

The health of people who live in slums 2



Improving the health and welfare of people who live in slums

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In the first paper in this Series we assessed theoretical and empirical evidence and concluded that the health of people living in slums is a function not only of poverty but of intimately shared physical and social environments. In this paper we extend the theory of so-called neighbourhood effects. Slums offer high returns on investment because beneficial effects are shared across many people in densely populated neighbourhoods. Neighbourhood effects also help explain how and why the benefits of interventions vary between slum and non-slum spaces and between slums. We build on this spatial concept of slums to argue that, in all low-income and middle-income countries, census tracts should henceforth be designated slum or non-slum both to inform local policy and as the basis for research surveys that build on censuses. We argue that slum health should be promoted as a topic of enquiry alongside poverty and health.

Introduction

The first paper in this Series was concerned with health in slums and with the determinants of health.¹ We noted that the intimately shared physical and social environment in slums is likely to generate strong neighbourhood effects. In this second paper, we consider what can be done to improve health and health care in slums and show how factors operating at the neighbourhood level can be turned to advantage when we intervene. We start by discussing general epidemiological principles that should be taken into account in interpreting the results of studies in slums. Next, we describe an intellectual framework to organise evidence on interventions. We then present such evidence as we were able to glean according to this intellectual framework. Lastly, we discuss the implications of the findings from this Series as a whole for policy and research.

Three factors interact to determine how an intervention can play out in slum neighbourhoods. First, densely packed slum neighbourhoods promote the spread of disease but also provide opportunities for economies of scale when interventions are promulgated. An iconic example is the dramatic effect John Snow achieved when he aborted a cholera epidemic by disabling a water pump in Soho, London in 1854.

Second, we showed in paper one that slums are not homogeneous, but present very different social and physical environments. Context should therefore be taken into account when interpreting the results of intervention studies. For example, the effect of raising the floors of slum dwelling to reduce contamination from the surroundings may have a much smaller effect on rates of

Key messages

- The neighbourhood effects in slums are likely to offer economies of scale and increasing returns to investments to create a healthy environment
- Although relocation and resettlement can be necessary for safety reasons, slum upgrading in situ is usually preferable to improve the health and welfare of people living in slums
- Sanitation, which started the public health revolution in Europe and America during the 19th century, remains a key neighbourhood challenge in slums
- Health services should be designed specifically to overcome barriers to utilisation, such as distance and cost, for people who live in slums
- Health services should be proactive in health protection—eg, by immunisation and surveillance for childhood malnutrition
- People who live in slums and their organisations should have an active say in the prioritisation, design, implementation, and evaluation of interventions in slums
- Slum enumeration areas should be identified in all census listings and sampling frames to enable clearer understanding of the neighbourhood effects of slums
- Enabled by this spatial construct, much more research is needed on slum health and how to improve it, and a greater proportion of this research should be based on multicentre studies with contemporaneous controls
- Finally, we advocate the development of capacity for research into slum health and the emergence of this as an academic specialty

Search strategy and selection criteria

To identify key literature for slum health, we did a systematic overview of reviews of determinants of health in slum settings and interventions that aim to improve the health of people who live in slums. We also identified randomised controlled trials done in a slum setting as part of a bibliometric analysis assessing the relative volume of research studies concerning rural, urban, and slum settings (see appendix p 3 in paper one). Acknowledging the important roles that international, governmental, and non-governmental organisations have in this area, we systematically searched the grey literature and reviewed relevant documents.

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This is the second in a Series of two papers about the health of people who live in slums

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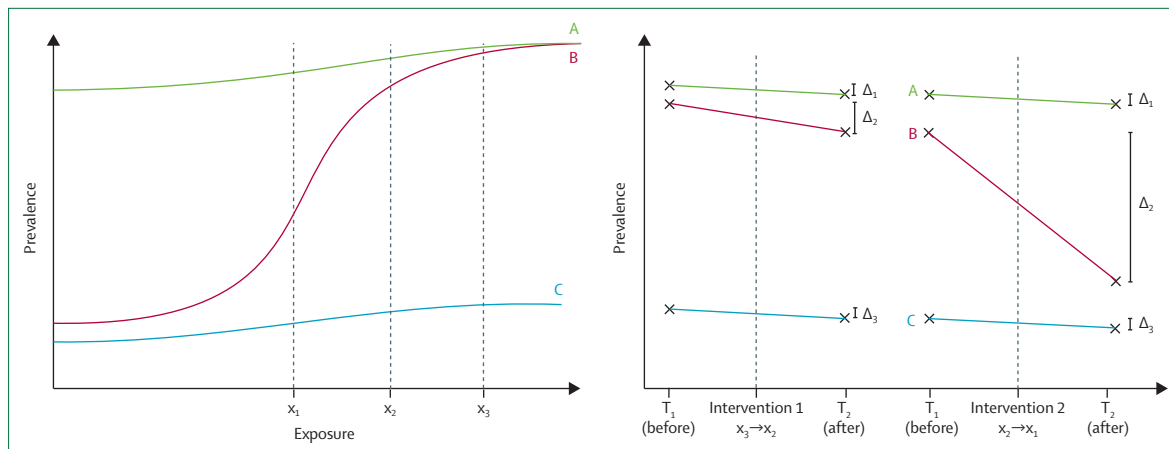


Figure 1: Hypothetical model of the association between exposure to a risk factor for a disease of interest and prevalence of the disease in three different neighbourhoods and observed effectiveness of an intervention aimed at reducing a specific exposure, with success measured by examination of prevalence of the disease of interest

Δ =intervention effect. This model shows how interventions designed to reduce the prevalence of a target disease will have differing levels of effectiveness in different areas and within the same area over time, depending on the conditions prevailing when the intervention is adopted, or whether there is a sufficient dose of the intervention. The left hand panel depicts three different dose response curves. Line A shows an inelastic response where increasing dose results in little change in outcome. Line C represents a scenario where there is little headroom for further improvement. Line B shows rapidly increasing and then decreasing responses to dose. The shape of the response curve can yield scenarios of increasing returns to investment. The right hand panel shows the wide range of possible intervention effects that can be measured in a study depending on these factors. In A and C, prevalence is quite inelastic over varying levels of exposure, perhaps because another powerful risk factor is present such as in A or because there is a ceiling effect as prevalence is already low such as in C, perhaps because the population has been vaccinated against the risk factor. In B, the dose response is non-linear so that an intervention might show increasing (and then decreasing) returns to scale. For this group, when an intervention is implemented that aims to reduce exposure to the risk factor, the effects are small in neighbourhoods A and C where this risk factor is not the main determinant of disease. In B, the pre-intervention exposure and the intervention dose have a crucial effect on the intervention effectiveness because of the non-linear dose response, so an intervention that reduces the exposure from $\times 3$ to $\times 2$ has much less effectiveness than an intervention that reduces the exposure from $\times 2$ to $\times 1$.

childhood diarrhoea if water supply and sewage disposal have been upgraded than if they have not.

And finally, the relationship between dose and response must be considered. This relationship may be non-linear, especially in dynamic scenarios where one person's risk affects another person's risk, either because the disease is infectious, or because one person's behaviour influences the health of others. In such a scenario, increasing returns on investment are likely. An example that we will discuss later concerns provision of sanitation which is likely to exhibit increasing returns to scale as faecal contamination is progressively reduced. Failure to realise the steep part of the curve by supplying sanitation at insufficient scale or intensity might explain why many sanitation improvement projects have yielded disappointing results and point the way for development and evaluation of more intense interventions.

