increase in complete immunization among infant from 32% to 72%.

II) Outreach programs

The outreach programs identified in the literature focused specifically on reducing physical distance between communities and health services, and not on interventions to reduce the social distance that some slum residents felt when accessing health services, especially those newly arrived migrants.

Two related studies reported on the Growth Monitoring Program Plus (GMP+), which involved providing monthly health outreach services embedded with immunization services, implemented in peri-urban areas of Lusaka, Zambia.^{69,78} Comparing sites that started the intervention early with those that started implementing it later, immunization coverage was shown to considerably increase by intervention from 52.6% to 68.8% in the early area and from 43.1% to 56.7% in the later area, which was statistically significant even after controlling for socio-economic characteristics. Using geographic proximity, the authors report that prior to the intervention lower coverage was found with further distance from health facilities, but when the distance was reduced using outreach services, coverage increased.

A study on an outreach services provided in Aligarh City, India, as part of a campaign reported success in immunizing over 2,500 children in a low-income district and improving overall full immunization coverage, demonstrating both feasibility and acceptability, although the authors note low coverage in the community overall.⁷⁹

III) Reminder/recall systems

Reminder/recall systems have good evidence for effectiveness in high-income countries and are considered as a core component of any vaccination program.⁸⁰ However, particular challenges face the provision of reminder/recall systems in urban areas of LMICs, especially in slums, e.g., informal road systems, lack of addresses, no postal system and limited access to electronic communications. Nonetheless, a number of studies have shown varying levels of success in the use of text message (SMS) or other reminder systems in low-income, urban environments. In Bangladesh, the use of SMS reminder system among urban street dwellers and a rural 'hard-to-reach' population was studied.⁸¹ The results showed an increase in immunization coverage in both populations after controlling for maternal education, phone

ownership, and sex of child, with an adjusted odds ratio of complete vaccination of 3.0 (95% confidence interval [CI]: 1.4–6.4) among the street-dwelling urban children.

A proof of concept study in an urban poor community in Guatemala City showed that the use of an SMS system to remind mothers of infants to receive pentavalent vaccine demonstrated that it was feasible and acceptable, but showed no difference in vaccine uptake and utilization in the intervention group.⁸² In Pakistan, an SMS system was successfully used to monitor provision of polio immunization by asking urban community members to report whether their children had been vaccinated, helping to monitor coverage during door-to-door polio campaigns.⁸³

IV) Incentives

Two studies were identified that considered the effect of incentives on encouraging vaccination uptake. A study of the Bolsa Familia program of conditional cash transfers in Salvador City slums, Brazil, found that families in receipt of payments had higher use of health clinics and increased odds of vaccination uptake (odds ratio (OR) 2.8; 95% CI: 1.4–5.2).⁸⁴ A study conducted in Pakistan involving nearly 4,000 children investigated the effect of providing a coupon redeemable for food or medicine (worth US\$2) to incentivize attendance amongst low-income mothers in Karachi to return for follow-up immunization appointments.⁸⁵ The results showed increase (OR 2.2, 95% CI: 1.95–2.48) in timely completion of the DTP immunization series among study group compared with their controls.

V) Education

Only one study was identified that considered the effect of an intervention focusing on education or information provision to parents living in low-income urban areas. This was a randomized controlled trial conducted in Karachi, Pakistan, and involved community health workers delivering pictorial messages in a low-income population to support and encourage vaccination.⁸⁶ The intervention resulted in a 39% increase (OR 1.39, 95% CI: 1.06–1.81) of DTP3/Hepatitis B completion in the intervention group although a considerable number (27% of the sampled population) of women invited, who may have been less likely to have their children vaccinated, declined to take part in the study. Maternal education levels were higher in the intervention group, which may also be a source of bias; however, this finding is encouraging because this type of intervention might be cost effective to implement.

