# Age-specific sex ratios: Examining rural-urban variation within low- and middle-income countries

**Rural/urban sex ratios by age**

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**Abstract**

The balance of men and women in society, captured by sex ratios, determines key social and demographic phenomena. Previous research has mostly explored sex ratios at birth and till age five at the national level, while we address rural/urban gaps in sex ratios for all ages. Our measures build on United Nations data on separate rural and urban population counts by age and sex for 112 low- and middle-income countries for 2015. We show that rural sex ratios are higher than urban sex ratios among children and the elderly. Urban sex ratios are predominantly male among the working-ages. Our analysis suggests that the urban transition itself is not driving the gap in rural/urban sex ratios. Rather, internal migration seems to be key in shaping rural/urban sex ratio divergence across the two sectors in sub-Saharan Africa, while both internal migration and mortality differentials appear to be the predominant mechanisms driving sex ratio gaps in Latin America.

**Keywords**

sex ratios, rural, urban, urbanisation, internal migration, mortality

**Introduction**

The ratio of men to women in a population, defined as the population sex ratio, is simultaneously both an outcome and cause of key biological, cultural, social and policy features

of all societies. The effect of population sex ratios may operate through both direct or more diffuse pathways. For example, relatively direct effects are observed where a relative shortage of reproductive-age women in the population may lead to a fall in fertility levels (Lutz et al. 2006). More indirectly, a relative abundance of young men can lead to higher tendencies for crime and disorder (Dyson 2012).

Higher population sex ratios – where men outnumber women – tend to be sustained power structures that limit women's opportunities, choices and freedoms (Miller 2001; Guilmoto 2009; Poston and Zhang 2009; Das Gupta 2010; Murphy et al. 2011). Thus, higher proportions of men contribute to maintaining male dominance within societies (Grossbard and Amuedo-Dorantes 2007). Conversely, low population sex ratios – where women outnumber men – can increase opportunities for women, providing avenues for their participation in the labour force. Thus, male conscription during WWII led to relative shortages of men and contributed to women penetrating new segments of the labour market (Schweitzer 1980; Milkman 1987). Typically, imbalanced sex ratios, whether low or high, make marriage partners harder to find, challenging traditional relationship types and even creating social adaptations and pressures for marital assimilation (Angrist 2002; Weiss and Stecklov 2020). Spatial imbalances in sex ratios within countries limit marriage opportunities and may stimulate

marriage migration by pushing people to migrate to regions with more balanced sex ratios (Watts 1984; Fan and Huang 1998; Mukherjee 2013).

Substantial research literature has documented variation in sex ratios as well as central sources of this variability (Teitelbaum 1970; Das Gupta 1987; Sen 1992; Ulizzi and Zonta 1995; Oster 2009; Guilmoto 2009; Anderson and Ray 2010). Yet much of the empirical focus has relied on national evidence to document exceptional levels of sex ratios either over time or across countries. One exception is child sex ratios, which have been shown to vary dramatically across states within India and China (Visaria 2007; Das Gupta 2010). Here, our primary aim is in understanding the variation of sex ratios over different ages of the life course – not just at the youngest ages – *within* countries. We focus on the sex ratios gaps across the urban and rural divide. Little is known about the extent and potential significance of the gap in age-specific sex ratios across rural and urban sectors of a country. However, with urbanisation still underway in many low- and middle-income countries (LMICs) (United Nations 2018), it is important to gauge the extent of rural/urban differences in sex ratios over the urban transition. Furthermore, while rural populations have shrunk in high income countries (HICs), over 80% of the world's population resides in LMICs, and only half of the population of these countries lives in urban areas (United Nations 2018). Understanding within country diversity in sex ratios in these

regions could be consequential for understanding their future social, demographic and economic development.

There are complex interactions between rural and urban populations at different levels of urbanization that play a key role for understanding how rural and urban sex ratios vary. This further means that rural/urban sex ratios are shaped by the differing pace of the demographic transition as it interacts with the urban transition (Dyson 2011; Menashe-Oren and Stecklov 2018). For example, since fertility decline typically commences first in the urban sector and technology will tend to become available at an earlier stage in cities, existing gender preferences will tend to be more pronounced in cities where parents aim to achieve their desired family composition with smaller family sizes (Guilmoto 2009). At this early stage of transition, rural to urban migration is also expected to be at its highest (Zelinsky 1971). These intertwined mechanisms determining sex ratios have diverse effects that complicate efforts to clearly identify whether each determinant, which we outline below, will expand or contract the gaps between rural and urban sex ratios. Considering this, we explore rural and urban sex ratios in LMICs and examine whether there are systematic patterns that can be identified in the relationship between rural and urban sex ratios and urbanisation levels.

*Rural and Urban Age-Specific Sex Ratio Determinants*

We consider the various determinants of sex ratios at different ages, and variation in these factors between sectors. Three principal factors determine sex ratios in any age group: sex ratios at birth, sex differences in age-specific mortality leading up to this age group, and male and female net migration (Coale 1991). Moreover, just as past sex ratios impact today's ratios, future sex ratios will be likewise determined by today's patterns of sex ratios. For example, sex ratios at age 20 will depend on sex ratios at birth 20 years ago, as well as on sex differences in mortality and migration at each age up to age 20. At the national level, sex ratios at birth are normally around 105 males to 100 females, though in sub-Saharan Africa they are slightly lower (Tafuro and Guilmoto 2020; Marco-Gracia and Fourie 2021). In the absence of sex differentials in mortality and migration, this ratio is expected to continue over the life-course. While this is evident at the national level, internal variation in sex ratios is further compounded: when any of these three determinants differ by rural/urban sector, at any point in time, the current and future gap between the rural and urban sex ratios will be affected. Below, we outline how potential mechanisms would lead to diverse effects of these determinants *across* rural and urban sectors.