In figure 1, we model the ways that context and dose-response correlations can interact.

Framework for review

We organised our analysis using a generic three level causal model^{2,3} that has been applied in previous research of slum upgrading⁴ and in a Cochrane Review of this topic.⁵ Figure 2 shows these three levels. The first or macro-level is constituted of institutions and policies affecting all citizens, including press freedom, an independent judiciary, monetary and fiscal policy, and other national or supranational influences. Second is the

middle or meso-level relating to slum specific policies. These policies, such as those for land zoning and provision of tenure, set the context where targeted interventions, such as improved sanitation, play out. It is therefore referred to as the enabling layer in the Cochrane Review.⁵ And finally, the micro-level encompassing interventions targeted at specific problems such as faecal contamination of the environment; referred to as the direct level in the Cochrane Review.

We will not consider the first (macro) level because it concerns politics and economics and although these are important influences on health, much can be done to improve health pending an improved macro-economic environment.^{7,8} Massive gains in health have been recorded even in countries with poor national governance⁹ and it is worth reflecting that infant mortality in slums is currently about 46 per 1000 livebirths,¹⁰ whereas in Victorian England (1837–1901) the upper class infant mortality rate in 1899 was three times higher (136 per 1000).¹¹ The search strategy and selection criteria panel shows how we searched for key literature on interventions to improve slum health.

Meso-level policies directed at slums

Restriction of migration or benign neglect

Restriction of free movement of citizens within a country is an illiberal policy reminiscent of apartheid South Africa—we believe that the days of pass laws

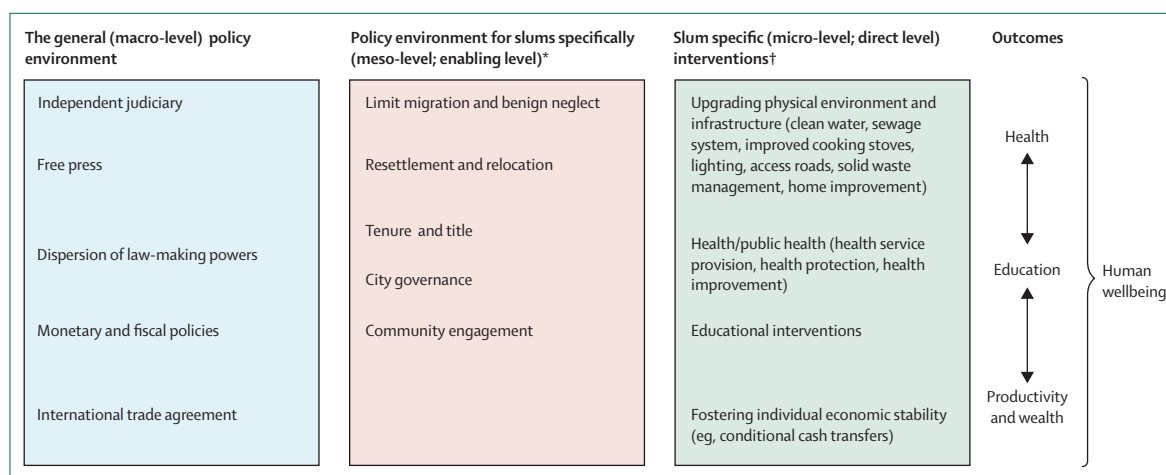


Figure 2: Representation of causal pathways affecting the lives of people who live in slums

*Topics under this heading were adapted from the framework in the Cochrane Review² augmented from the literature review. †Topics under this heading were based on the Social Determinants of Health, Office of Disease Prevention and Health Promotion.⁶ We do not discuss microfinance here because none of the three systematic reviews evaluated this topic for slums specifically. We do not cover education because this substantial topic is worthy of its own review.

should be consigned to history. The converse of authoritarian restrictions on movement is a *laissez-faire* policy of benign neglect. Proponents of this hands-off policy adhere to modernisation principles, arguing that slums are a temporary phenomenon, and that intervening to improve the lives of people in slums is self-defeating because it encourages inward migration—the so-called Todaro effect.¹² This argument can be rejected because we have seen (paper one) that slums in low-income and middle-income countries (LMICs) are anything but temporary and continue to enlarge even when economic growth is stagnant and that migration is no longer the main driver of slum growth in many countries—eg, 86% of people in South America already live in urban centres.¹³

Resettlement and reallocation programmes

During the reign of Napoleon III in France (1852–70), Baron Haussmann rebuilt central Paris, destroying the medieval city but installing a massive sewerage system and creating the current cityscape. Haussmann's intervention was not assessed scientifically but the results of resettlement programmes in LMICs are often disappointing.^{14–16} Sometimes this is because the programmes are a covert form of expropriation when rents on new buildings are unaffordable for displaced residents. Even when residents are resettled in alternative accommodation, they are liable to find themselves ghettoised in the suburbs of cities, where land is cheap. Commuting times are extended and in some instances settlers return to their original settlement. Absent development of infrastructure (eg, transport, water, electricity, high quality housing, and sewerage) and the cheaper policy of in-situ slum upgrading is generally preferable to relocation.¹⁷ A lottery system enabling people to move to better-off neighbourhoods that was

successful in the USA¹⁸ was not successful in India largely because many residents returned to their original location.¹⁹ Of course relocation is sometimes necessary for the safety of residents, but should be done with as much community assent as possible, high quality housing must be provided, and mixed-income destinations give rise to better outcomes than dense areas of deprivation.¹⁸

Security of tenure

Many slums are informal settlements in which residents do not have title or secure tenure. According to economic theory, people are unlikely to invest in their properties unless they feel secure against summary eviction,²⁰ a theory confirmed empirically with respect to farm land.²¹ Further empirical support comes from two natural experiments of providing tenure to slum residents,^{22,23} one in Peru that showed a sharp increase in investment in home infrastructure, including sanitation, in the intervention slums;²² and the second in Uruguay that showed a significant reduction in a score based on number of reported illnesses.²³ Title is maximally effective when financial systems that allow residents to release collateral value exist (ie, when financial systems are in place to allow residents to borrow against the collateral value in their homes).²⁴ Furthermore, awarding title might be a long-winded and expensive legal process. In such cases, systems of tenure or registration that instil confidence that homes will not be bulldozed might be enough to encourage residents to invest in developments likely to promote health.²⁵

Governance

Failures in planning and governance contribute to the generation and maintenance of large slums,¹ so good local authority policies promulgated by the Healthy Cities

movement are conducive to slum health, as discussed in the *Lancet* Commission on healthy cities in China.²⁶ Local government can help to ensure that land markets work efficiently and that the playing field is not tilted in favour of powerful elites wishing to build expensive houses for the middle-class and that building restrictions do not price the poorest people out of the market.²⁷ Although such planning processes can be corrupt or incompetent, leading to ghost cities,^{28,29} they can also be successful (eg, in Porto Alegre and Belo Horizonte in Brazil).^{30–32} Formalisation of slum areas to provide rights and entitlements³³ is associated with improved education and health, and might partly explain the results of a recent Indian study in which infant mortality was 25 per 1000 livebirths on average in notified slums versus 58 per 1000 in a non-notified slum in the same city.³⁴ However, only half of Indian slums are notified, and Chinese people who migrate to cities cannot gain access to basic services without registration numbers (Hukou).³⁵ Access to amenities should not be made contingent on tenure.³⁶

Community engagement

There is an expanding literature confirming the effectiveness of interventions to promote local engagement, action, and innovation,^{37,38} and the more the community drives the intervention the greater the effect.³⁹ A systematic review⁴⁰ of women's groups to improve perinatal outcomes included seven randomised clinical trials. Although the results were positive overall, most of these studies were done in rural settings and the effect was highly dependent on participation rates. Findings of the one study done in a slum showed a null result probably because participation rates were low.⁴¹ This trial provides an example of an intervention that might need to be modified to take into account the exigencies of slum life, perhaps by providing support groups at places of work.

