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Improving the Health and Welfare of People who Live in Slums

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Summary

In the first paper in this series we examined 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 ‘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 one slum and another. We build on this spatial concept of slums to argue that, in all low-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. Now we consider what can be done to improve health and healthcare in slums. In paper one we showed that the intimately shared physical and social environment in slums is likely to generate strong neighbourhood effects. In this paper we show that neighbourhood effects have a potential up-side. First, densely packed slum neighbourhoods not only provide economies of scale as John Snow showed when he aborted a cholera epidemic by disenabling a water pump in Soho, London in 1854. Second, densely packed and unhealthy slum neighbourhoods may provide situations where escalating intervention ‘dose’ yields particularly rapidly accelerating health returns to scale. This idea is further explicated in Panel A.

The rest of this paper is organised as follows. First, we describe an intellectual framework to organise evidence on interventions. Second, we present the reviewed evidence according to
this intellectual framework. Third, we discuss the implications of the findings across both
papers for policy and research. Finally we conclude.

Panel A. Neighbourhood effects and the effectiveness of interventions: non-linear
returns to scale

As stated in paper one, a person’s risk of disease is affected by both personal factors, such
as diet and genetic constitution, and factors in the local environment, such as faecal
contamination, vectors of disease, and pollution. The latter results in neighbourhood effects.

Also stated in paper one, slums are not homogenous and individual slums present very
different scenarios in which a neighbourhood level intervention will play out. Two major
influences determine how this happens. First, there are both within and between
neighbourhood differences in the extent to which the prevalence of a disease is affected by
exposure to a risk factor. Second, the dose response may vary and can be non-linear. The
latter is particularly likely 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 another person’s risk. We have modelled the way that these two influences
interact in the left hand panel of the Figure below. The model shows how interventions
designed to reduce the prevalence of a target disease will demonstrate 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 shape of the response curve may yield scenarios of increasing
returns to investment. The right hand panel illustrates the wide range of possible intervention
effects that may be measured in a study depending on these factors. A model such as this
can aid in specifying theories for future testing. For example, providing sanitation 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
may explain why many sanitation improvement projects have yielded disappointing results
as described later, and point the way for development and evaluation of more intense interventions.

[Figure Panel A]

**Framework for review**

We organise our material using a generic three level causal model¹,² that has been applied in previous research to slum upgrading³ and in a Cochrane Review concerned with this topic.⁴ The three levels, shown in Figure 2.1, are as follows:

1. Macro-level institutions and policies affecting all citizens, including press freedom, an independent judiciary, monetary and fiscal policy, and other national/supranational influences.

2. A 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.⁴

3. 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 lies in the province of politics/economics and because, while these are crucially important influences, much can be done to improve health pending an improved macro-economic environment.⁵,⁶ Massive gains in health have been recorded even in countries with poor national governance⁷ and it is worth reflecting that infant mortality in slums is currently about 46 per thousand,⁸ whereas in Victorian England the *upper* class infant mortality rate in 1899 was three times higher (136 per thousand).⁹ We now turn our attention to interventions to improve slum health, supplementing the knowledge of the authors with a wide-ranging literature review (Panel B).
In order to identify key literature for the diffuse topic of slum health, we conducted a systematic overview of reviews covering determinants of health in slum settings and/or interventions that aim to improve the health of slum dwellers. We also identified randomised controlled trials (RCTs) conducted in a slum setting as part of a bibliometric analysis examining the relative volume of research studies concerning rural, urban and slum settings (Web Appendix 1.2.1 – paper one of this series). Acknowledging the important roles that international, governmental and non-governmental organisations play in this area, we systematically searched the grey literature and reviewed relevant documents. Details of the literature search process and study selection criteria are provided in the text below. Please note, much of the text below is duplicated from the first paper in this series.

