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Abstract

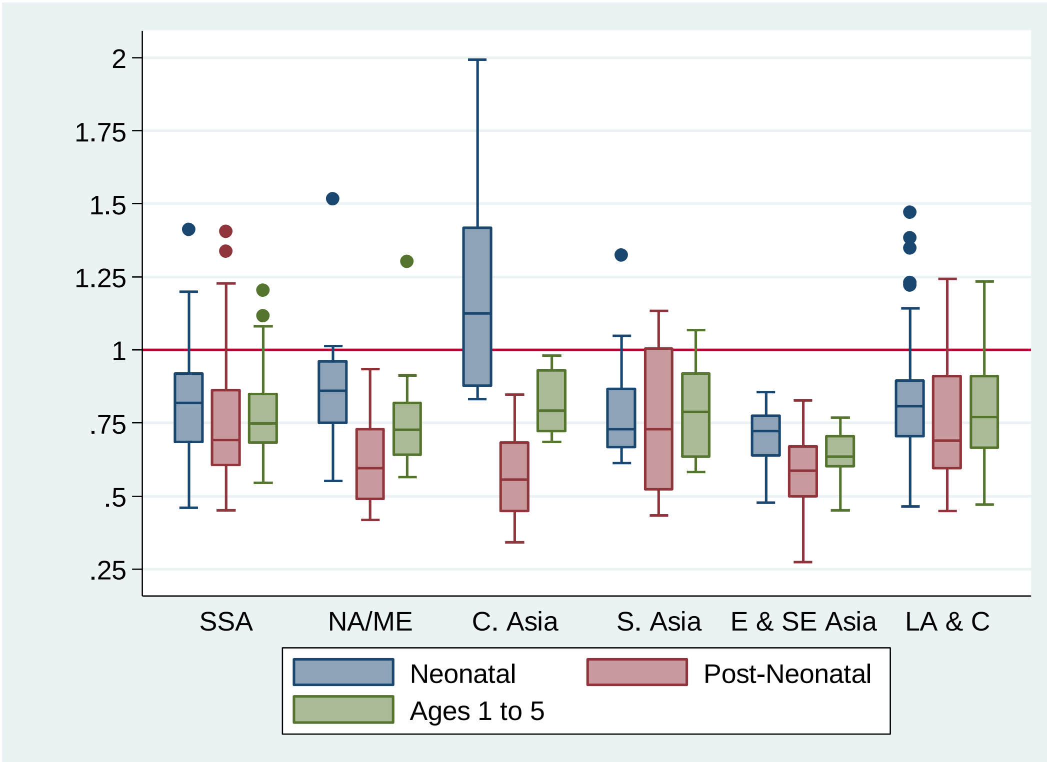
High urban mortality delayed transitions to low mortality in 19th century Europe, but an urban mortality advantage emerged as European transitions progressed into the 20th century. Recent analysis has suggested that high mortality in the rapidly growing urban slums of developing countries might once again delay transitions to low mortality in the 21st century. In this paper we use data from Demographic and Health Surveys across 37 countries to investigate this hypothesis. We document the changes in child mortality over the last twenty years, with a special focus on urban slums and on differences between small and large cities. We show that slum areas fare worse than other urban areas across all child mortality categories and all city categories, but that generally children growing up in urban slums fare at least as well as children in rural areas. Moreover, the improvements in child mortality appear to have affected slum residents at least as much as other urban and rural residents, indicating a neutral role of slum settlements in the mortality transition of developing countries.

1. Introduction

From a historical perspective, the relation between urban residence and health outcomes has been mixed, with rather remarkable changes in trends over time. During the 19th century, European cities still showed higher mortality rates than rural areas (Williamson 1990; Woods 2003; Cain and Hong 2009). The urban mortality penalty disappeared with the rollout of public health interventions in high income countries at the end of the 19th century (Haines 1995), and turned into an urban mortality advantage with the introduction of effective therapeutic interventions in the early 20th century.

The low and middle income countries (LMICs) of today may have followed a different trajectory. Gould (1998) and Johnson (1964) argue that urban areas in developing countries have had lower mortality than rural areas since the 19th century and at least by the end of the 20th century urban populations typically had lower mortality levels than rural populations in all developing countries. Figure 1 summarizes urban to rural mortality ratios in childhood across a large number of nationally-representative household surveys conducted by the Demographic and Health Surveys program in several LMICs starting in the mid-1980's. Three measures of mortality are displayed: the neonatal mortality rate, post-neonatal mortality rate, and the probability of dying between the ages of one and five years. Since for all (except one) measures and all regions the median ratio is below 1.0,the existence of an urban child mortality advantage seems to be clear.

Figure 1: Country-specific ratios of urban to rural child mortality by world region



Note: Data accessed through Statcompiler 18 July 2011. Based on 198 surveys over the period 1985-2010.

The ratios presented in Figure 1 - indicating a clear urban mortality advantage – might, however, hide important mortality differentials resulting from the dual nature of LMIC cities, combining low with high mortality urban areas. The increasingly large populations living in, and moving to, LMIC cities have led to the formation of large and rapidly growing informal urban settlements often referred to as "slums" over the past decades. According to the United Nations, more than 1 billion people, or about 14 percent of the total global population live in slum areas today (UN–HABITAT 2007). Outsiders visiting such slums are often repulsed by the sights and smells they encounter, and assume that the health consequences must be disastrous (bringing to mind the 19th century concept of miasma in European cities). Given the similarities between these areas and high income country cities in 19th century in terms of income, overcrowding and low water and sanitation standards, a mortality disadvantage is generally presumed for urban slums. Recent analysis has therefore suggested that excess mortality in slums is delaying mortality transitions in LMICs, reminiscent of the history of high income countries in the 19th century

(Moore, Gouldet et al. 2003; Sclar, Garau et al. 2005; Konteh 2009). However, evidence on mortality differentials and on their potential effects on the mortality transition is scarce and far from conclusive. Montgomery et al.(2003) analyze Demographic and Health Survey (DHS) data from 56 surveys and document a general mortality childhood mortality risk gap in favor of urban households, while highlighting that specific urban sub-populations can face higher mortality risks than rural populations. In a related study of 85 DHS surveys, Montgomery and Hewett (2005) find that poor households are often spatially intermingled with well-off households in urban areas, but also that areas of concentrated poverty are generally associated with lower rates of health service utilization. Fotso et al. (2007) use DHS data from African cities supplemented with data from demographic surveillance sites to examine trends in urban child mortality. They find that the pace of decline in urban mortality in sub-Saharan Africa has in most countries been below that needed to achieve the target of Millennium Development Goal 4 (to reduce the under-5 mortality rate by two-thirds between 1990 and 2015), and also note the emergence of intra-urban mortality differentials. In a study of 18 African countries, Bocquier et al. (2011) find that after controlling for known demographic and socio-economic correlates of childhood mortality, urban advantages are greatly reduced or indeed reversed. Günther and Harttgen (2012) analyze data from 18 African countries and find that child mortality rates in slum areas are significantly higher than in non-slum urban areas but lower than in rural areas in most countries. Timaeus and Lush (1995) analyze four countries for intra-urban differentials in child health and find that the mortality difference between the urban poor and non-poor is larger than the difference between rural and urban populations.