Several examples exist of successful grass-roots networks in slums.^{39,42–45} The programme in Porto Alegre, Brazil, incorporated participatory budgeting in which communities were included in setting priorities.^{30,46} Such groups have provided important help for women in labour in Nairobi slums, in Kenya,⁴⁷ enhanced protection for sex workers in Zimbabwe,⁴⁸ and improved self-organisation of waste pickers in slums who have gone on to bid successfully for municipal contracts.⁴⁹ City and national slum dwellers federations have been active in conducting slum surveys using these to provoke and plan action with local authorities.⁵⁰

Specific (micro-level) interventions in slums

Here we discuss specific physical and engineering approaches to slum upgrading and service development (figure 2). We augment the few studies done specifically in slums with studies that cover slums and other areas; the systematic reviews we rely on are listed in the appendix pp 5–7).

Physical and engineering approaches in slum upgrading Water and sanitation

The poor quality of water and inadequate sanitation in slums and the resulting high incidence of diarrhoea, especially in children younger than 5 years, was documented in paper one.¹ The problem can be tackled with behavioural interventions or physical interventions. Physical interventions can be targeted at water provision, sanitation, and point of use methods to decontaminate water (eg, filters). A Cochrane Review⁵ of physical and engineering interventions (appendix p 7) in slums cited three main studies that satisfied its quality threshold and included a health outcome. In one of these studies⁵¹ investigators noted reduced incidence of diarrhoea in households connected to a water supply but confidence intervals were wide (risk ratio [RR] 0·53; 95% CI 0·27–1·04). A multi-component intervention⁵² that included piped water in homes and lavatories connected to a sewer along with street paving and drainage reported a substantial reduction in waterborne diseases (RR 0·64; 0·27–0·98). Finally, a study of improved water and sanitation⁵³ that looked only at effect on sanitation-related mortality reported no change (RR and CIs not given). The appendix (pp 1–4) provides results for case studies based in slums. Another important study⁵⁴ that was not specific to slums used the Demographic Health Survey to analyse data from 70 countries and noted reductions in the incidence of diarrhoea of 13% and 7%, respectively, for improved water and sanitation.⁵⁵ Therefore, the effect sizes recorded in the mentioned studies are highly variable and some are disappointing in view of the theoretical headroom for improvement and the results credited to the 19th century sanitary revolution in Europe and North America. A plausible explanation for these effect sizes can be found in the analysis of context and increasing returns to scale (figure 1).

Wolf and colleagues⁵⁶ provide a classification of intervention water comprehensiveness, a proxy for dose. Water provision can be improved (according to the United Nations [UN] definition) by making it readily available from standpipes outside the house, or it can be piped into the home, or piped and quality assured. Likewise, sanitation can be improved by providing pit latrines or it can be extended to include sewer connections. The literature on slums specifically is insufficient to further examine the role of dose and we therefore turned to systematic reviews on water and sanitation interventions generally (ie, including but not restricted to slums).^{56–58} Results show increasing returns to comprehensiveness (ie, dose) of the intervention (appendix pp 1–2 and figure 3), conforming to the theoretical representation in figure 1. Although the UN classifies pit latrines as improved sanitation, these findings suggest that they are of minimal effectiveness. Furthermore, some researchers have reported that they do little to reduce environmental contamination in

congested slum neighbourhoods.⁵⁹ When adequately quality assured piped water cannot be provided, point of use methods provide an alternative since the above systematic reviews consistently show substantial effect sizes (relative risk 0.65, 95% CI 0.48–0.88) in Fewtrell's review⁵⁸ and 0.55 (0.38–0.81) for filtered and safely stored water in Wolf's review.⁵⁶

Effectiveness is probably affected by contextual factors as well as dose. For example, effectiveness will be attenuated if people do not make use of facilities; the likely explanation for null results in two recent cluster randomised clinical trials of making pit latrines available in India.^{60,61} A further reason for variable results from physical interventions could be poor maintenance of facilities and inadequate installations; piped water distribution systems are often contaminated.⁵⁹ It might be expected that combining sanitation and water interventions would be more effective than either alone, but this remains unproven (appendix pp 1–4).

Home improvements

The Cochrane review of slum interventions identified a natural experiment⁶² in Mexico in which the provision of a cement floor reduced the incidence of diarrhoea in children younger than 6 years (RR 0.87, 0.76–1.00). Findings of a subsequent experimental study⁶³ done in El Salvador, Mexico, and Uruguay that assessed home improvements including a raised floor also showed a significant reduction in diarrhoea incidence (2.7% absolute risk reduction from 15.1%) if Uruguay, which had low rates at baseline, is excluded from the analysis.

Lighting, repaving, and garbage removal

Improved street lighting and paving have been strongly recommended by UN-Habitat on the basis of observational studies but the one randomised clinical trial in the Cochrane Review⁴ did not confirm improved security or health.⁶⁴ Removal of solid waste is undoubtedly a good idea in view of its effects on health and wellbeing,¹ but little evidence was found on how best to dispose of garbage or on the health benefits of doing so.

Taken together, the literature provides several case studies of interventions but very few large-scale studies in which in-depth findings complement comparisons across sites, such as can be found, for example, in studies of home improvements in high-income countries.⁶⁵

Health and public services

Several health improvement studies have been done in general populations but also replicated in slums specifically. First, results of a meta-analysis of 11 studies across urban and rural locations showed that behavioural interventions to promote handwashing resulted in a lower prevalence of diarrhoea,⁵⁸ and this was also shown in trials specifically in slums in Pakistan⁶⁶ and Nepal.⁶⁷

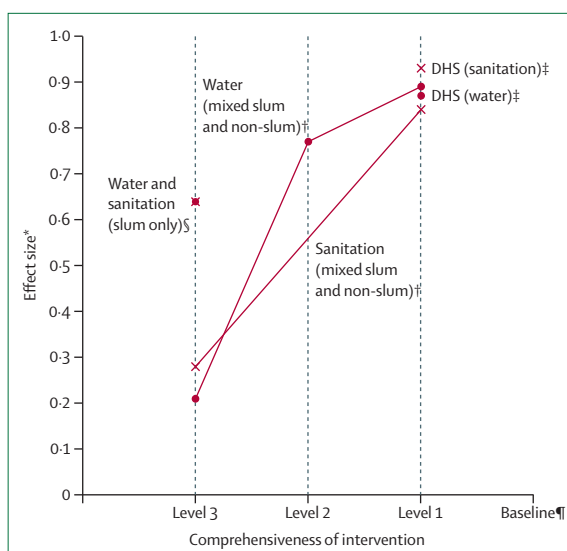


Figure 3: Representation of magnitude of effect by comprehensiveness of intervention across studies in slum and non-slum systematic reviews and the DHS

DHS=Demographic and Health Surveys. *Relative risk ratio for episodes of diarrhoea or waterborne disease in the Cochrane review² of interventions in slums. †Wolf's review.⁵⁶ ‡DHS study.⁵⁴ §Butala and colleagues, 2010.⁵²

¶Water: level 1=improved supply of piped water into vicinity of homes; level 2=piped into home; level 3=piped into home and quality assured. Sanitation: level 1=improved (pit latrine); level 3=pit latrine connected to sewage system. This classification is based on Wolf and colleagues, 2014.⁵⁶

Second, a systematic review looking at paediatric burn prevention identified 30 studies from high-income and low-income countries (appendix p 6). The benefits of reducing hazards such as unsafe paraffin cook-stoves were replicated in a randomised clinical trial in a slum environment (in South Africa).⁶⁸ Finally, a systematic review⁶⁹ of behaviour change interventions to reduce indoor pollution across 20 countries reported that these could result in an 88% fall in indoor particulate levels (13.2–1.6 parts per million), a 21% reduction in respiratory disease (absolute risk not given) and savings on fuel costs. Two of the interventions were conducted in slums (Bangladesh and Uganda), but results are not broken down by location.