5. Conclusions

As urbanization trends accelerate over the next three decades, the population of urban slum dwellers is expected to increase in Africa and Asia. Health outcomes differ between urban rich and urban poor communities, and these disparities are driven by demographic, geographic, and socio-economic factors. The coverage of health interventions, including vaccination, are usually lower among urban poor communities, increasing their vulnerability to vaccine preventable diseases. Recent migrants to cities (resident for < 12 months), particularly those who arrive into slum areas, are even more vulnerable compared with settled slum dwellers. Factors that underpin this increased vulnerability include a lack of social networks, no knowledge of where and what social services exist, and limited or absent assimilation into their new environment. Current EPI systems and delivery strategies in urban areas do not appear to effectively meet the circumstances of the urban poor, particularly those living in slum conditions.

Because slums are heterogeneous, multi-component interventions designed to meet the specific needs of a local slum communities have evidence for effectiveness in a number of different slum contexts. Outreach services may also be useful to reduce geographic distance to health services. More research is required to evaluate the effectiveness of reminder/recall systems, financial incentives and educational interventions, as well as monitoring and evaluation of existing services to ensure they meet the needs of rapidly expanding urban communities. No interventions were identified to provide services for migrant populations in low and middle income countries, who are a particularly vulnerable group. Policy makers and immunization stakeholders should develop strategies to address the challenge of deprivation afflicting the urban poor and strive to reduce the marked disparities in immunization and wider health outcomes when compared to the wealthier urban dwellers. More research, including qualitative studies, will be needed to describe slum populations and to inform policy formulation, strategy development, and intervention planning. A reallocation of resources and a change in focus of current immunization strategies will be needed in order to meet the needs of children living in low-income urban areas.

The increasing populations of people living in urban areas, particularly urban slums, is introducing new challenges for health programs, especially in effectively addressing the health disparities between the urban poor and wealthy. This is being reflected in changing

patterns of vaccine preventable disease outbreaks, which are becoming more common and severe in urban areas, and are exacerbated by existing vulnerability of slum dwellers characterized by low immunization coverage, poor sanitation, or crowded living conditions. The attainment of global and national goals of immunization in future will require specific attention on slum environments in urban settings.

6. References

1. UN Habitat. World Cities Report 2016. Urbanization and Development: Emerging Futures. Pub, UN Habitat, 2016.
2. United Nations. World Urbanization Prospects: 2014 Revision. Pub. UN, 2014.
3. WHO. Global Health Observatory Data: Urban health. WHO, 2016 [cited 2016 Sep 6]. Available from: http://www.who.int/gho/urban_health/en/
4. UN Habitat. The Challenge of Slums: Global Report on Human Settlements 2003. Pub. UN Habitat, 2003.
5. Roy D, Lees MH, Palavalli B, Pfeffer K, Sloot MAP. The emergence of slums: A contemporary view on simulation models. *Environ Model Softw*; 2014;59(2014):76–90.
6. Eley, H. Thomson, D. R. Lin, R., Maharjan, U, Sgarwal, S, Newell J. Addressing Inequities in Urban Health: Do Decision-Makers Have the Data They Need? Report from the Urban Health Data Special Session at International Conference on Urban Health Dhaka 2015. *J Urban Heal.*; 2016;19(109):1–12.
7. Garenne M. Urbanisation and child health in resource poor settings with special reference to under-five mortality in Africa. *Arch Dis Child*. 2010;95(6):464–8.
8. WHO. GHO | By category | DTP3 immunization - Data by residence. WHO, [cited 2016 Sept 6]. Available from: http://www.who.int/gho/urban_health/en/.
9. Mathew JL. Inequity in childhood immunization in India: a systematic review. *Indian Pediatr.*; 2012;49(3):203–23.
10. Naeem M, Khan MZUI, Adil M, Abbas SH, Khan MU, Khan A, et al. Inequity in childhood immunization between urban and rural areas of Peshawar. *J Ayub Med Coll.*;2011;23(3):134–7.
11. Wiysonge CS, Uthman OA, Ndumbe PM, Hussey GD. Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis. *PLoS One*;2012;7(5):e37905.
12. Friel S, Akerman M, Hancock T, Kumaresan J, Marmot M, Melin T, et al. Addressing the social and environmental determinants of urban health equity: Evidence for action and a research agenda. *J Urban Heal*. 2011;88(5):860–74.
13. Marmot M, Friel S, Bell R, Houweling TA, Taylor S. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet*. 2008;372(9650):1661–9.
14. International Institute for Population Sciences. National Family Health Survey (NFHS-3), 2005-06: India: Volume I. Vol. 18. 2007. 765 p. Pub, Government of India, 2007.
15. Population Division: Ministry of Health and Population. Nepal Demographic and Health Survey 2011. Pub. Government of Nepal, 2011.
16. National Institute of Population Studies. Pakistan Demographic and Health Survey 2006-07. Vol. 40, Studies in Family Planning. Pub. Government of Pakistan, 2008.
17. Save the Children. The Urban Disadvantage: State of the Worlds Mothers 2015. Pub. Save The Children, 2015.
18. Unger A. Children's health in slum settings. *Arch Dis Child*; 2013;98(10):799–805.
19. Fink G, Gunther I, Hill K. Slum Residence and Child Health in Developing Countries. *Demography*. 2014;51(4):1175–97.
20. Kulkarni S V, Chavan MK. A study to assess the immunization coverage in an urban slum of Mumbai by lot quality technique. *International Journal of Medicine and Public Health*: 2013;3:21–5.
21. Damor RD, Pithadia PR, Lodhiya KK, Mehta JP, Yadav SB. A study on assessment of nutritional and immunization status of under-five children in urban slums of Jamnagar city, Gujarat. *Healthline, Journal of Indian Association of Preventive and*