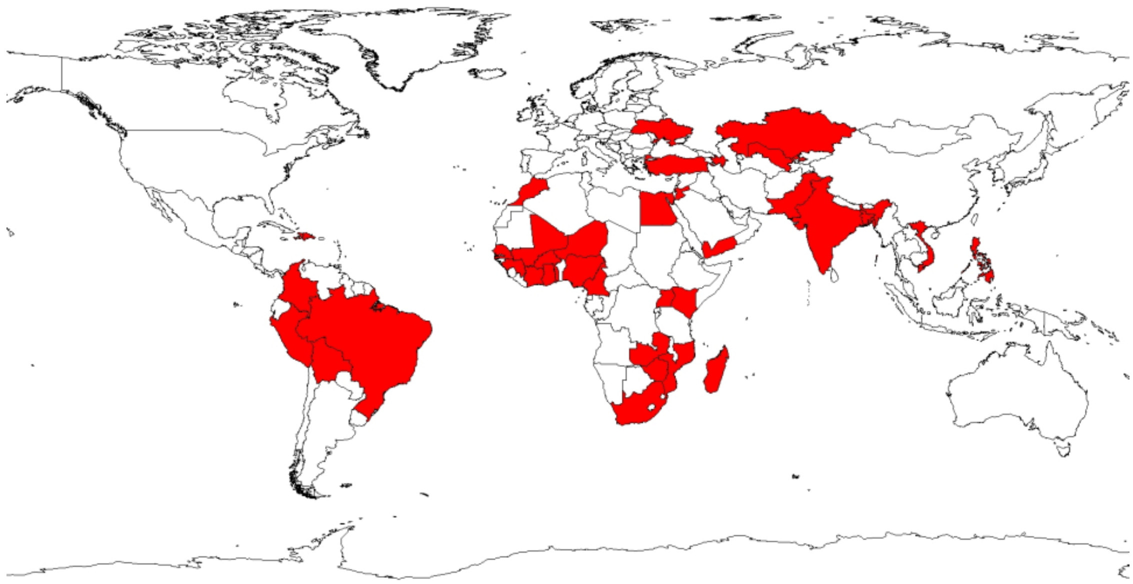
We build and expand on this literature, investigating both the overall within-urban mortality differentials and their impact on the mortality transition in LMICs. Methodologically, this paper deviates from the existing literature along two dimensions: the use of age-specific mortality measures, and the introduction and application of a community- rather than household-based definition of slums. Given that the urban context is likely to have differential effects on mortality risks at different ages due to the differences in the underlying epidemiology, we separately analyze three age brackets: neonatal mortality, post-neonatal mortality, and mortality 12-36 months. In contrast to previous studies and UN Habitat (2007) – which define a slum household as a household lacking one or more key facilities independent of the household's surroundings - we adopt a community-based definition of slums, classifying only those urban areas where a majority of households lack basic infrastructure as slum neighborhoods, and further distinguish slum areas within small and large urban settlements.

2. Data and Methodology

The data used in this paper are from the Demographic and Health Surveys (DHS). The DHS are population-based nationally representative surveys with a particular focus on fertility and reproductive health. Largely funded by USAID, 188 DHS surveys have been conducted in 76 countries since 1986 and made publicly available.[1] Since we want to distinguish small towns from large urban areas, we limit our analysis to countries with at least one city with a population of one million or larger in 2010, as estimated by the United Nations Population Division (2010). Out of the countries covered by the DHS, 49 countries (and 146 surveys) have at least one such large city in 2010, and thus meet the primary inclusion criterion for this paper. Out of these 146 surveys, 74 surveys do not have information on the household characteristics needed for the slum coding, and thus could not be included, leaving us with a total of 72 surveys across 37 countries. As Figure 2 illustrates, about half of our sample is in sub-Saharan Africa with the rest evenly distributed among Asian and Latin American countries. A full country and year listing is provided in Appendix Table 1.

[1] 23 August 2011, www.measuredhs.com.

Figure 2: Sample of 37 countries with large cities and available DHS



City Classification

The DHS surveys do not provide – at least in the publicly accessible data sets - information on the exact household location. The main geographic information provided by the DHS is the region (administrative unit) the household is located in (DHS standard recode variable hv024). In addition, DHS surveys provide information on the "type" of residence (urban vs. rural, hv025) as well as the "place" of residence, which is divided into rural, small town, and larger city (hv026).

For the purpose of our analysis, households are classified as rural if their "type" of residence is rural (hv025). To investigate whether large urban agglomerations or "cities" as well as their respective slum areas fare differently from smaller urban settlements, we divide urban type of residence (hv025) into "towns" (small urban areas) and "cities" (urban settlements with a total population estimated to be at least one million in 2009 (UNDP 2011). Most developing countries have only one or two large cities – in most cases the capital – with the notable exceptions of Brazil and India with over 20 and 40 urban agglomerations above 1 million inhabitants, respectively (see Appendix 1).

In order to distinguish towns from cities, we use a combination of spatial variables provided by the DHS. In many cases, large agglomerations, and especially capital areas, constitute separate administrative regions (hv024), in which case the coding is straightforward. To make sure none of the households in these areas are rural settlements at the outskirts of larger urban areas, we check that all of the households placed in these areas are classified as urban according to the "type" of residence (hv025).

For some countries - namely Brazil, Colombia, Egypt, India, Jordan, Morocco, Nigeria, Pakistan, South Africa, Ukraine, Turkey, and Yemen - the regional coding was too coarse to allow a direct mapping from administrative regions into specific urban areas. For these countries we used the DHS variable on "type of place" of residence (hv026), categorizing observations into rural, small town and large city. Given that the DHS definition of "large city" is not necessarily consistent with our one million population threshold, the coding outcomes in these countries are not as precise as the coding in the rest of the sample. We address this issue in a robustness check later in the paper.