Many individual randomised clinical trials of health promotion interventions have been done specifically in slums (appendix pp 8, 9) yielding positive results concerning behavioural interventions to reduce obesity in women and children in Brazil,^{70,71} childhood malnutrition in Peru,⁷² breastfeeding in Kenya,⁶⁷ and so-called delinquent behaviour in Uganda.⁷³ Provision of fortified snack bars resulted in improved nutritional status in India⁷⁴ and Bangladesh⁷⁵ (arguably avoiding the harmful effects resulting from imbalance of competing elements—eg, zinc and copper, with chemical formulations of micro-nutrients).

Taken together, these results support the theory that slum populations benefit from health promotion measures as long as they receive them. This conclusion,

	Aim	Effect
Meso-level (enabling policies)		
Limit free movement	Discourage growth of slums	Does not solve underlying problem, illiberal, and is not a permanent solution
Benign neglect	Limit size of slums on the grounds that they are self-correcting	Leaves vulnerable people in prolonged and severe need and generates poverty traps; too late for many countries where urbanisation is already advanced
Relocation and resettlement	Clear slums and provide alternative, improved living environment	Countries with large slums generally have insufficient resources or lack political will to do a proper job, and provide necessary infrastructure; this approach often promises more than it delivers
Title and tenure	Encourage in-situ regeneration by giving people a stake in their community and homes	Providing title is effective but might not be possible where title is disputed; security of tenure without title might be sufficient
City governance	Recognising slums and conferring rights creates conditions conducive to health; land zoning protects vulnerable citizens	Many examples of good and bad practice; providing rights and services is an effective policy
Community engagement and empowerment	Uses assets of the community; empowers citizens	Many empirical examples of success; most effective when citizens are genuinely empowered
Specific (micro-level) interventions		
Physical methods of slum improvement	Untaminated water piped into homes and point of use decontamination; reduces environmental contamination through sanitation	Dose-dependent effect; pit latrines have very small benefit especially in slums; point of use methods of decontamination effective where clean tap water not provided
Home and environment	Improve home insulation, street paving, lighting and drainage; garbage removal	Sensible measures for reasons given in paper one ¹ but poorly studied in slum contexts
Health services	Improve access to health protection, health improvement, and clinical care	Public health and clinical services effective in slums as elsewhere, barriers to access have been studied, ¹ but the most cost-effective mix of services is in need of urgent study

Table: Summary of intervention effectiveness across both meso-level and micro-level interventions

that access is the rate-limiting step to achieving benefit for people who live in slums, seems to also apply to health protection. Child immunisation is regarded as the most cost-effective intervention for health in LMICs,⁷⁶ yet children in slums are less likely to be vaccinated than other urban infants.⁷⁷ This situation is especially unjust because slums are often used as a convenient sample in vaccine trials (appendix p 4 in paper one). In terms of screening, we are unaware of studies specific to slums, but rates are very low across low-income countries; 4·1% and 2·2%⁷⁸ in the relevant populations for cervical and breast cancer respectively, for example. However, slum populations benefit when access to health protection is provided. For example, results of five randomised clinical trials done in slums^{79–83} showed that parasite loads can be reduced by treatment targeted at high risk groups and some showed improved child growth (although the latter is a highly contested topic across all populations).⁸⁴

The problem with clinical services is also one of access on the assumption that indications for treatment do not change because a person lives in a slum. The unifying theme across health provision of all types in slums is the need to improve access. Services need to be available

outside normal office hours and be pro-active for the reasons listed in paper one related to determinants of health. Such services include a judicious and comprehensive mix of community health workers, local clinics, and use of mobile technology to ensure coverage with respect to health protection, health improvement, and clinical services. A recent paper⁸⁵ in the *Lancet* Series on universal healthcare, markets, profit and the public good noted that providing a network of accessible free clinics crowded out low quality, under-qualified providers. Further work to design services that meet local preferences⁸⁶ is urgently required and we note that high population densities allow many people to be reached per unit of staff time; another potential example of increased economies to scale when intervening at the neighbourhood level in slums. In the table we summarise the literature on the likely effectiveness of both enabling (meso-level) and specific (micro-level) interventions.

Recommendations for policy and research

In paper one, we noted that very little research has been devoted to the subject of slum health. Consequently, despite nearly 1 billion people already living in slum locations in LMICs, we do not understand enough about their health vulnerabilities and what effect slum-focused health interventions could have. In particular, we need to understand how neighbourhood effects operate so that we can get the intensity of interventions right (figure 1).

Identification and study of slums as spatial entities

Although slums are easily identifiable physically in many cities in LMICs, they remain invisible in many data systems that drive research and policy. Slums are rarely identified in national censuses, which form the sampling frames for national surveys. We recommend that all censuses include identification for slum and non-slum clusters for all urban areas. This inclusion will encourage all studies and national surveys to generate separate health indicators for slum and non-slum areas both for research purposes and to identify local priorities for action—eg, to establish where diarrhoea and stunting are most prevalent. As we have seen repeatedly in this Series, most research provides data for urban areas as a whole. Such data are of limited value; for example, if slums have worse outcomes than non-slum urban areas and the slum population (as a proportion of urban population), has been changing, then urban trend indicators may represent nothing more than differences in the respective growth rates of slum versus non-slum urban populations.

All measures of place of residence should move from a binary urban–rural construct to one that splits urban into slum and non-slum (panel). Pending implementation of the recommended changes to include identification of slums in censuses, individual researchers can estimate the locations of high risk areas using geo-located data. We illustrate this idea by mapping the prevalence of diarrhoea and stunting in children to well-known slums

in three urban areas in Nairobi, Kenya, Port-au-Prince, Haiti, and Lagos, Nigeria using data from the Demographic Health Survey in figure 4. There is clustering of cases in the vicinity of well known slums but precision would be much improved if slum areas were clearly demarcated.

Child health

Although the evidence base in slum health is underdeveloped, some recommendations for improvement can be made. In particular, the evidence in paper one highlighted the plight of children who are exposed to high risk of infection while their immune systems are immature. Children are also a priority because conditions at the start of life will limit their subsequent life chances. Interventions that should be considered, contingent on local circumstances, include: improved uptake of vaccination; promotion of breastfeeding, nutrition, clean water, and sanitation; and indoor protection against burns, and inhalation of particles and noxious fumes. As they grow into young adulthood, violent crime is a big challenge, although we need to better understand how supportive and destructive neighbourhood cultures develop and hence how interventions can help.