1. Systematic overview of reviews concerned with slum health

We searched the following eight databases in January 2016: MEDLINE, including in-process and non-indexed citations, Embase, PsycINFO, LILACS, SciELO, WHO Global Health Library, Database of Abstracts of Reviews of Effects, maintained by the NHS Centre for Reviews and Dissemination, and CINAHL (all but two of the reviews detailed here were found in MEDLINE or Embase). We put no limits on dates covered. In order to make the search as sensitive as possible we included a wide range of synonyms for slums, derived from a list in a UN-Habitat report [11] and augmented by other terms we have encountered: (see the companion paper for a full list of terms). We further broadened our search by combining free-text synonyms with controlled vocabulary for slums and, where supported in the database, filters for systematic reviews. No language restrictions were applied. We examined the titles and abstracts of unique records and selected reviews (both systematic...
and narrative reviews) that: 1) specifically provided results for people who live in slums; 2) specifically included people who live in slums but did not provide specific results for the sub-group; and 3) included the urban poor and hence were likely to have included slum dwellers but this was not specified. We selected reviews dealing with primarily: a) the distribution and determinants of health relevant to slum settings; and b) interventions for slum populations, reporting health outcomes. Some of the identified reviews reported both on the epidemiology of health conditions, and interventions to improve these health conditions, in which case they are included in the evidence base for both papers. A flow diagram for study retrieval and selection is available in Web Appendix 1.3.1 – paper one.

2. Identifying randomised controlled trials in a slum setting
As part of a bibliometric analysis (see Web Appendix 1.2.1 of the companion paper), we searched MEDLINE and Embase 2001-2015 for studies recorded as being conducted in an urban, rural or slum locations. Search filters and key words related to various study designed, including RCTs, were applied in order to retrieve studies of a particular design. Retrieved records related to RCTs conducted in a slum setting were reviewed by the authors. Forty-eight RCTs were identified and included in the evidence base for this paper. Many (especially vaccine trial and trials of micro-nutrients) used slums to provide a ‘convenience’ sample.

3. Systematic review of the grey literature
We searched the grey literature by reviewing official reports from the publication databases of the World Bank, World Health Organization, and UN-Habitat on the basis of expert advice from the authors. We covered the literature from January 2010 to February 2016. Our search terms included synonyms for slums in searches one and two above. Eight hundred and eighty-four results were returned, and after examining the titles, abstracts, and text of these
studies and reports we selected 245 publications that dealt partially or wholly with issues arising in slums. For a breakdown of publications see Web Appendix 1.3.2 of the companion paper. Many important articles were found in this literature, including those relating to the economics of slum formation, system level interventions (such as the effect of providing tenure/title), and certain notable large scale studies, including a randomised trial of home improvement.

We supplemented the evidence retrieved as described above with additional searches as needed on the advice of experts and further extended these with authors’ collections of references and additional papers identified by subject experts.

**Meso-level policies directed at slums**

**Restricting migration or benign neglect**

Restricting free movement of citizens within a country is an illiberal policy redolent of the Cultural Revolution and apartheid South Africa – the days of ‘pass laws’ 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 ‘Todaro effect’. This argument can be rejected because we have seen (paper one) that:

1. Slums in LMICs are anything but temporary and continue to enlarge even when economic growth is stagnant.
2. Migration is no longer the main driver of slum growth in many countries – 86% of people in South America already live in urban centres, for example.

**Resettlement / relocation programmes**
During the reign of Napoleon III, Baron Haussman rebuilt central Paris, France, destroying the medieval city but installing a massive sewerage system and creating the cityscape we see today. Haussman's intervention was not evaluated scientifically but the results of resettlement programs in low- and middle-income countries (LMICs) are often disappointing.\textsuperscript{14-16} Sometimes this is because they amount to 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 'ghettoized' on the periphery of sprawling cities, where land is cheap. Commuting times are extended and in some instances settlers return to their original settlement. Absent development of infrastructure (transport, water, electricity, high quality housing, and sewerage) the cheaper policy of \textit{in situ} slum upgrading is generally preferable to relocation.\textsuperscript{17} Interestingly, a lottery system enabling people to move to better-off neighbourhoods which worked well in the USA \textsuperscript{18} (Panel B, paper one), was not successful when tried in India largely because many residents returned to their original location.\textsuperscript{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 may give rise to better outcomes than dense areas of deprivation.\textsuperscript{18}

\textbf{Security of tenure}

It is in the nature of most slums that they tend to be informal settlements where 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,\textsuperscript{20} a theory confirmed empirically with respect to farm land.\textsuperscript{21} Further empirical support comes from two natural experiments in slums,\textsuperscript{22, 23} one in Peru showing a sharp increase in investment in home infrastructure, including sanitation, in the intervention slums;\textsuperscript{22} and the second in Uruguay, finding statistically significant reduction in a score based on number of reported illnesses.\textsuperscript{23} Title is maximally effective when financial systems that allow residents to release collateral
value are in place. Furthermore, awarding title may be a longwinded and expensive legal process. In such cases, systems of tenure or registration that instil confidence that homes will not be bulldozed may be enough to encourage residents to invest in developments likely to promote health.