- Social Medicine;2013;4:35–9.
22. Kadarkar KS, Velhal GD. Lots quality coverage survey technique for assessment of determinants of immunization coverage in urban slum of Mumbai. *National Journal of Community Medicine*; 2016;7:165–70.
 23. Trivedi R, Singh S, Adhikari P, Jatav DP. Coverage evaluation of primary immunization and the associated determinants in an urban slum of Rewa. *Indian Journal of Community Health*;2014;26:37–40.
 24. Kar M, Reddaiah VP, Kant S. Primary Immunization Status of Children in Slum Areas of South Delhi - The Challenge of Reaching the Urban Poor. *Indian J Community Med*. 2001;26(3).
 25. Wadgave H V, Pore PD. Missed opportunities of immunization in under-fives in adopted area of Urban Health Centre. *Annals of Tropical Medicine and Public Health*; 2012;5:436–40.
 26. Kusuma YS, Kumari R, Pandav CS, Gupta SK. Migration and immunization: determinants of childhood immunization uptake among socioeconomically disadvantaged migrants in Delhi, India. *Trop Med Int Health*; 2010;15(11):1326–32.
 27. Awasthi A, Pandey C, Singh U, Kumar S, Singh T. Maternal determinants of immunization status of children aged 12-23 months in urban slums of Varanasi, India. *Clin Epidemiol Glob Heal.*;2015;3(3):110–6.
 28. Khan QH, Sinha T, Shrivastava PK, Brahmapurkar KP, Brahmapurkar VK. Assessment of immunization status among children aged 12-23 months, at an urban slum area of Jagdalpur city, Bastar. *Healthline, Journal of Indian Association of Preventive and Social Medicine*;2015;6:55–60.
 29. Desai V, Kapadia S, Kumar P, Nirupam S. Study of measles incidence and vaccination coverage in slums of surat city. *Indian J Community Med*. 2003;28(1):10–4.
 30. Sachdeva S, Datta U. Hepatitis B immunization coverage evaluation amongst Slum Children. *Indian Journal of Public Health Research and Development*; 2012;3:191–4.
 31. Kulkarni P, Hamid HSS, Shah M. Immunisation coverage status and reasons for underimmunisation in urban slums of Hyderabad city, Telangana state. *Indian Journal of Basic and Applied Medical Research*. 2014;3:152–7.
 32. Nath B, Singh J V, Awasthi S, Bhushan V, Kumar V, Singh SK, et al. A study on determinants of immunization coverage among 12-23 months old children in urban slums of Lucknow district, India. *Indian J Med Sci.*;2007;61(11):598–606.
 33. Agarwal N, Sharma RP, Chandra S, Varma P, Midha T, Nigam S. Immunization status and childhood morbidities as determinants of PEM among under-five children in slums of Kanpur. *Indian Journal of Community Health*. 2014;26:396–400.
 34. Gupta SK, Nandeshwar S. Status of maternal and child health and services utilization patterns in the urban slums of Bhopal, India. *National Journal of Community Medicine*. 2012;3:330–2.
 35. Angadi MM, Jose AP, Udgiri R, Masali KA, Sorganvi V. A study of knowledge, attitude and practices on immunization of children in urban slums of Bijapur city, Karnataka, India. *J Clin Diagn Res*. 2013;7(12):2803–6.
 36. Jain T, Jai Veer S, Manjul B, Sunil Kumar G, Harivansh G, Shailendra Kumar B, et al. A cross sectional study on the coverage of immunization in the slums of western Uttar Pradesh, India. *Journal of Clinical and Diagnostic Research*. 2010;4:3480–3.
 37. Sharma R, Desai VK, Kavishvar A. Assessment of immunization status in the slums of Surat by 15 clusters multi indicators cluster survey technique. *Indian J Community Med.*; 2009;34(2):152–5.
 38. Mathew JL, Babbar H, Yadav S. Reasons for non-immunization of children in an urban, low income group in North India. *Trop Doct*. 2002;32(3):135–8.
 39. Sharma V, Singh A, Sharma V. Provider's and user's perspective about immunization