Sanitation and water quality

Improvements in water supply and sanitation have yielded modest health benefits in modern slums by comparison with the massive effects credited to the major works carried out in European and North American cities during the so-called sanitary awakening in the 19th century.⁵⁵ We speculate that there is a straightforward reason for this which turns on the issue of increasing returns to scale described in the introduction; most interventions have simply not achieved their aims. Piped water installations have been prone to contamination, and sanitation has removed insufficient waste to reduce faecal contamination of the environment to the tipping point where rapidly increasing returns to scale might be achieved (figure 1). The international community might even have exacerbated the problem by setting standards for improved sanitation (eg, pit latrines) that are unsuitable for densely crowded slum conditions.⁵⁰ Therefore, we recommend that this inadequate standard should be withdrawn for slum contexts and that, working with local communities, comprehensive installations (eg, linked to a sewerage system) should be installed as a matter of urgency within the framework of robust large-scale comparative studies to work out which types of installation are suitable for which types of slum environment.

The art of the possible in slum improvement

If some standards are set too low, others might be too high. It has become fashionable for scholars to argue that the whole slum nexus should be tackled in a

Panel: Suggested process to identify slums for inclusion in censuses

To identify slums and include them in censuses so that studies and surveys based on a census sampling frame can distinguish between slum and non-slum locations, the following are necessary: first, enumeration areas should be designated (ie, tagged) to one of three categories (slum, non-slum, or rural) in such a way that no one urban enumeration area straddles slum and non-slum areas; second, while nations classify slums according to their own context, their methods should be transparent, and should consider the five household level criteria in the UN-Habitat definition; and finally, quality assurance should check that all clusters are enumerated and then that all dwellings are recorded within each cluster. This approach will ensure all national surveys and data systems can effectively sample and report indicators using three residential domains: rural, urban slum, and urban non-slum. Some countries, notably Kenya and Bangladesh, already follow a process to identify slum enumeration areas and include identification of slum and non-slum clusters in national master sampling frames. This is why these countries were selected for the study in paper one.

It would be impossible (or at least it would take a very long time) to negotiate a common definition of a slum across all countries and, in any case, a common definition is not a prerequisite for examination of the proposed spatial construct of slum health. The subject can develop, notwithstanding differences in definitions, just as the topic of urban health has developed despite different national definitions of an urban area.

coordinated way.^{87–89} At the limit, such an approach amounts to a programme to convert slum to non-slum. Although this is a laudable aim, we are concerned that the ideal should not become the enemy of the good; as Buckley⁹⁰ has argued, cost-effective interventions, such as vaccination and installing sanitation systems, should not wait until the moment is propitious for a holistic strategy, and access to amenities should not be dependent on title or tenure.⁹¹ We also caution that reliance on community assets should not be taken too far; work in rural areas shows that the greatest potential health and wellbeing gains are among those most deeply trapped in poverty and hence most in need of outside help.^{92,93}

A call for multicentre studies with contemporaneous controls

The literature on policy interventions and on physical upgrading of slums is based largely on case studies. We do not wish to disparage such studies, but we advocate balancing the literature with a greater proportion of studies with contemporaneous controls.^{94,95} While not reifying experimental methods, Field and Kremer cite empirical evidence that supports theoretical arguments for use of experimental methods in a slum context.^{96–98}

Consideration of several outcomes and populations

The effects of policy and service are often broad; they spill over to affect outcomes different to the original target. For instance, improving water and sanitation has beneficial effects on education, wellbeing, and productivity in addition to those on health (appendix pp 1–3). A corollary is the importance of capturing both dimensions of health (eg, disability-adjusted life-years)

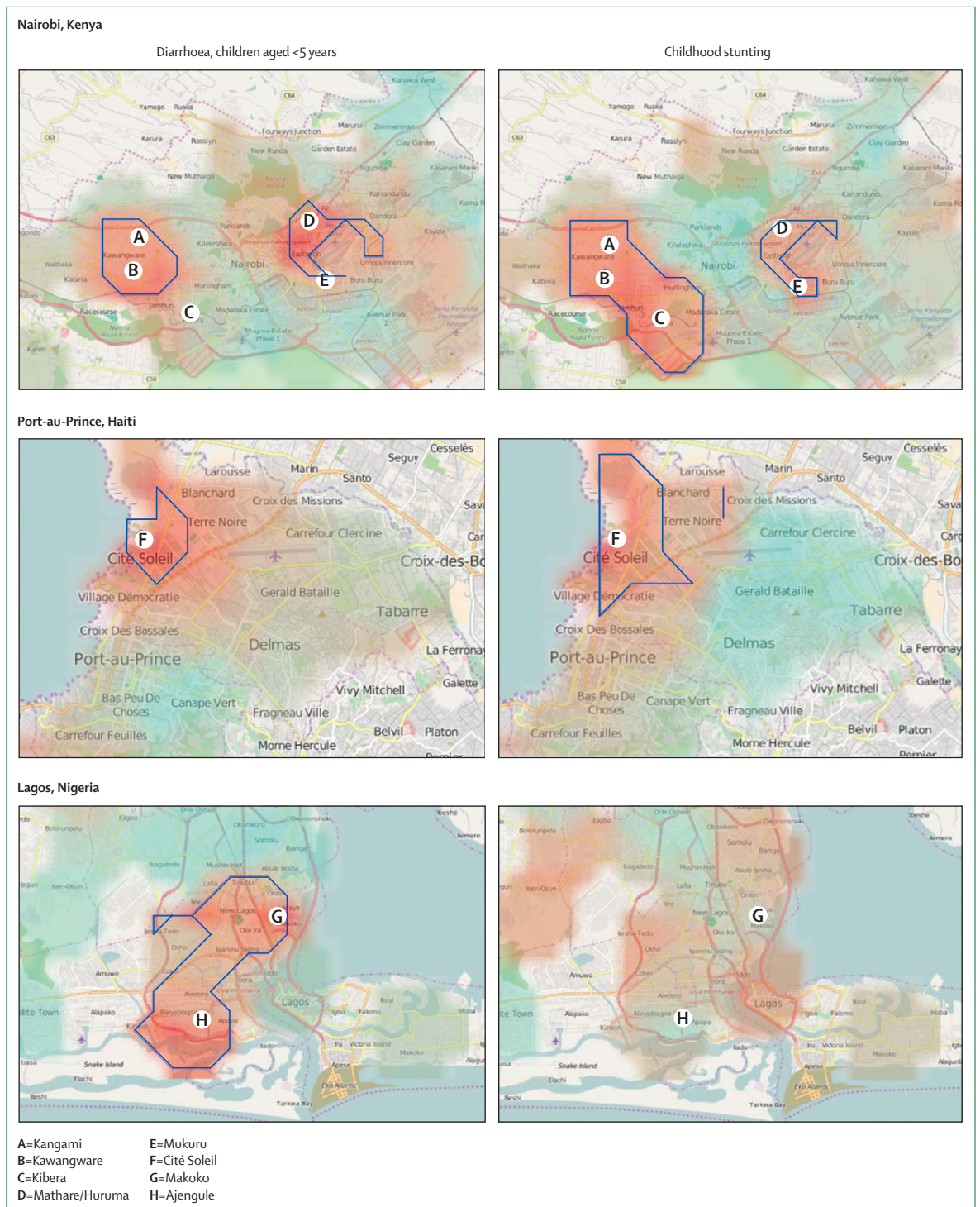


Figure 4: Maps showing risk of diarrhoea in children younger than 5 years and childhood stunting across Nairobi, Port-au-Prince, and Lagos
 Major slum areas are indicated by circled letters. Red indicates higher risk and turquoise lower risk. Blue lines outline areas with a greater than 80% probability of increased risk of the disease relative to other areas in the city. Disease risk is estimated by applying a spatial filter across a regular lattice grid over each urban area using data from the Demographic and Health Surveys (DHS) and then estimating a binomial model to predict disease risk at each grid point. Contact the authors for further information about the methods used to produce these maps. Map data © OpenStreetMap contributor.