Slum Classification

We are interested in slum mortality relative to mortality in other urban or rural areas. One of the main challenges with this research question lies in the fact that the concept of slums is not clearly defined in general. UN Habitat (UN Habitat, 2011) uses a household-based slum definition, and considers any household a slum household if it lacks any one of the following five elements:

- **Access to improved water** (*access to sufficient amount of water for family use, at an affordable price, available to household members without being subject to extreme effort);*
- **Access to improved sanitation** (*access to an excreta disposal system, either in the form of a private toilet or a public toilet shared with a reasonable number of people);*
- **Durability of housing** (*permanent and adequate structure in non-hazardous location)*
- **Sufficient living area** (*not more than two people sharing the same room)*
- **Security of tenure** (*evidence of documentation to prove secure tenure status or de facto or perceived protection from evictions*)

While we view each of the five aspects as a good indicator of poor living conditions, the household-based definition of slums appears inconsistent with the more commonly used concept of slums as generally poor areas, i.e. an agglomeration, settlement or neighborhood of substandard housing rather than a single poor house in an otherwise possibly wealthy neighborhood. For example, Merriam Webster defines a slum as "*a densely populated usually urban area marked by crowding, dirty run-down housing, poverty, and social disorganization*" (Merriam Webster, 2011). This distinction appears particularly relevant in the context of health, where a large fraction of health hazards is determined by the household surroundings and environment, and not necessarily by the household itself.

To concur with this general perception of slums we focus on neighborhoods to define slums in this study. The main unit of analysis for defining slums are the sampling units used by the DHS. DHS surveys are usually carried out applying a two-stage sampling procedure with clusters of about 200 households as a sampling unit, typically representing a single census enumeration area. Prior to the survey, all households are listed, and approximately one in eight households in each areas are randomly selected for the interview.

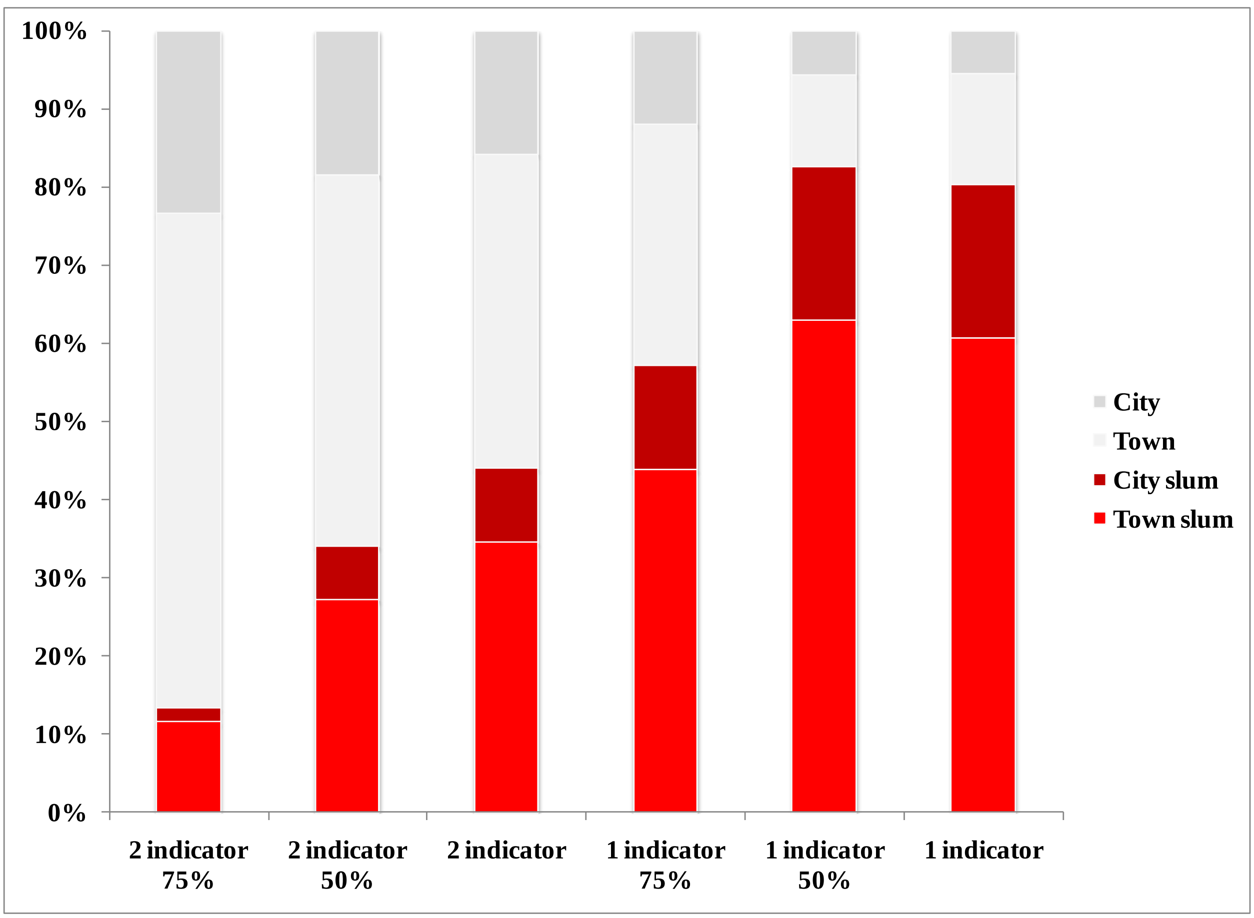
Based on the UN Habitat characteristics listed above, we define a neighborhood (or, to be precise, a cluster) to be a slum if it is located in an urban area and at least 75 percent of households lack at least two of the following characteristics: safe water access, adequate sanitation access, sufficient living space, and solid housing material[2]. The DHS surveys do not collect data on property rights, so that we are unable to address security of tenure as the 5th criterion of slum households as proposed by UN Habitat. While it would have been preferable to include all five UN criteria, security of tenure is extremely hard to define in many developing countries. However, given that all slum measures appear to be highly correlated, adding a fifth dimensions is unlikely to change the classification of households more than marginally.

The use of cluster-level characteristics for the residential coding has important implications for the interpretation of the estimated coefficient on the slum variable. In our definition, households lacking basic facilities but not located in a slum area are hence not defined as slum households. On the other hand, households that are not reported as having poor housing conditions but are

[2] Households are considered without access to safe water if the household does not have access to a private or public pipe, bore hole, or a protected well or spring. Households are defined as being deprived of basic sanitation if they either rely on open defecation or use an unimproved pit latrine. Shared sanitation facilities are considered as basic sanitation if they provide access to a flush toilet or ventilated improved pit latrine. A dwelling is considered as overcrowded if there are more than three persons per habitable room. If the floor material of a house is made of earth, dung, sand or wood its structure is considered inadequate.

located in an area where most other households do lack basic infrastructure are considered as slum households. It is also worth highlighting that our definition is stricter than the UN Habitat's definition in that it requires households to display more than one slum characteristic. The reason for this choice is simply that most households in urban areas of developing countries are deficient of at least one housing characteristic (Günther and Harttgen, 2011), so that a majority of households and neighborhoods would be considered as slums using the standard "one-criterion" cutoff. Similarly, nearly all urban areas would be classified as slums due to the presence of a single household, or small share of households, lacking basic services. Determining a minimum critical threshold for a neighborhood to be defined as slum is not obvious, and as illustrated in Figure 3, results in largely different fraction of neighborhoods being defined as slums.