- coverage among migratory and non-migratory population in slums and construction sites of Chandigarh. *J Urban Health*. 2015;92(2):304–12.
40. Ghei K, Agarwal S, Subramanyam MA, Subramanian S V. Association between child immunization and availability of health infrastructure in slums in India. *Arch Pediatr Adolesc Med*. 2010;164(3):243–9.
 41. Soura AB, Mberu B, Elungata P, Lankoande B, Millogo R, Beguy D, et al. Understanding inequities in child vaccination rates among the urban poor: evidence from Nairobi and Ouagadougou health and demographic surveillance systems. *J Urban Health*. 2015;92(1):39–54.
 42. Maina LC, Karanja S, Kombich J. Immunization coverage and its determinants among children aged 12 - 23 months in a peri-urban area of Kenya. *Pan Afr Med J*. 2013;14:3.
 43. Egondi T, Oyolola M, Mutua MK, Elung'ata P. Determinants of immunization inequality among urban poor children: evidence from Nairobi's informal settlements. *Int J Equity Health*. 2015;14(1):24.
 44. Bobossi-Serengbe G, Fioboy R, Ndoyo J. Missed opportunities for immunization in children of 0 to 11 months in Bangui. *Journal de Pediatrie et de Puericulture*. 2014;27:289–93.
 45. Mutua MK, Kimani-Murage E, Ettarh RR. Childhood vaccination in informal urban settlements in Nairobi, Kenya: who gets vaccinated? *BMC Public Health*. 2011;11(1):6.
 46. Mohamud AN, Feleke A, Worku W, Kifle M, Sharma HR. Immunization coverage of 12-23 months old children and associated factors in Jijjiga District, Somali National Regional State, Ethiopia. *BMC Public Health*. 2014;14:865.
 47. Fatiregun AA, Adebowale AS, Ayoka RO, Fagbamigbe AF. Assessing full immunisation coverage using lot quality assurance sampling in urban and rural districts of southwest Nigeria. *Trans R Soc Trop Med Hyg*. 2013;107(11):731–40.
 48. Antai D. Migration and child immunization in Nigeria: individual- and community-level contexts. *BMC Public Health*. 2010;10:116.
 49. Loening WE, Coovadia HM. Age-specific occurrence rates of measles in urban, peri-urban, and rural environments: implications for time of vaccination. *Lancet* 1983;2(8345):324–6.
 50. Sharma MK, Bhatia V, Swami HM. Outbreak of measles amongst vaccinated children in a slum of Chandigarh. *Indian J Med Sci*. 2004;58(2):47–53.
 51. Saha I, Haldar D, Paul B, Shrivastava P, Das DK, Pal M, et al. An epidemiological investigation of mumps outbreak in a slum of Kolkata. *J Commun Dis*. 2012;44(1):29–36.
 52. Lodha R, Dash NR, Kapil A, Kabra SK. Diphtheria in urban slums in north India. *Lancet*. 2000;355(9199):204.
 53. Rahman SR, Ahmed MF, Islam MA, Rahman MM. Effect of risk factors on the prevalence of influenza infections among children of slums of Dhaka city. *Springerplus*. 2016 May;5.
 54. Breiman RF, Cosmas L, Njuguna H, Audi A, Olack B, Ochieng JB, et al. Population-based incidence of typhoid fever in an urban informal settlement and a rural area in Kenya: implications for typhoid vaccine use in Africa. *PLoS One*. 2012;7(1):e29119.
 55. Sur D, von Seidlein L, Manna B, Dutta S, Deb AK, Sarkar BL, et al. The malaria and typhoid fever burden in the slums of Kolkata, India: data from a prospective community-based study. *Trans R Soc Trop Med Hyg*. 2006;100(8):725–33.
 56. Brooks WA, Hossain A, Goswami D, Nahar K, Alam K, Ahmed N, et al. Bacteremic typhoid fever in children in an urban slum, Bangladesh. *Emerg Infect Dis*. 2005;11(2):326–9.
 57. Bahl R, Sinha A, Poulos C, Whittington D, Sazawal S, Kumar R, et al. Costs of illness