and of subjective wellbeing (eg, happiness, life satisfaction, and mental health). Special attention should be paid to groups who are marginalised or especially vulnerable,⁹⁹ and cost-effectiveness analyses should seek to examine dimensions of equity, particularly catastrophic out-of-pocket expenses, and proportions of people pushed below the poverty line (US\$2 per day at purchasing power parity).¹⁰⁰

Slum health as an academic discipline

This Series has been predicated on the idea that there is merit in abstracting the idea of slum health from that of poverty in general or urban health in particular. In view of the importance of space, and the massive scale of modern slums, we think there is a need for a subject dedicated to improving conditions in slums. We identify four groups of people who can promote this cause: those who control the purse strings, those who control the intervention, those whose lives are at stake, and those who have experience and expertise in the design, conduct, and reporting of academic studies. Organisations that promulgate interventions across jurisdictions, such as the World Bank, agencies of the UN, and major donors, are in a good position to exert both the necessary leadership and provide practical support to kick-start a community of practice across the above four groups. Multidisciplinary research collaboration will be needed to make progress in improving slum health.

Conclusion

While it is no longer true to say that people who live in slums are invisible, they are insufficiently visible and as a result continue to be marginalised. Many slums are not identified in national surveys based on census sampling frames; research effort in slums is incommensurate with the size of the issue (especially with respect to multicentre controlled studies); people who live in slums remain politically weak and subject to expropriation; and conditions in slums are improving only slowly. The profile of slum health and welfare needs to be raised, and the time to do so is propitious in view of the forthcoming UN-Habitat III conference, the third of its type in 40 years, and the first UN global summit after the adoption of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals. The time is ripe to revisit the Urban Agenda with a strong emphasis on slum health and slum upgrading and on strengthening the capacities of urban governments to work with people who live in slums to act on these. This will help in securing commitments to ensure that policies are backed up with adequate finance. Above all, we advocate the academic development of slum health in the form of a partnership between policy makers, academics, and representatives of those who live in slums, so that knowledge can grow in tandem with efforts to improve health and wellbeing.

The supposed neighbourhood effect in slums is both a problem and an opportunity. It is a problem because it is likely to amplify health hazards and it is an opportunity because one intervention can simultaneously improve so many lives in one densely packed community. It is time for a concerted effort to generate political momentum and bear down heavily on known threats to health and wellbeing in slums. Because young children are especially vulnerable in slums, and because the effects of chronic illnesses are indelible, we recommend a concerted and sustained international movement to provide effective interventions to improve child health such as vaccinations, water and sanitation, breastfeeding and nutrition, and safe non-polluting cook stoves.

Contributors

This Series on slum health has been an international collaboration led by the University of Warwick, African Population and Health Research Centre, United Nations Human Settlements Programme (UN-Habitat), International Institute for Environment and Development, United Nations University, Federal University of Minas Gerais, and Oxford Policy Management Institute. RJL and AE jointly conceptualised the intellectual framework and initial draft of this report. GJM-T, JS, SIW, and Y-FC conducted the systematic reviews and OO led on the health aspects. All authors provided references and material and contributed actively to the drafting and reviewing of the report.

Declaration of interests

We declare no competing interests.

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References

- 1 Ezeh A, Oyebo O, Satterthwaite D, et al. The history, geography, and sociology of slums and the health problems of people who live in slums. *Lancet* 2016; published online Oct 13. [http://dx.doi.org/10.1016/S0140-6736\(16\)31650-6](http://dx.doi.org/10.1016/S0140-6736(16)31650-6).
- 2 Lilford RJ, Chilton PJ, Hemming K, Girling AJ, Taylor CA, Barach P. Evaluating policy and service interventions: framework to guide selection and interpretation of study end points. *BMJ* 2010; **341**: c4413.
- 3 Donabedian A. Explorations in Quality Assessment and Monitoring, Volume I: The Definition of Quality and Approaches to Its Assessment. Ann Arbor, MI: Health Administration Press, 1980.
- 4 Hardoy JE, Cairncross S, Satterthwaite D. The Poor Die Young: Housing and Health in Third World Cities. London: Earthscan Publications, 1990.
- 5 Turley R, Saith R, Bhan N, Rehfuess E, Carter B. Slum upgrading strategies involving physical environment and infrastructure interventions and their effects on health and socio-economic outcomes. *Cochrane Database Syst Rev* 2013; **1**: CD010067.
- 6 Office of Disease Prevention and Health Promotion. Social Determinants of Health. 2016. <https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health> (accessed Feb 17, 2016).