Figure 3: Prevalence of slum households according to different definitions



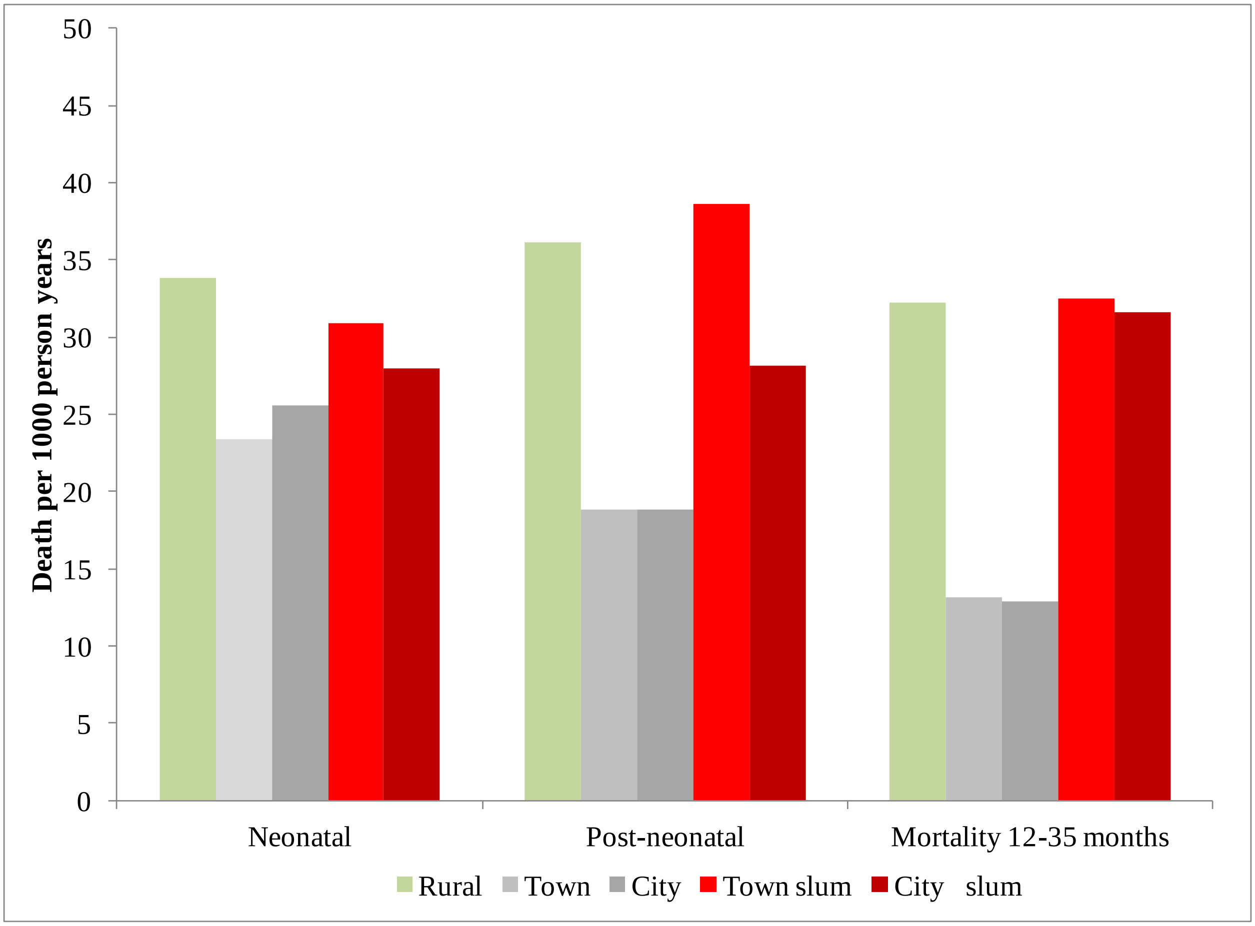
The first column of Figure 3 shows the most restrictive coding, which requires that at least 75 percent of households lack basic services. Under this assumption, 13 percent of urban households are coded as slums. Under a coding rule relying on a simple majority of deprived households (column 2), 34 percent of children would live in areas classified as slums. If a household-based definition was used with 2 indicators, 44 percent of households would be defined as slum households (column 3). If a large majority (75percent) of households lacking only at least one basic facility were the criterion for a slum neighborhood, 56 percent of urban households would be considered slum households (column 4). Last, if the UN-Habit definition of households lacking at least one feature were applied - either at the individual or with a simple majority 50 percent cutoff at the cluster level - more than 80 percent of urban households would be classified as slum households. Since we are mostly interested in the poorest neighborhoods we use the first definition for our preferred empirical specification, and show results for alternative classification rules later in the robustness check section.

Mortality Outcomes

The main objective of this study is to evaluate the effect of living in slums on early child mortality. We differentiate three phases of early childhood mortality. Neonatal mortality is defined as any death occurring during the first month after birth. Post-neonatal mortality covers children's death between the 1^{st} and 12^{th} months of a child's life, and what we call here "early child mortality" covers deaths of children between the ages of 1 and 3 years (between the 12^{th} and 36^{th} months). For all three measures we analyze only children who have completed the relevant exposure period. In order to keep the risk of incorrect residence coding due to mobility to a minimum, we restrict our analysis to mortality that occurs during the 3 years before the respective survey year. For neonatal mortality, we exclude children born in the month of the interview, and focus on children who were born at least one month prior to the survey interview. For post-neonatal mortality, we restrict our analysis to children born at least 12 months prior to the interview, and still alive at the age of one month. Similarly, for early child mortality, we restrict our analysis to children born at least 36 month prior to the interview who did not die before the age of 12 months. Accordingly, our measure of "early child mortality" does not correspond to the standard ${}_4q_1$ measure of the probability of dying between the ages of one and five, but rather reflects the cohort-specific probability of dying between the 12^{th} and 36^{th} months.

Figure 4 summarize the three mortality variables for rural, town, and city, as well as for slum areas. All figures reflect sample averages, and thus represent unweighted estimates across our entire sample. On average, mortality rates for neonatal, post-neonatal and early child periods are 30, 30, and 26 deaths per 1000, respectively. Towns and cities show substantially lower rates for all three mortality rates. The mortality gap between residential areas appears to be smallest for neonatal mortality, and largest for early child mortality.