**Governance**

Failures in planning and governance contribute to the generation and maintenance of large slums (paper one), so good local authority policies promulgated by the ‘Healthy Cities movement’ are conducive to slum health, as discussed in a Lancet Commission. Local government can help 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. While such planning processes may be corrupt or incompetent, leading to ‘ghost cities’, they can also be successful, as in Porto Alegre and Belo Horizonte in Brazil. Formalising slum areas to provide rights and entitlements is associated with better education and health, and this might partially explain the results of a recent Indian study where infant mortality rates were 25 per 1000 live births on average in ‘notified’ slums versus 58 per 1000 in a non-notified slum in the same city. Yet only half of Indian slums are notified and Chinese people who migrate to cities cannot gain access to basic services without registration numbers (Hukou). Access to amenities should not be made contingent on tenure.

**Community Engagement**

There is an expanding literature confirming the effectiveness of interventions to promote local engagement, action, and innovation, and the more the community drives the intervention the greater the effect. A systematic review of women’s groups to improve perinatal outcomes included seven RCTs. While the results were positive overall, most of
these studies were conducted in rural settings and the effect was highly dependent on participation rates. The single study conducted in a slum showed a null result plausibly because participation rates were low. This is 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. There are a number of examples of successful grass-roots networks in slums. The programme in Porto Alegre mentioned above incorporated participatory budgeting where communities were involved in setting priorities. Such groups have provided successful escort for women in labour in Nairobi slums, in Kenya enhanced protection for sex workers in Zimbabwe, and improved self-organisation of waste pickers in slums who have gone on to bid successfully for municipal contracts. City and national slum dwellers federations have been active in conducting slum surveys using these to provoke and plan action with local authorities.

**Specific (micro-level) interventions in slums**

Here we discuss specific physical / engineering approaches to slum upgrading and service development (Figure 1.2). We augment the limited literature conducted specifically in slums with studies that cover slums and other areas; the systematic reviews we rely on are listed in Table A2, Web Appendix 2.2 and RCTs in Table A3 in Web Appendix 2.3.

**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 under the age of five, was documented in paper one. The problem can be tackled with behavioural interventions (discussed in the next section) or physical interventions. Physical interventions may be targeted at water provision, sanitation, and point of use methods to decontaminate water (filters for example). A Cochrane Review of physical / engineering interventions (Table A2, Web Appendix 2.2) in slums cited three
main’ studies that satisfied its quality threshold and included a health outcome. One of these studies found a 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 intervention (that included piped water in homes and lavatories connected to a sewer along with street paving and drainage) found a substantial reduction in waterborne diseases (RR 0.64; 0.27 - 0.98). Lastly, a study of improved water and sanitation 53 that looked only at effect on ‘sanitation related mortality’ found no change (RR and CIs not given). Results for case studies based in slums are given in Web Appendix 2.1. Another substantial study that was not specific to slums used the Demographic Health Survey (DHS) to analyse data from 70 countries and found reductions in the incidence of diarrhoea of 13% and 7% respectively for improved water and sanitation. The effect sizes recorded in the above studies are thus highly variable and some are disappointing given the theoretical headroom for improvement and the results credited to the 19th century ‘sanitary revolution’ in Europe and North America. A plausible explanation can be found in the analysis of context and increasing returns to scale described in the section on neighbourhood interventions (Panel A). Wolf and colleagues, provide a classification of intervention water comprehensiveness, a proxy for ‘dose’. Water provision may be ‘improved’ (according to the United Nations (UN) definition) by making it readily available from standpipes outside the house, or it might be piped into the home or piped into the home and quality assured. Likewise, sanitation may 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 (i.e. including but not limited to slums). Results are given in Web Appendix 2.1 and shown in Figure 2.2, where increasing returns to comprehensiveness (‘dose’) of the intervention can be seen, conforming to the theoretical representation in Panel A, Box A. It would appear from these findings that pit-latrines, for all that the UN classifies them as ‘improved’ sanitation, are of minimal effectiveness generally and there is further evidence that they do little to reduce environmental contamination in
congested slum neighbourhoods. Where adequately quality assured piped water cannot be provided, then point of use methods provide an alternative since the above systematic reviews consistently demonstrate substantial effect sizes; 0.65 (0.48, 0.88) in Fewtrell’s review and 0.55 (0.38, 0.81) for filtered and safely stored water in Wolf’s review.