- 7 Baker J. Urban Poverty: A Global View. Washington, DC: The World Bank, 2008.
- 8 Abuya B, Kassahun A, Ngware M, Onsomu E, Oketch M. Free primary education and implementation in Kenya: the role of primary school teachers in addressing the policy gap. *SAGE Open* 2015; 1–10.
- 9 WHO. World Health Statistics. Geneva: World Health Organization, 2015.
- 10 Kyu HH, Shannon HS, Georgiades K, Boyle MH. Association of urban slum residency with infant mortality and child stunting in low and middle income countries. *BioMed Res Int* 2013; 2013: 1–12.
- 11 Mitchell S. Victorian Britain Encyclopedia. New York: Garland Publishing, 1988.
- 12 Harris JR, Todaro MP. Migration, unemployment and development: a two-sector analysis. *Am Econ Rev* 1970; 60: 126–42.
- 13 UN-Habitat. World Cities Report 2016: Urbanization and Development Emerging Futures. Nairobi, Kenya: UN-Habitat, 2016.
- 14 Xavier HN, Magalhães F. Urban slums report: The case of Rio de Janeiro. London: University College London, 2003.
- 15 Bradlow B, Bolnick J, Shearing C. Housing, institutions, money: the failures and promise of human settlements policy and practice in South Africa. *Environ Urban* 2011; 3: 267–75.
- 16 Kapse V, Pofale A, Mathur M. Paradigm of relocation of urban poor habitats (slums): case study of Nagpur city. *Int J Soc Behav Educ Econ Bus Ind Eng* 2012; 6: 2916–23.
- 17 Collins W, Shester KL. Slum clearance and urban renewal in the United States. *Am Econ J: Appl Econ* 2013; 5: 239–73.
- 18 Chetty R, Hendren N, Katz L. The effects of exposure to better neighbourhoods on children: new evidence from the moving to opportunity experiment. *Am Econ Rev* 2016; 106: 855–902.
- 19 Barnhardt S, Field E, Pande R. Moving to opportunity or isolation? Network effects of a randomised housing lottery in urban India. NBER working paper 21419. Massachusetts: National Bureau of Economics, 2015.
- 20 Patel SB. Dharavi: makeover or takeover? *Econ Polit Weekly* 2010; 45: 47–54.
- 21 Banerjee A, Gertler P, Ghatak M. Empowerment and efficiency: tenancy reform in west Bengal. *J Polit Econ* 2002; 110: 239–80.
- 22 Field E. Property rights and investment in urban slums. *J Eur Econ Assoc* 2005; 3: 279–90.
- 23 Gandelman N. Property rights and chronic diseases: evidence from a natural experiment in Montevideo, Uruguay 1990–2006. *Econ Hum Biol* 2010; 8: 159–67.
- 24 Buckley RM, Kalarickal J. Housing Policy in Developing Countries: Conjectures and Refutations. Oxford: Oxford University Press, 2005.
- 25 Handzic K. Is legalized land tenure necessary in slum upgrading? Learning from Rio's land tenure policies in the Favela Bairro Program. *Habitat Int* 2010; 34: 11–17.
- 26 Rydin Y, Bleahu A, Davies M, et al. Shaping cities for health: complexity and the planning of urban environments in the 21st century. *Lancet* 2012; 379: 2079–108.
- 27 Muller A, Mitlin D. Securing inclusion: strategies for community empowerment and state redistribution. *Environ Urban* 2007; 19: 425–39.
- 28 Njoku J. Why Festac, Shagari housing schemes failed 29th April 2014. <http://www.vanguardngr.com/2014/04/festac-shagari-housing-schemes-failed-expert/> (accessed March 4, 2016).
- 29 Etim EE, Atser J, Akpabio F. The new social housing scheme in Nigeria: how beneficial for the less privileged? *Glob J Soc Sci* 2007; 6: 1–6.
- 30 Vlahov D, Caiiffa WT. Healthy urban governance and population health. Participatory budgeting in Belo Horizonte, Brazil. In: Sclar ED, Volavka-Close N, Brown P, eds. The urban transformation: health, shelter and climate change. London: Taylor & Francis, 2013: 63–81.
- 31 Viero OM, Cordeiro AP. New Rules, New Roles: Does PSP Benefit the Poor? The Case for Public Provisioning in Pôrto Alegre. Pôrto Alegre: Wateraid, 2003.
- 32 Goldsmith WW, Vainer CB. Participatory budgeting and power politics in Porto Alegre. *Land Lines* 2001; 13: 1.
- 33 Wang F, Xuejin Z. Inside China's cities: institutional barriers and opportunities for urban migrants. *Am Econ Rev* 1999; 89: 276–80.
- 34 Subbaraman R, O'Brien J, Shitole T, et al. Off the map: the health and social implications of being a non-notified slum in India. *Environ Urban* 2012; 24: 643–63.
- 35 Qiu P, Yang Y, Zhang J, Ma X. Rural-to-urban migration and its implication for new cooperative medical scheme coverage and utilization in China. *BMC Public Health* 2011; 11: 520.
- 36 Mudege NN, Zulu EM. Discourses of illegality and exclusion: when water access matters. *Glob Public Health* 2011; 6: 221–33.
- 37 Brunton G, Caird J, Stokes G, et al. Review 1: Community engagement for health via coalitions, collaborations and partnerships: a systematic review. London: EPPI Centre UCL, 2015.
- 38 Cyril S, Smith BJ, Possamai-Inesedy A, Renzaho AM. Exploring the role of community engagement in improving the health of disadvantaged populations: a systematic review. *Glob Health Act* 2015; 8: 29842.
- 39 Rosato M. A framework and methodology for differentiating community intervention forms in global health. *Community Dev J* 2015; 50: 244–63.
- 40 Prost A, Colbourn T, Seward N, et al. Women's groups practising participatory learning and action to improve maternal and newborn health in low-resource settings: a systematic review and meta-analysis. *Lancet* 2013; 381: 1736–46.
- 41 More NS, Bapat U, Das S, et al. Community mobilization in Mumbai slums to improve perinatal care and outcomes: a cluster randomized controlled trial. *PLoS Med* 2012; 9: e1001257.
- 42 Dias S. Overview of Legal Framework for Social Inclusion in Solid Waste Management in Brazil. Cambridge, USA: WIEGO, 2010.
- 43 Chen M, Vanek J, Lund F, Heintz J, Jhabvala R, Bonner C. Progress of the World's Women 2005: Women, Work and Poverty: United Nations Development Fund for Women (UNIFEM). New York: United Nations, 2005.
- 44 Chen M, Jhabvala R, Kanbur R, Richards C. Membership based organisations of the poor. London: Routledge, 2007.
- 45 Chen M, Snodgrass D. Managing resources, activities, and risk in urban India: The impact of SEWA Bank. Washington, DC: AIMS, 2001.
- 46 Cabannes Y. The impact of participatory budgeting on basic services; municipal practices and evidence from the field. *Environ Urban* 2015; 27: 257–84.
- 47 Bakibinga P, Ettarh R, Ziraba AK, et al. The effect of enhanced public-private partnerships on maternal, newborn and child health services and outcomes in Nairobi-Kenya: the PAMANECH quasi-experimental research protocol. *BMJ Open* 2014; 4: e006608.
- 48 Kerrigan D, Kennedy CE, Morgan-Thomas R, et al. A community empowerment approach to the HIV response among sex workers: effectiveness, challenges, and considerations for implementation and scale-up. *Lancet* 2015; 385: 172–85.
- 49 Fergutz O, Dias S, Mitlin D. Developing urban waste management in Brazil with waste picker organizations. *Environ Urban* 2011; 23: 597–608.
- 50 Patel S, Baptist C. Documenting by the undocumented. *Environ Urban* 2012; 24: 3–12.
- 51 Galiani S, Gonzalez-Rozada M, Schargrodsky E. Water expansions in Shantytowns: Health and Savings. Washington DC: Inter-American Development Bank, 2007.
- 52 Butala NM, VanRooyen MJ, Patel RB. Improved health outcomes in urban slums through infrastructure upgrading. *Soc Sci Med* 2010; 71: 935–40.
- 53 Soares F, Soares Y. The socio-economic impact of Favela-Bairro. What do the data say? Washington DC: Inter-American Development Bank, 2005.
- 54 Gunther I, Gunther F. Water, sanitation and children's health: evidence from 172 DHS surveys. Policy Research working paper WPS 5275. Washington, DC: The World Bank, 2010.
- 55 Chaplin SE. Cities, sewers and poverty: India's politics of sanitation. *Environ Urban* 1999; 11: 145–58.
- 56 Wolf J, Prüss-Ustün A, Cumming O, et al. Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. *Trop Med Int Health* 2014; 19: 928–42.