Figure 4: Child mortality by residence (full sample)



Empirical Model

To investigate the effect of residence on child mortality in more detail we estimate a series of empirical models with an increasing set of control variables. The basic logistic model we estimate can be described as follows:

$$\ln(\frac{p_{ick}}{1-p_{ick}}) = \alpha + \sum_{j=1}^{4} R_j\beta_j + \sum_{k=1}^{71} S_k\delta_k + \varepsilon_{ick}, \qquad (1)$$

where p_{ik} is the probability of death of child i in cluster c and survey k in the interval of interest, α is a generic constant, R_j are indicator variables for town and city residence, as well as for town and city slums. S_k are survey fixed effects to capture country-period or survey fixed factors affecting all children in a given survey.

Since we want to investigate the total effect of slum residence as well as the effect of slum residence conditional on household characteristics, we show a series of empirical estimates: we control for a varying set of child, mother and family structure characteristics, to allow us to identify the mortality differences directly attributable to local living conditions keeping individual and family characteristics constant.

To see how much our mortality estimates are affected by differences in the underlying population, we start by estimating a basic model without additional controls as described in equation (1). In model 2, we add a set of child characteristics, including the child's sex, the child's age, and an indicator of whether the child was one of a multiple birth. In Model 3, we control both for child and for mother characteristics, including mother's age, mother's education and mother's marital status. Last, in model 4, we also add controls for the partner's education, household size, and sex of the household head.

3. Results

Table 1 shows unweighted descriptive statistics for the sample of children used in our analysis. The total sample consists of 510,994 children under the age of 3 observed across 72 surveys in 37 countries. The average age of children in the neonatal death sample is 1.2 years, the average age in the post-neonatal group is 2.1, and the average child in the early child sample is 3.2 years old. The other characteristics look fairly similar across the three subsamples. 49 percent of children are female, and about 2.5 percent of children are multiple births. The average age of mothers is 28.5 years. Mothers' educational attainment is low on average, with only 6.5 percent having pursued higher education, 25 percent having attained some secondary, 31 percent having attained some primary education, and 38 percent of mothers not having received any schooling. Seventy-five percent of mothers are married at the date of the interview, with average education levels of partners only slightly above maternal educational attainment. The average household contains 7.5 members, and 13.4 percent of households are headed by a female. In total, 22,767 deaths under the age of 3 are recorded and analyzed in our sample.

Table 1: Descriptive Statistics

	Neonatal Mortality		Post-neonatal Mortality		Early Child Mortality	
	N=344,984		*N=315,101*		*N=101,694*	
Neonatal mortality, *N (%)*	10,512	(3.0)				
Infant mortality			9,573	(3.0)		
Early child mortality					2,591	(2.5)
Child Characteristics						
Female, *N (%)*	169,101	(49.0)	154,647	(49.1)	49,779	(48.9)
Multiple births, *N (%)*	8,952	(2.6)	7,078	(2.2)	2,126	(2.1)
Child age in yeas, *mean (SD)*	1.12	(0.9)	2.08	(0.9)	3.18	(0.4)
Mother Characteristics						
Age mother, *mean (SD)*	27.77	(6.7)	28.66	(6.7)	29.72	(6.6)
Mother primary education, *N (%)*	107,967	(31.3)	98,460	(31.2)	31,105	(30.6)
Mother secondary education, *N (%)*	87,239	(25.3)	79,008	(25.1)	25,062	(24.6)
Mother tertiary education, *N (%)*	21,469	(6.2)	20,312	(6.4)	6,970	(6.9)
Mother currently married, *N (%)*	258,898	(75.0)	236,728	(75.1)	76,380	(75.1)
Family Characteristics						
Partner primary education, *N (%)*	91,625	(26.6)	85,291	(27.1)	27,575	(27.1)
Partner secondary education, *N (%)*	99,776	(28.9)	90,889	(28.8)	29,129	(28.6)
Partner tertiary education, *N (%)*	29,718	(8.6)	28,078	(8.9)	9,533	(9.4)
Household size, *mean (SD)*	7.43	(4.5)	7.42	(4.5)	7.54	(4.5)
Household head female, *N (%)*	46,686	(13.5)	42,397	(13.5)	13,386	(13.2)

Residential Differences in Mortality

Tables 2-4 show the main results (as odd ratios) for the three mortality variables of interest as well as for the four empirical models described in the previous section. Three main findings emerge from these tables. First, the protective effects of town and city residence are large and statistically significant at all standard confidence intervals. Once we fully control for child, mother and household structure (column 4), we find that urban residence substantially lowers the odds of neonatal, post-neonatal and early child mortality relative to rural. On average, urban children faces 25-35 percent lower odds of mortality, with the largest effect for early child mortality in cities: an estimated odds ratio of 0.554 suggests that all else equal, children living in large cities faces 44.6 percent lower odds of dying between age 12 and 36 months. As already suggested by Figure 2, the protective effect of living in urban areas appears smallest for neonatal mortality with estimated protective effects of 13.6 (town) and 14.7 (city) percent, respectively.

Second, and most importantly for the question raised in this paper, we find that children in slums have mortality risks that are not statistically significantly different from those of children in rural areas, but are in general much higher than those of non-slum urban children. While the point estimates reported in Tables 2 and 3 suggest that slum residents fare on average slightly better than rural residents for neonatal as well as post-neonatal mortality we cannot reject the null that mortality in these areas does not differ from mortality in rural areas once a full set of controls is added. Taking all three age brackets together, the overall risks faced by urban slum dwellers appear to be largely the same as the risks faced by children growing up in rural areas.

With respect to different model specifications, maternal education appears to be the main confounder in the unconditional comparisons between urban and rural, as well as between urban non-slum and slum areas. A basic comparison of the odds ratios presented in columns 2 and 3 of Tables 2-4 suggests that controlling for maternal characteristics reduces the observed odds ratios by 10-20 percent across all three age brackets. These differences appear to be mostly driven by differences in maternal education. On average, 48 percent of mothers in rural areas have less than primary education, while the same is true only for 18 percent of women in towns, and 19 percent of women in cities. In the sample analyzed, educational attainment of slum dwellers lies nearly perfectly in between these two groups, with 34 percent (35 percent) of mothers living in town slums (city slums) with less than primary education. Hence, controlling for mothers' education, which is higher in both urban non-slum and slum areas than in rural areas, the urban mortality advantage decreases (in relation to rural areas), but, as Tables 2-4 suggest, does not disappear.

Table 2: Neonatal Mortality

Dependent :	Probability of Death During First Month of Life			
	(1)	(2)	(3)	(4)
Town	0.784***	0.778***	0.859***	0.864***
	(0.0257)	(0.0256)	(0.0286)	(0.0290)
City	0.762***	0.764***	0.860***	0.853***
	(0.0352)	(0.0355)	(0.0409)	(0.0407)
Town slum	0.920	0.916*	0.943	0.957
	(0.0489)	(0.0486)	(0.0501)	(0.0507)
City slum	0.801*	0.795*	0.819	0.811
	(0.102)	(0.103)	(0.107)	(0.106)
Survey fixed effects	Yes	Yes	Yes	Yes
Child controls	No	Yes	Yes	Yes
Mother controls	No	No	Yes	Yes
Household controls	No	No	No	Yes
Observations	344984	344984	344984	344984

Notes: Robust z-statistics in parentheses are clustered at the country-cluster level.