- due to typhoid fever in an Indian urban slum community: Implications for vaccination policy. *J Health Popul Nutr.* 2004;22(3):304–10.
58. Awoh AB, Plugge E. Immunisation coverage in rural-urban migrant children in low and middle-income countries (LMICs): a systematic review and meta-analysis. *Journal of Epidemiology & Community Health.* 2016;70:305–11.
 59. Peng G, Liang S, Carlton EJ, QingWu J, Wu JY, Lei W, et al. Urbanisation and health in China. *Lancet.* 2012;379(9818):843–52.
 60. Koneiga A. Family migration: a vehicle of child morbidity in the informal settlements of Nairobi city, Kenya? Chapter from de Sherbiniin A, A. Rahman, A. Barbieri, J.C. Fotso, and Y. Zhu (eds.). 2009. *Urban Population-Environment Dynamics in the Developing World: Case Studies and Lessons Learned.* Pub. Committee for International Cooperation in National Research in Demography, Paris, 2009.
 61. Sun M, Ma R, Zeng Y, Luo F, Zhang J, Hou W. Immunization status and risk factors of migrant children in densely populated areas of Beijing, China. *Vaccine.* 2010;29:1264–74.
 62. Arokiasamy P, Jain K, Goli S, Pradhan J. Health inequalities among urban children in India: a comparative assessment of Empowered Action Group (EAG) and South Indian states. *J Biosoc Sci.* 2012;45(2):167–85.
 63. Siddiqui NT, Owais A, Agha A, Karim MS, Zaidi AKM. Ethnic disparities in routine immunization coverage: a reason for persistent poliovirus circulation in Karachi, Pakistan? *Asia Pac J Public Health.* 2014;26(1):67–76.
 64. Ettarh RR, Mutua MK, Kyobutungi C. Ethnicity and delay in measles vaccination in a Nairobi slum. *Trop Med Health.* 2012;40(2):59–62.
 65. Patel P, Desai K, Modi B, Bansal RK. Urban slums are new and important areas for inequalities in maternal and newborn health in many areas. *Turk Silahl Kuvvetleri, Koruyucu Hekimlik Bulteni.* Ankara: Gulhane Military Medical Academy; 2014;13:217–24.
 66. Adil M, Zubair M, Alam A, Khan S, Ishtiaque Z, Quereshi A. Knowledge of mothers about children’s immunization status in the urban areas of Islamabad. *Rawal Medical Journal.* 2009;34:33–5.
 67. Maketa V, Vuna M, Baloji S, Lubanza S, Hendrickx D, Inocencio da Luz RA, et al. Perceptions of health, health care and community-oriented health interventions in poor urban communities of Kinshasa, Democratic Republic of Congo. *PLoS One.* 2013;8(12):e84314.
 68. Agarwal S. The state of urban health in India; comparing the poorest quartile to the rest of the urban population in selected states and cities. *Environ Urban.* 2011 Apr;23(1):13–28.
 69. Igarashi K, Sasaki S, Fujino Y, Tanabe N, Muleya CM, Tambatamba B, et al. The impact of an immunization program administered through the Growth Monitoring Program Plus as an alternative way of implementing Integrated Management of Childhood Illnesses in urban-slum areas of Lusaka, Zambia. *Trans R Soc Trop Med Hyg.* 2010;104(9):577–82.
 70. Adams AM, Islam R, Ahmed T. Who serves the urban poor? A geospatial and descriptive analysis of health services in slum settlements in Dhaka, Bangladesh. *Health Policy Plan.* 2015;30 Suppl 1:i32-45.
 71. Prakash R, Kumar A. Urban poverty and utilization of maternal and child health care services in India. *J Biosoc Sci.* 2013;45(4):433–49.
 72. Nath B, Singh J V, Awasthi S, Bhushan V, Singh SK, Kumar V. Client satisfaction with immunization services in urban slums of Lucknow district. *Indian J Pediatr.* 2009;76(5):479–83.
 73. Sridhar S, Maleq N, Guillermet E, Colombini A, Gessner BD. A systematic literature