- 57 Clasen TF, Bostoen K, Schmidt WP, et al. Interventions to improve disposal of human excreta for preventing diarrhoea. *Cochrane Database Syst Rev* 2010; **6**: CD007180.
- 58 Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L, Colford JM, Jr. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infect Dis* 2005; **5**: 42–52.
- 59 Nakagiri A, Niwagaba CB, Nyenje PM, Kulabako RN, Tumuhairwe JB, Kansiime F. Are pit latrines in urban areas of sub-Saharan Africa performing? A review of usage, filling, insects and odour nuisances. *BMC Public Health* 2016; **16**: 120.
- 60 Clasen T, Boisson S, Routray P, et al. Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection, and child malnutrition in Odisha, India: a cluster-randomised trial. *Lancet Glob Health* 2014; **2**: e645–53.
- 61 Patil SR, Arnold BF, Salvatore AL, et al. The effect of India's total sanitation campaign on defecation behaviors and child health in rural Madhya Pradesh: a cluster randomized controlled trial. *PLoS Med* 2014; **11**: e1001709.
- 62 Cattaneo M, Galiani S, Gertler P, Martinez S, Titiunik R. Housing, Health and Happiness. *Am Econ J: Econ Policy* 2009; **1**: 75–105.
- 63 Galiani S, Gertler P, Cooper R, Martinez S, Ross A, Undurraga R. Shelter from the storm: upgrading housing infrastructure in Latin American slums. Working Paper 19322. Cambridge, MA: National Bureau of Economics, 2013.
- 64 Gonzalez-Navarro M, Quintana-Domeque C. Urban infrastructure and economic development: experimental evidence from street pavement. IZA discussion paper No. 5346. Germany, 2010.
- 65 Thomson H, Thomas S, Sellstrom E, Petticrew M. Housing improvements for health and associated socio-economic outcomes. *Cochrane Database Syst Rev* 2013; **2**: CD008657.
- 66 Bowen A, Agboatwala M, Luby S, Tobery T, Ayers T, Hoekstra RM. Association between intensive handwashing promotion and child development in Karachi, Pakistan: a cluster randomized controlled trial. *Arch Pediatr Adolesc Med* 2012; **166**: 1037–44.
- 67 Ernst KC, Phillips BS, Duncan BD. Slums are not places for children to live: vulnerabilities, health outcomes, and possible interventions. *Adv Pediatr* 2013; **60**: 53–87.
- 68 Parbhoo A, Louw QA, Grimmer-Somers K. Burn prevention programs for children in developing countries require urgent attention: a targeted literature review. *Burns* 2010; **36**: 164–75.
- 69 Goodwin NJ, O'Farrell SE, Jagoe K, et al. Use of behavior change techniques in clean cooking interventions: a review of the evidence and scorecard of effectiveness. *J Health Commu* 2015; **20**: 43–54.
- 70 Alves JG, Gale CR, Souza E, Batty GD. Effect of physical exercise on bodyweight in overweight children: a randomized controlled trial in a Brazilian slum. *Cad Saude Publica* 2008; **24**: S353–59.
- 71 Alves JG, Gale CR, Mutrie N, Correia JB, Batty GD. A 6-month exercise intervention among inactive and overweight favela-residing women in Brazil: the Caraquejo Exercise Trial. *Am J Public Health* 2009; **99**: 76–80.
- 72 Penny ME, Creed-Kanashiro HM, Robert RC, Narro MR, Caulfield LE, Black RE. Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: a cluster-randomised controlled trial. *Lancet* 2005; **365**: 1863–72.
- 73 Rotheram-Borus MJ, Lightfoot M, Kasirye R, Desmond K. Vocational training with HIV prevention for Ugandan youth. *AIDS Behav* 2012; **16**: 1133–37.
- 74 Kehoe SH, Chopra H, Sahariah SA, et al. Effects of a food-based intervention on markers of micronutrient status among Indian women of low socio-economic status. *Br J Nutr* 2015; **113**: 813–21.
- 75 Ahmed T, Choudhury N, Hossain MI, et al. Development and acceptability testing of ready-to-use supplementary food made from locally available food ingredients in Bangladesh. *BMC Pediatr* 2014; **14**: 164.
- 76 Shillcutt SD, Walker DG, Goodman CA, Mills AJ. Cost effectiveness in low- and middle-income countries: a review of the debates surrounding decision rules. *Pharmacoeconomics* 2009; **27**: 903–17.
- 77 Mathew JL. Inequity in childhood immunization in India: A systematic review. *Indian Pediatr* 2012; **49**: 203–23.
- 78 Akinyemiju TF. Socio-economic and health access determinants of breast and cervical cancer screening in low-income countries: analysis of the World Health Survey. *PLoS one* 2012; **7**: e48834.
- 79 Pilger D, Heukelbach J, Khakban A, Oliveira FA, Fengler G, Feldmeier H. Household-wide ivermectin treatment for head lice in an impoverished community: randomized observer-blinded controlled trial. *Bull World Health Organ* 2010; **88**: 90–96.
- 80 Awasthi S, Peto R, Pande VK, Fletcher RH, Read S, Bundy DA. Effects of deworming on malnourished preschool children in India: an open-labelled, cluster-randomized trial. *PLoS Negl Trop Dis* 2008; **2**: e223.
- 81 Sur D, Saha DR, Manna B, Rajendran K, Bhattacharya SK. Periodic deworming with albendazole and its impact on growth status and diarrhoeal incidence among children in an urban slum of India. *Trans R Soc Trop Med Hyg* 2005; **99**: 261–67.
- 82 Sarkar NR, Anwar KS, Biswas KB, Mannan MA. Effect of deworming on nutritional status of ascariis infested slum children of Dhaka, Bangladesh. *Indian Pediatr* 2002; **39**: 1021–26.
- 83 Awasthi S, Pande VK. Six-monthly de-worming in infants to study effects on growth. *Indian J Pediatr* 2001; **68**: 823–27.
- 84 Taylor-Robinson DC, Maayan N, Soares-Weiser K, Donegan S, Garner P. Deworming drugs for soil-transmitted intestinal worms in children: effects on nutritional indicators, haemoglobin, and school performance. *Cochrane Database Syst Rev* 2015; **7**: CD000371.
- 85 McPake B, Hanson K. Managing the public-private mix to achieve universal health coverage. *Lancet* 2016; **388**: 622–30.
- 86 Samb B, Evans T, Dybul M, et al. An assessment of interactions between global health initiatives and country health systems. *Lancet* 2009; **373**: 2137–69.
- 87 Keare D, Parris S. Evaluation of shelter programs for the urban poor: principal findings. Washington, DC: The World Bank, 1982.
- 88 Thieme T, Kovacs E. Services and slums: rethinking infrastructures and provisioning across the nexus. The Nexus Network Think Piece Series, Paper 004. Brighton: The Nexus Network, 2015.
- 89 Lobo J. The science and practice of urban planning in slums. 2016. URL: <https://ugceviewpoints.wordpress.com/2016/05/31/the-science-and-practice-of-urban-planning-in-slums/> (accessed June 29, 2016).
- 90 Buckley R. Social inclusion in Mumbai: economics matters too. *Environ Urban* 2011; **23**: 277–84.
- 91 Murthy SL. Land security and the challenges of realizing the human right to water and sanitation in the slums of Mumbai, India. *Health Hum Rights* 2012; **14**: 61–73.
- 92 Banerjee A, Duflo E, Chattopadhyay R, Shapiro J. Targeting the hard-core poor: an impact assessment. New York: Public Affairs, 2011.
- 93 Banerjee AV, Duflo E. Mandated empowerment: handing anti-poverty policy back to the poor? Reducing the impact of poverty on health and human development: scientific approaches. *Ann N Y Acad Sci* 2008; **1136**: 333–41.
- 94 Brown C, Hofer T, Johal A, et al. An epistemology of patient safety research: a framework for study design and interpretation. Part 2. Study design. *Qual Saf Health Care* 2008; **17**: 163–69.
- 95 Chen YF, Hemming K, Stevens AJ, Lilford RJ. Secular trends and evaluation of complex interventions: the rising tide phenomenon. *BMJ Qual Saf* 2016; **25**: 303–10.
- 96 Field E, Kremer M. Impact evaluation for slum upgrading interventions. Washington DC: The World Bank, 2006.
- 97 Hemming K, Haines TP, Chilton PJ, Girling AJ, Lilford RJ. The stepped wedge cluster randomised trial: rationale, design, analysis, and reporting. *BMJ* 2015; **350**: h391.
- 98 Girling AJ, Hemming K. Statistical efficiency and optimal design for stepped cluster studies under linear mixed effects models. *Stat Med* 2016. **35**: 2149–66.
- 99 Sweeney S, Vassall A, Foster N, et al. Methodological issues to consider when collecting data to estimate poverty impact in economic evaluations in low-income and middle-income countries. *Health Econ* 2016; **25**: 42–52.
- 100 Greco G, Lorgelly P, Yamabhai I. Outcomes in economic evaluations of public health interventions in low- and middle-income countries: health, capabilities and subjective wellbeing. *Health Econ* 2016; **25**: 83–94.