Table 3: Post-neonatal Mortality

Dependent :	Probability of Death Month 1-11			
	(1)	(2)	(3)	(4)
Town	0.640***	0.638***	0.762***	0.787***
	(0.0221)	(0.0220)	(0.0270)	(0.0282)
City	0.550***	0.552***	0.678***	0.694***
	(0.0281)	(0.0282)	(0.0351)	(0.0361)
Town slum	0.989	0.984	1.034	1.065
	(0.0485)	(0.0481)	(0.0507)	(0.0522)
City slum	0.805	0.811	0.869	0.877
	(0.116)	(0.118)	(0.124)	(0.125)
Survey fixed effects	Yes	Yes	Yes	Yes
Child controls	No	Yes	Yes	Yes
Mother controls	No	No	Yes	Yes
Household controls	No	No	No	Yes
Observations	315101	315101	315101	315101

Notes: Robust z-statistics in parentheses are clustered at the country-cluster level

Table 4: Early Child Mortality (Months 12-35)

Dependent :	**Probability of Death Age 12-35 Months**			
	(1)	(2)	(3)	(4)
Town	0.576***	0.576***	0.695***	0.709***
	(0.0375)	(0.0375)	(0.0469)	(0.0482)
City	0.439***	0.441***	0.545***	0.554***
	(0.0464)	(0.0467)	(0.0582)	(0.0594)
Town slum	0.974	0.971	1.024	1.042
	(0.0902)	(0.0898)	(0.0952)	(0.0974)
City slum	0.924	0.920	0.981	0.979
	(0.230)	(0.231)	(0.242)	(0.244)
Survey fixed effects	Yes	Yes	Yes	Yes
Child controls	No	Yes	Yes	Yes
Mother controls	No	No	Yes	Yes
Household controls	No	No	No	Yes
Observations	101694	101694	101694	101694

Notes: Robust z-statistics in parentheses are clustered at the country-cluster level. 760 observations are perfectly predicted by the covariates and dropped from analysis.

Robustness Checks

One of the main challenges faced during the data coding for this study was the proper classification of households into residential categories. As discussed in section 2, in some surveys classification of urban households into “town” or “city” residence was not obvious, raising concerns regarding the quality of the coding as well as the potential biases induced by measurement error. To ensure that this type of measurement error does not affect our main results, we have run a series of auxiliary regressions, where we re-estimate column 4 of Tables 2-4 for a subsample of surveys where the urban coding is unambiguous. The comparison of columns 1-3 (full sample) with columns 4-6 (high quality sample) of Table 5 shows that no major differences between the full and the restricted (high-quality) sample can be detected. The only notable change is a slightly lower odds-ration for neonatal mortality in town slums; however, the difference between the estimated coefficients in columns 1 and 4 is however not significantly different from zero at standard confidence intervals.

Table 5: Robustness Check 1: Urban Coding Quality

	Full Sample			High Quality Coding Sample		
Dependent	Neonatal	Post-neonatal	Early Child Mortality	Neonatal	Post-neonatal	Early Child Mortality
	(1)	(2)	(3)	(4)	(5)	(6)
Town	0.864***	0.787***	0.709***	0.850***	0.788***	0.760***
	(0.0290)	(0.0282)	(0.0482)	(0.0349)	(0.0316)	(0.0601)
City	0.853***	0.694***	0.554***	0.859***	0.685***	0.591***
	(0.0407)	(0.0361)	(0.0594)	(0.0503)	(0.0407)	(0.0681)
Town slum	0.957	1.065	1.042	0.883**	1.068	1.141
	(0.0507)	(0.0522)	(0.0974)	(0.0527)	(0.0564)	(0.114)
City slum	0.811	0.877	0.979	0.836	0.745	0.885
	(0.106)	(0.125)	(0.244)	(0.130)	(0.135)	(0.265)
Observations	344984	315101	101694	257090	231068	71439

Notes: All specifications include a complete set of child, mother and household characteristics as well survey fixed effects. Robust z-statistics in parentheses are clustered at the country-cluster level. The sample used in columns 4-6 exclude Brazil, Colombia, Egypt, India, Jordan, Morocco, Nigeria, Pakistan, South Africa, Turkey, Ukraine and Yemen.

To address any concerns with regard to the validity of our slum definition, we compare our main results to a set of regression estimates based on the much wider household-based slum definition suggested by UN Habitat in Table 6. Similar to the structure in Table 5, we show the results from our preferred specification in columns 1-3 of Table 6, and then show the results based on the alternative model in columns 4-6. While the estimated coefficients continue to highlight a general urban mortality advantage, the results for slums change under the UN Habitat definition, suggesting a substantial and statistically significant mortality gap in favor of urban slum dwellers relative to their rural counterpart for infant and post-neonatal mortality. It is important to stress here that these estimates cannot be directly compares. Given that 80 percent of urban children are considered slum dwellers under this definition as illustrated in Figure 3, the results displayed in columns 4-6 of Table 6 simply show that i) the average urban child fares betters than the average rural child, and that ii) the top quintile of urban children (those not classified as slums) fare better than the rest of urban children only with respect to post-neonatal and early child mortality.

Table 6: Robustness Check 2: Relevance of Slum Definition

	Cluster Definition			UN Habitat Definition		
Dependent	Neonatal	Post-neonatal	Early Child Mortality	Neonatal	Post-neonatal	Early Child Mortality
	(1)	(2)	(3)	(4)	(5)	(6)
Town	0.864***	0.787***	0.709***	1.025	0.741***	0.686***
	(0.0290)	(0.0282)	(0.0482)	(0.0655)	(0.0577)	(0.0629)
City	0.853***	0.694***	0.554***	0.923	0.682***	0.615**
	(0.0407)	(0.0361)	(0.0594)	(0.0900)	(0.0728)	(0.129)
Town slum	0.957	1.065	1.042	0.859***	0.872***	1.064
	(0.0507)	(0.0522)	(0.0974)	(0.0265)	(0.0269)	(0.0837)
City slum	0.811	0.877	0.979	0.841***	0.717***	0.611***
	(0.106)	(0.125)	(0.244)	(0.0404)	(0.0380)	(0.0667)
Observations	344984	315101	101694	344935	314926	101488

Notes: All specifications include a complete set of child, mother and household characteristics as well survey fixed effects. Robust z-statistics in parentheses.