- review of missed opportunities for immunization in low- and middle-income countries. *Vaccine*. 2014;32(51):6870–9.
74. Uddin MJ, Larson CP, Oliveras E, Khan AI, Quaiyum MA, Saha NC, et al. Child immunization coverage in urban slums of Bangladesh: impact of an intervention package. *Health Policy Plan*. 2010;25(1):50–60.
 75. Hayford K, Uddin MJ, Koehlmoos TP, Bishai DM. Cost and sustainability of a successful package of interventions to improve vaccination coverage for children in urban slums of Bangladesh. *Vaccine*. 2014;32(20):2294–9.
 76. Pradhan N, Ryman TK, Varkey S, Ranjan A, Gupta SK, Krishna G, et al. Expanding and improving urban outreach immunization in Patna, India. *Trop Med Int Health*. 2012;17(3):292–9.
 77. Agarwal S, Satyavada A, Patra P, Kumar R. Strengthening functional community-provider linkages: lessons from the Indore urban health program. *Glob Public Health*. 2008 Jul;3(3):308–25.
 78. Sasaki S, Igarashi K, Fujino Y, Comber AJ, Brunsdon C, Muleya CM, et al. The impact of community-based outreach immunisation services on immunisation coverage with GIS network accessibility analysis in peri-urban areas, Zambia. *J Epidemiol Community Health*. 2011;65(12):1171–8.
 79. Ansari M, Khan Z. Routine immunization coverage in underserved children of Aligarh (India): an effort with UNICEF. *J Child Health Care*. 2010;14(2):142–50.
 80. Harvey H, Reissland N, Mason J. Parental reminder, recall and educational interventions to improve early childhood immunisation uptake: A systematic review and meta-analysis. *Vaccine*. 2015;33(25):2862–80.
 81. Uddin MJ, Shamsuzzaman M, Horng L, Labrique A, Vasudevan L, Zeller K, et al. Use of mobile phones for improving vaccination coverage among children living in rural hard-to-reach areas and urban streets of Bangladesh. *Vaccine*. 2016;34:276–83.
 82. Domek GJ, Contreras-Roldan IL, O’Leary ST, Bull S, Furniss A, Kempe A, et al. SMS text message reminders to improve infant vaccination coverage in Guatemala: A pilot randomized controlled trial. *Vaccine*. 2016;34:2437–43.
 83. Kazi AM, Murtaza A, Khoja S, Zaidi AK, Ali SA. Monitoring polio supplementary immunization activities using an automated short text messaging system in Karachi, Pakistan. *Bull World Health Organ*. 2014 Mar;92(3):220–5.
 84. Shei A, Costa F, Reis MG, Ko AI. The impact of Brazil’s Bolsa Familia conditional cash transfer program on children’s health care utilization and health outcomes. *BMC Int Health Hum Rights*. 2014;14(1):10.
 85. Chandir S, Khan AJ, Hussain H, Usman HR, Khowaja S, Halsey NA, et al. Effect of food coupon incentives on timely completion of DTP immunization series in children from a low-income area in Karachi, Pakistan: a longitudinal intervention study. *Vaccine*. 2010;28(19):3473–8.
 86. Owais A, Hanif B, Siddiqui AR, Agha A, Zaidi AKM. Does improving maternal knowledge of vaccines impact infant immunization rates? A community-based randomized-controlled trial in Karachi, Pakistan. *BMC Public Health*. 2011;11:239.