Effectiveness is likely to be influenced 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 RCTs of making pit latrines available in India. A further reason for variable results from physical interventions lies in poor maintenance of facilities and inadequate installations; piped water distribution systems are often contaminated. It might be expected that combining sanitation and water interventions would be more effective than either alone but this remains unproven (Web Appendix 2.1).

**Home improvements**

The Cochrane review of slum interventions identified a natural experiment in which the provision of cement floor reduced the incidence of diarrhoea in children under six years old (RR 0.87 [0.76-1.00]) in Mexico. A subsequent experimental study evaluating home improvements that included a raised floor across El Salvador, Mexico and Uruguay also showed a borderline significant reduction in diarrhoea incidence (2.7% absolute risk reduction from 15.1%) in two of the countries excluding Uruguay.

**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 single RCT in the Cochrane Review did not confirm improved security or health. Removing solid waste is doubtless a good idea given its...
effects on health and wellbeing (paper one) but little evidence was found on how best to
dispose of garbage or on the health benefits of doing so.

Taken in the round, the literature provides numerous case studies of interventions but
woefully insufficient large-scale studies where in depth observations complement
comparisons across sites, such as can be found, for example, in studies of home
improvements in high-income countries.65

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Health and public services

A number of health improvement studies have been carried out in general populations but
also replicated in slums specifically:

- A meta-analysis of 11 studies across urban and rural locations showed that
  behavioural interventions to promote hand washing resulted in a lower prevalence of
diarrhoea68 and this was mirrored in trials specifically in slums in Pakistan66 and
  Nepal.67.

- A systematic review examining paediatric burn prevention identified 30 studies from
  high and low income countries (Table A2, Web Appendix 2.2). The benefits observed
  from reducing hazards such as unsafe paraffin cook-stoves were replicated in a
  single RCT in a slum environment (in South Africa).68

- A systematic review 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 to 1.6 parts per million), a 21% reduction in respiratory
disease (absolute risk not given) and savings on fuel costs.69 Two of the interventions
  were carried out in slums (Bangladesh and Uganda) but results are not broken down
  by location.

A substantial number of individual RCTs of health promotion interventions have been
conducted specifically in slums (Web Appendix 2.2 Table A3) yielding positive results
concerning behavioural interventions to reduce obesity in women and children in Brazil, childhood malnutrition in Peru, breast feeding in Kenya, and ‘delinquent’ behaviour in Uganda. Providing fortified snack bars resulted in improved nutritional status in India and Bangladesh (arguably avoiding the harmful effects resulting from imbalance of competing elements, e.g. zinc and copper, with chemical formulations of micro-nutrients).

These results, taken in the round, support the theory that slum populations benefit from health promotion measures as long as they receive them. This conclusion, that access is the rate limiting step to achieving benefit for people who live in slums appears to apply also to health promotion. Child immunisation is considered the single most cost effective intervention for health in LMIC yet children in slums are less likely to be vaccinated than other urban infants. This is especially unjust given that, as stated in the search strategies, slums are often used as a convenient sample in vaccine trials (Panel B). When it comes to screening, we do not know of studies specific to slums but rates are very low across low income countries; 4.1% and 2.2% in the relevant populations for cervical and breast cancer respectively, for example. However, slum populations benefit when access to health protection is provided. For instance five RCTs specifically in slums have shown that parasite loads can be reduced by treatment targeted at high risk groups and some show improved child growth (although the latter is a highly contested topic across all populations).

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 all health provision of all types in slums is the need to improve access. Services must be available outside normal office hours and be pro-active for the reasons given under ‘determinants of health’ in paper one. 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 paper contributing to the Lancet Commission on Universal Healthcare, Markets, Profit
and the Public Good, showed that providing a network of accessible free clinics ‘crowded
out’ low quality, under-qualified providers. Further work to design services that meet local
preferences is urgently required and we note that the 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.