Mortality Transitions

In order to investigate changes in childhood mortality by residence over time, we divide our sample into observations pre- and post 2000, and repeat the regressions displayed in Tables 2-4 interacting the residential indicators with a dummy variable which marks observations based on surveys conducted in 2000 or later. We carry out this analysis using both ordinary least squares regression (OLS) to show absolute differences in mortality probabilities and using logistic regression to estimate relative change (odds ratios). In order to avoid compositional bias, we restrict our analysis to countries with at least one survey before 2000 and after 2000, and include country fixed effects in all of our specifications[3]. Table 7 shows the results of this estimation: the first three columns show results using standard OLS models; columns 4-6 show odds ratios estimated in standard logistic models.

The most striking result emerging from Table 7 is the rather remarkable progress in child mortality: made between the 1990s and early 2000s. The estimated coefficient on the post-indicator suggests that on average neonatal, post-neonatal and child mortality declined by 8, 15

[3] In order to be able to estimate pre-post differences, survey-fixed effects cannot be included in the empirical model.

and 18 deaths per 1000 children in rural areas (columns 1-3), which translates into 23, 35 and 47 percent lower odds of death in the respective age groups. Urban children appear to have on average experienced slightly smaller improvements relative to rural children with respect to post-neonatal mortality. Estimated coefficients of 0.005 and 0.007 suggest that urban areas experienced approximately only half the mortality improvements experienced by rural children in this age range. Town slums appear to have improved more than rural areas with respect to early child mortality; no such patterns can be detected for the two other mortality categories as well as for city slums, suggesting that overall the improvements in mortality experienced in slum is fairly similar to the improvements seen in rural areas, and slightly above the improvements in urban areas. In terms of relative improvement, the differences across residential areas appear even smaller, with all areas experiencing unconditional improvements in mortality rates of approximately 20 percent relative to the pre 2000 period.

Table 7: Changes in Mortality 1990s-2000s

Model	**Absolute Changes (OLS)**			**Relative Changes (Logistic Model, Odds-Ratios)**		
Dependent	Neonatal	Post-neonatal	Early Child Mortality	Neonatal	Post-neonatal	Early Child Mortality
	(1)	(2)	(3)	(4)	(5)	(6)
Town	-0.00632***	-0.00827***	-0.0104***	0.794***	0.810***	0.740**
	(0.00145)	(0.00162)	(0.00269)	(0.0472)	(0.0503)	(0.0891)
City	-0.00382	-0.0122***	-0.0128***	0.893	0.712***	0.699**
	(0.00244)	(0.00228)	(0.00410)	(0.0840)	(0.0664)	(0.119)
Town slum	-0.00437*	0.00297	0.0109*	0.863*	1.075	1.396**
	(0.00233)	(0.00301)	(0.00567)	(0.0695)	(0.0750)	(0.195)
City slum	-0.00430	-0.00595	-0.00325	0.857	0.874	0.871
	(0.00630)	(0.00774)	(0.0159)	(0.194)	(0.192)	(0.354)
Post	-0.00751***	-0.0148***	-0.0176***	0.772***	0.645***	0.525***
	(0.00109)	(0.00125)	(0.00234)	(0.0275)	(0.0228)	(0.0382)
Town x post	0.00252	0.00509***	0.00447	1.070	0.982	0.907
	(0.00181)	(0.00190)	(0.00307)	(0.0828)	(0.0828)	(0.137)
City x post	-0.000432	0.00680**	-0.00306	0.961	1.180	0.706
	(0.00345)	(0.00341)	(0.00523)	(0.133)	(0.169)	(0.190)
Town slum x post	0.00415	-0.00459	-0.0186***	1.170	0.901	0.565***
	(0.00370)	(0.00414)	(0.00713)	(0.150)	(0.106)	(0.117)
City slum x post	-0.00112	0.00810	0.00666	0.996	1.279	1.372
	(0.0100)	(0.0125)	(0.0255)	(0.368)	(0.479)	(0.856)
Observations	221,109	202,146	65,386	221,109	202,146	65,386
R-squared	0.020	0.015	0.025			

Notes: All specifications include a complete set of child, mother and household characteristics as well country fixed effects. Robust standard errors in parenthesis are clustered at the sample cluster level. Countries analyzed are Bangladesh, Dominican Republic, Ghana, Haiti, Jordan, Kenya, Madagascar, Mali, Niger, Nigeria, Peru, Philippines, Senegal, Uganda, Vietnam, Zambia, Zimbabwe.

4. Discussion and Conclusion

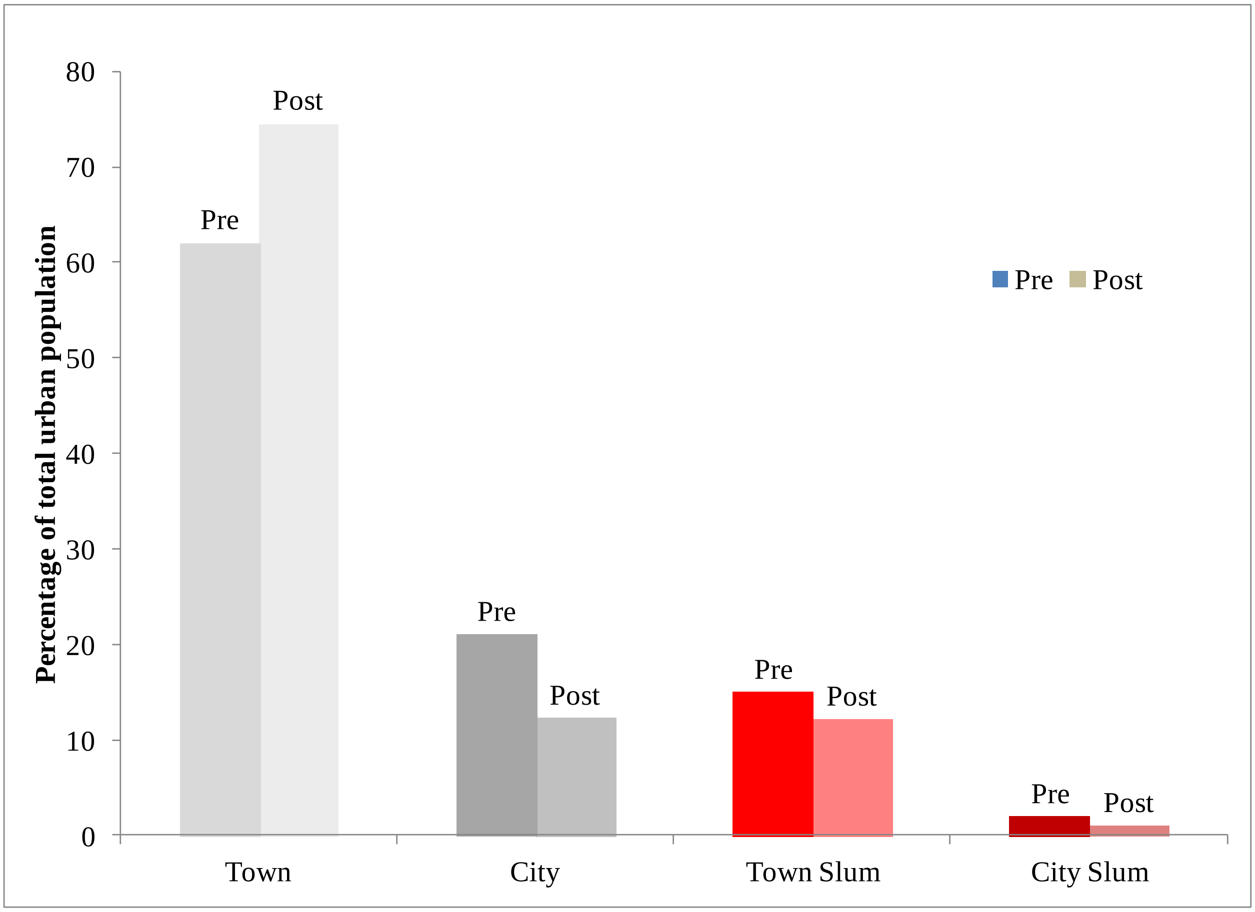
The results presented in the previous section of this paper demonstrate that children in non-slum urban settlements experience up to 15 percent lower odds of neonatal, 30 percent lower odds of post-neonatal, and up to 45 percent lower odds of early child mortality compared to children in rural areas, but that no systematic mortality differences exist between rural children and children residing in the most deprived slum neighborhoods. Moreover, child mortality changes over time do not seem to appear slower in urban slum areas than among rural households. Given the rapid pace of urbanization observed over the past decades in developing countries (Bloom, Canning et al. 2010), this raises the question of how urbanization in general, and the formation of urban slums in particular, have affected mortality rates and changes at the country level.