APPENDIX 1: Additional Data

Table A: Urban and Slum populations in global regions in 2014. Adapted from UN Habitat, 2016 (1).				
Region	Total urban population ('000s)	Proportion urban population (%)	Proportion urban population living in slums (%)	Total urban slum population ('000s)
<i>Developing regions</i>	2,968,517	48.4	29.7	881,080
Latin America & Caribbean	495,857	79.5	21.1	104,847
Western Asia	151,084	69.6	24.9	37,550
Eastern Asia	960,235	58.9	26.2	251,593
Northern Africa	151,084	51.4	11.9	11,418
South-Eastern Asia	294,409	47.0	28.4	83,528
Sub-Saharan Africa	359,009	37.4	55.9	200,667
Southern Asia	609,139	34.4	31.3	190,875
Oceania	2,448	23.0	24.1	591

Table B: Mean annual rate of change in urban populations by region, showing 1995-2015 and 2010-2015. Adapted from UN Habitat, 2016 (1).			
Region	2000-2005 (%)	2005-2010 (%)	2010-2015 (%)
World	2.27	2.20	2.05
HIC	1.00	1.00	0.76
MIC	2.77	2.61	2.42
LIC	3.70	3.70	3.77
Africa	3.42	3.55	3.55
Asia	2.79	2.79	2.50
Latin America & Caribbean	1.76	1.55	1.45
Europe	0.34	0.34	0.33
North America	1.15	1.15	1.04
Oceania	1.49	1.78	1.44

APPENDIX 2: Countries and Regions

The countries and regions used in this report are based on the UN classification, as described in the World Cities Report 2016, published by UN Habitat (1):

- **Sub-Saharan Africa**
 - **Eastern Africa**
 - Burundi
 - Comoros
 - Djibouti
 - Eritrea
 - Ethiopia
 - Kenya
 - Madagascar
 - Malawi
 - Mauritius
 - Mayotte
 - Mozambique
 - Reunion
 - Rwanda
 - Seychelles
 - Somalia
 - South Sudan
 - Uganda
 - United Republic of Tanzania
 - Zambia
 - Zimbabwe
 - **Middle Africa**
 - Angola
 - Cameroon
 - Central African Republic
 - Chad
 - Congo
 - Democratic Republic of the Congo
 - Equatorial Guinea
 - Gabon
 - Sao Tome & Principe
 - **Southern Africa**
 - Botswana
 - Lesotho
 - Namibia
 - South Africa
 - Swaziland
 - **Western Africa**
 - Benin
 - Burkina Faso
 - Cabo Verde
 - Cote d'Ivoire
 - Gambia
 - Ghana

- Guinea
 - Guinea-Bissau
 - Liberia
 - Mali
 - Mauritania
 - Niger
 - Nigeria
 - Saint Helena
 - Senegal
 - Sierra Leone
 - Togo
- **Asia**
 - **Eastern Asia**
 - China
 - Hong Kong
 - Macao
 - DPR Korea
 - Japan
 - Mongolia
 - Republic of Korea
 - **Central Asia**
 - Kazakhstan
 - Kyrgyzstan
 - Tajikistan
 - Turkmenistan
 - Uzbekistan
 - **Southern Asia**
 - Afghanistan
 - Bangladesh
 - Bhutan
 - India
 - Iran
 - Maldives
 - Nepal
 - Pakistan
 - Sri-Lanka
 - **South-Eastern Asia**
 - Brunei Darussalam
 - Cambodia
 - Indonesia
 - Lao People's Democratic Republic
 - Malaysia
 - Myanmar
 - Philippines
 - Singapore
 - Thailand
 - Timor-Leste
 - Vietnam
 - **Western Asia**
 - Armenia
 - Azerbaijan

- Bahrain
- Cyprus
- Georgia
- Iraq
- Israel
- Jordan
- Kuwait
- Lebanon
- State of Palestine
- Oman
- Qatar
- Saudi Arabia
- Syrian Arab Republic
- Turkey
- United Arab Emirates
- Yemen