We summarise what can be said given current information on the likely effectiveness of both
enabling (meso-level) and specific (micro-level) interventions in Table 2.1.

Table 2.1: Summary of intervention effectiveness across both meso-level and micro-
level interventions

<table>
<thead>
<tr>
<th>Policy</th>
<th>Aim</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit free movement</td>
<td>Discourage growth of slums.</td>
<td>Does not solve underlying problem, illiberal and is not a permanent solution.</td>
</tr>
<tr>
<td>Benign neglect</td>
<td>Limit size of slums on the grounds that they are self-correcting.</td>
<td>Leaves vulnerable people in prolonged and severe need and generates poverty traps. Too late for many countries where urbanisation is already advanced.</td>
</tr>
<tr>
<td>Relocation and resettlement</td>
<td>Clear slums and provide alternative, superior living environment.</td>
<td>Countries with large slums generally have insufficient resources / lack political will to do a proper job, and provide necessary infrastructure. Promises more than it delivers.</td>
</tr>
<tr>
<td>Title and tenure</td>
<td>Encourage ‘in situ’ regeneration by giving people a stake in their community and homes.</td>
<td>Providing title is effective but may not be possible where title is disputed. Security of tenure without title may be sufficient.</td>
</tr>
<tr>
<td>City governance</td>
<td>Recognising slums and conferring rights creates conditions conducive to health. Land zoning</td>
<td>Many examples of good and bad practice. Providing rights and</td>
</tr>
<tr>
<td>Specific (micro-level) interventions</td>
<td>Community engagement / empowerment</td>
<td>Physical methods of slum improvement</td>
</tr>
<tr>
<td>-------------------------------------</td>
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<tr>
<td>protects vulnerable citizens.</td>
<td>Uses ‘assets’ of the community; empowers citizens.</td>
<td>Uncontaminated water piped into homes / point of use decontamination. Reduce environmental contamination through sanitation.</td>
</tr>
<tr>
<td>services is an effective policy.</td>
<td>Many empirical examples of success – most effective where citizens are genuinely empowered.</td>
<td>‘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.</td>
</tr>
</tbody>
</table>
Recommendations for Policy and Research

We have shown that very little research has been devoted to the subject of slum health (paper one). Consequently, despite nearly a billion people already living in slum locations in LMICs, we do not understand enough about their health vulnerabilities and what impact can be achieved from slum-focused health interventions. In particular, we need to understand how neighbourhood effects operate so that we can get the intensity of interventions right as discussed in Panel A. We offer below a number of research and policy recommendations to advance the field of slum health.

Identifying and studying slums as spatial entities

Although slums are easily identifiable physically in many LMIC cities, 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 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: for instance determining where diarrhoea and stunting are most prevalent (Figure 2.3). 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 vs. 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. We spell out how this could be achieved in Panel C. 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, Port-au-Prince, Haiti and Lagos, Nigeria using data from the Demographic Health Survey (DHS) in Figure 2.3. There is clustering of cases in the vicinity of well-known slums but precision would be much improved if slum areas were clearly demarcated.

Panel C. Suggested process to identify slums and include them in censuses so that studies/surveys based on a census sampling frame can distinguish between slum and non-slum locations.

In order to achieve the above objective: 1) enumeration areas should be designated (tagged) to one of three categories (slum, non-slum, or rural) in such a way that no single urban enumeration area straddles slum and non-slum areas; 2) while nations classify slums according to their own context, their methods should be transparent, and consider the five household level criteria in the UN-Habitat definition; and 3) quality assurance should check that all clusters are enumerated and then that all dwellings are recorded within each cluster. This 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 Table 1.2, 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.
Child health

While the evidence base in slum health is under-developed, 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, indoor protection against burns, and inhalation of particles/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 may 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 ‘sanitary awakening’ in the 19th century. 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 been up to the job. 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 (Panel A). The international community may even have exacerbated the problem by setting standards for ‘improved’ sanitation (pit latrines) that are unsuitable for densely crowded slum conditions. We therefore recommend that this inadequate standard should be withdrawn.
for slum contexts and that, working with local communities, comprehensive installations (e.g. 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 may be too high. It has become fashionable for scholars to argue that the whole ‘slum nexus’ should be tackled in a co-ordinated way.\(^{86-88}\) At the limit such an approach amounts to a programme to convert slum to non-slum. While this is a laudable aim, we are concerned that the ideal should not become the enemy of the good; as Buckley has argued, cost-effective interventions, such as vaccination and installing sanitation systems, should not wait until the moment is propitious for a holistic strategy\(^ {89}\) and access to amenities should not be dependent on title or tenure.\(^ {90}\) 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 a helping hand.\(^ {91, 92}\)