In order to provide some sense of how big a shift in the population distribution occurred over the sample period, we use data from the World Population Prospect (UN, 2010) to compute the fraction of the population living in urban areas. Restricting the data to our sample of 37 countries, we find that the fraction of the population living in areas classified as urban increased from 35.6 to 40.3 percent between the 1990 and the 2005.

Given the overall urban mortality advantages documented in Tables 2-5, the conclusion that the overall changes in residential distribution has been accelerating, rather than slowing down the mortality transition appears tempting. This conclusion, however, is only true if most, or at least some, of the urban growth occurred in the better-off urban areas rather than in the slum areas more similar in terms of child mortality to rural areas.

To investigate this, we plot the division of the urban population in our sample before and after 2000 in Figure 6 below. To make sure the observed patterns do not reflect differences in sample composition, we restrict this comparison to countries with at least one survey pre, and one survey post 2000 (the results look highly similar without this restriction). As the Figure shows, there is no evidence of particularly large growth in slum areas; on average, the percentage of town slum residents declined from 15.0 to 12.2 percent, while the percentage of urban residents residing in city slums declined from 1.9 to 1.1 percent. Overall, this suggests that urban growth is not particularly strong in slum areas, but, if anything most pronounced in small urban centers.

Figure 6: Urban Trends: Pre and Post 2000



5. Conclusions

In this paper, we have analyzed the relation between child mortality and type of place of residence across 37 low and middle income countries. We have shown that the average childhood mortality gap between rural and urban places remains sizeable, with urban children experiencing on average about 25 percent lower odds of death in the first three years of life relative to their rural counterparts. The same differences do not, however, apply to urban slum areas, where we find mortality levels generally very similar to those observed in rural areas. We also analyzed the changes in relative mortality over time. The overall improvements in child mortality over the past 10 years are rather remarkable and the average mortality gap across the residential areas analyzed in this paper does not appear to have changed much. Given the rapid pace of urbanization experienced in most developing countries, this suggests that the overall shifts in residential distribution has contributed and will continue to contribute positively to the overall mortality transitions. While the existence of slums implies large mortality differentials within cities, their overall effect on the mortality transition is likely to be small.

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Appendix 1: Countries and Urban 1 Mill. Agglomerations

Country	**Year(s)**	**Urban Agglomerations above 1 Mill. Inhabitants in 2000**
Azerbaijan	2006	Baku
Bangladesh	1993, 2008	Chittagong, Dhaka Khulna
Bolivia	1993, 1998	La Pay, Santa Cruz
Brazil	1991, 1996	20 cities
Burkina Faso	1992, 1998	Ouagadougou
Cameroon	1991, 1998	Douala, Yaounde
Colombia	1990, 1995	Barrangquilla, Bogota, Bucaramanga, Cali, Medellin
Cote d'Ivoire	1994, 1998	Abidjan
Dominican Rep.	1991, 1996, 2007	Santo Domingo
Egypt, Arab Rep.	1992, 1995	Cairo, Alexandria
Ghana	1993, 1998, 2008	Accra, Kumasi
Guinea	1999	Conakry
Haiti	1994, 2005	Port-au-Prince
India	2005	43 cities
Jordan	1997, 2007	Amman
Kazakhstan	1995	Almaty
Kenya	1993, 1998, 2008	Nairobi
Madagascar	1992, 1997, 2008	Antananarivo
Mali	1995, 2006	Bamako
Morocco	1992	Casablanca, Fes, Rabat
Mozambique	1997	Maputo
Niger	1992, 1998, 2006	Niamey
Nigeria	1999, 2008	Abuja, Benin City, Ibadan Kaduna, Kano, Lagos, Ogbomosho, Port Harcourt
Pakistan	2006	Faisalabad, Gujranwala, Hyderabad, Karachi, Lahore, Multan, Peshawar, Rawalpindi
Peru	1991, 1996, 2003	Lima
Philippines	1993, 1998, 2008	Davao, Manila
Senegal	1992, 1997, 2006, 2008	Dakar
South Africa	1998	Cape Town, Durban, East Rand, Johannesburg, Port Elizabeth, Pretoria, Vereeniging
Togo	1998	Lome
Turkey	1993, 1998	Adana, Ankara, Bursa, Gaziantep, Istanbul, Izmir
Uganda	1995, 2006	Kampala
Ukraine	2007	Dnipropetrovsk, Kharkiv, Kiev, Odesa
Uzbekistan	1996	Tashkent
Vietnam	1997, 2000	Ha Noi, Hai Phong,Ho Chi Minh City
Yemen, Rep.	1991	Sanaa

Zambia	1992, 1996, 2007	Lusaka
Zimbabwe	1994, 2005	Harare

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat; World Population Prospects: The 2008 Revision; World Urbanization Prospects: The 2009 Revision