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.\(^ {93, 94}\) While not reifying experimental methods, Field and Kramer cite empirical evidence that supports theoretical arguments for use of experimental methods in a slum context.\(^ {95-97}\)

Consider multiple 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 (Web Appendix 2.1). A corollary is the importance of capturing both dimensions of health (for example in Disability Adjusted Life Years) and of subjective wellbeing (happiness, life satisfaction, and mental health). Special attention should be paid to groups who are marginalised or especially vulnerable, 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).

**Slum health as an academic discipline**

These papers have 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. Given the salience 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 (particularly 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 given 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 policymakers, academics, and representatives of those who live in slums, so that knowledge can grow in tandem with efforts to improve health and wellbeing.

The putative 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 a single 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. Since young children are especially vulnerable in slums, and since the effects of chronic illnesses are indelible, we recommend a concerted and sustained international movement to provide effective interventions to improve child health – vaccinations, water/sanitation, breastfeeding and nutrition, and safe non-polluting cook stoves.
Key messages

1. The neighbourhood effects in slums are likely to offer economies of scale and increasing returns to investments to create a healthy environment.

2. While relocation and resettlement can be necessary for reasons of safety, slum upgrading in situ is usually preferable.

3. Sanitation, which started the public health revolution in Europe and America during the 19th century, remains a cardinal neighbourhood challenge in slums. Interventions must be sufficiently comprehensive to impact the steep part of the returns to scale curve.

4. Health services should be designed specifically to overcome barriers to utilisation, such as distance and cost, for people who live in slums.

5. Further to the above health services should be pro-active in health protection, e.g. by immunisation and surveillance for childhood malnutrition.

6. People who live in slums and their organisations should have an active say in the prioritisation, design, implementation, and evaluation of interventions in slums.

7. Slum enumeration areas should be identified in all census listings and sampling frames to enable clearer understanding of the neighbourhood effects of slums.

8. 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.

9. In addition, we advocate the development of capacity for research into slum health and the emergence of this as an academic discipline.
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 paper. GJMT, JS, SW and YFC 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 manuscript.

Declaration of interests
The authors declare no competing interests

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Figure Legends

Figure Panel A. (Left) Relationship between exposure to a risk factor for a disease of interest and prevalence of the disease in three different neighbourhoods. (Right) Observed effectiveness of an intervention aimed at reducing a specific exposure, with success measured by examination of prevalence of the disease of interest.

\[ \Delta = \text{intervention effect} \]

(Left) A, B and C represent three different slum neighbourhoods. In A and C, prevalence is relatively inelastic over varying levels of exposure, perhaps because another powerful risk factor is present (A) or because there is a ceiling effect as prevalence is already low (C) perhaps because the population has been vaccinated against the risk factor. In B, the dose response is non-linear so that an intervention may show increasing (and then decreasing) returns to scale.

(Right) When an intervention is implemented which aims to reduce exposure to the risk factor, the effects are minimal 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 x3 to x2 has much less effectiveness than an intervention that reduces the exposure from x2 to x1.

Figure 2.1. Representation of causal pathways impacting on the lives of people who live in slums

*Topics under this heading adapted from the framework in the Cochrane Review \(^4\) augmented from the literature review.

**Topics under this heading based on the Social Determinants of Health – Office of Disease Prevention and Promotion.\(^10\)
We do not discuss microfinance in this paper as none of the three systematic reviews evaluated this topic for slums specifically. We do not cover education as this substantial topic is worthy of its own review.

Figure 2.2 Representation of Magnitude of Effect by Comprehensiveness of Intervention Across Studies in Slum and Non-Slum Systematic Reviews and the DHS Survey

† 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, et al. 2014.56

Figure 2.3. Maps showing risk of diarrhoea in children aged under five and childhood stunting across Nairobi, Port-au-Prince, and Lagos with major slum areas 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.


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