The first factor, sex ratios at birth, is determined by biological components including parity, voluntary and spontaneous abortions and stillbirths, probability of male conception and

mother's age (Guilmoto 2012). Stillbirths are reported to be more common in the urban sector in some countries (Aminu et al. 2014), and mothers tend to be younger in the rural sector (Shapiro and Gebreselassie 2008), but overall biologically determined sex ratio differences at birth between rural/urban sectors should be modest. However, sex ratios at birth can be strongly affected by son preference, rising from patrilineal kinship systems (Bélanger 2002; Das Gupta 2010;). This preference may be particularly important in relation to land inheritance in the rural sector, where agriculture is the main livelihood (Tafuro 2020). Stronger preference for boys is also noted in higher parity births (Pebley and Amin 1991; Muhuri and Preston 1991; Das Gupta 2005; Chung and Das Gupta 2007), suggesting that rural sex ratios at birth could be higher since fertility is higher in the rural sector (Shapiro and Tambashe 1999; Lerch 2017; Garenne 2017). On the other hand, lower fertility in the urban sector puts pressure to achieve desired family sex structure with fewer children. The availability of technologically-based prenatal sex determination, such as ultrasounds, are more widely available in urban areas (Jha et al. 2006; Guilmoto et al. 2009; Chen et al. 2013; Frost et al. 2013; Madan and Breuning 2014), allowing for sex discriminating abortions (Goodkind 1996; Arnold et al. 2002), and subsequently higher sex ratios.

The second factor determining sex ratios, sex-specific mortality, vary across stages of the life course. Among children, son preference may be manifested through the biased allocation of

resources such as vaccinations and nutritious meals (Pande 2003; Mishra et al. 2004; United Nations 2011). Given that resources are typically scarcer and fertility higher in the rural sector, limited resources may need to be stretched between children making gender preferences more perceptible among rural children. Among youth and young adults, evidence suggests that males tend to take more risks and die from injuries (Heligman and Pollard 1980; Wilson and Daly 1985; Hannerz 2001; Goldstein 2011), though the "accident hump" is less obvious in LMICs (Tabutin and Masquelier 2015). From this perspective, sex ratios should be lower in the urban sector, where violence, accidents and alcohol consumption are more common (Kishore et al. 1999; Dunsire and Baldwin 1999; Khorashadi et al. 2005; Erskine et al. 2010). An opposite effect might be expected due to the fact that young adult women are exposed to maternal mortality, especially in LMICs, and these should lead to high sex ratios in the rural sector where fertility is higher and access to health facilities more limited (Patton et al. 2009; Hogan et al. 2010; Liang et al. 2011). Finally, in older ages, higher mortality is seen in men (Wingard et al. 1989; Oksuzyan et al. 2008; Rogers et al. 2010), but there is relatively little available evidence to predict strong rural or urban differences in sex-specific old age mortality.

The third factor, migration, probably has its greatest effect on rural/urban sex ratios among young adults who make up the majority of migrants (Rogers and Castro 1981). Where male international migration flows dominate they will lower urban sex ratios in country of origin

since migration is more likely from the urban sector (Bocquier 2004; Liu 2013). Urban sex ratios in destination countries will tend to increase unless migration flows are occupation specific, like miners or farmers, which would raise sex ratios in rural areas. Predominantly young adult female international migration, exemplified by the care-givers from the Philippines (Hofmann and Buckley 2013; Cortes 2015), often originate in urban areas and would tend to increase urban sex ratios at origin and lower them at destination.

Internal migration flows are likely to drive particularly sharp imbalances in within country gaps in sex ratios for working age adults. This is because internal migration flows account for the majority of movement globally (Deshingkar and Grimm 2005; Skeldon 2008). Furthermore, if internal flows are biased by sex then outflows from one sector will have an opposite and polarizing impact on sex ratios in the other sector. Finally, internal migration rates between rural and urban sectors shift in intensity and direction over the course of urbanisation and the mobility transition (Zelinsky 1971). Initially when populations are predominantly rural, movement is principally from the countryside to towns and cities. In urbanised societies, rural to urban migration continues, though at a reduced level, while intra-urban movement is vigorous. Migration from the rural to urban sector is the primary direction of flow that will determine sex ratios in both sectors. Like international migration, rural to urban migration peaks in young adult age groups, as they often move for life-course transitions including education, marriage

and entry into the labour force (Montgomery et al. 2003; Rogers et al. 2005; Raymer and Rogers 2006; Bernard et al. 2014). Hence, the effects of internal migration on sex ratios is most perceptible during those ages. Rural to urban migration is *typically* dominated by male flows (Montgomery et al. 2003; Menashe-Oren and Stecklov 2018). In sub-Saharan Africa, labour markets built on the legacy of colonial policies have driven internal migration of men, though there is also evidence of increased independent female rural-urban migration related to schooling or employment that may work to counter the imbalance in rural and urban sex ratios resulting from male migration (Gugler and Ludwar-Ene 1995; Adepoju 2002; Beauchemin 2011; Awumbila 2015).

Ultimately, the mechanisms shaping rural/urban sex ratios are complex and intertwined though our descriptive analyses contribute to understanding these processes. We supplement our analysis of sector-specific sex ratios over the urban transition by examining age- and sex-specific internal migration and mortality patterns, as key proximate determinants of rural/urban sex ratios.

## Data and Methodology

*Data on Rural and Urban Populations*

We use the most recent available data on urban and rural population by age and sex (URPAS) produced by the United Nations (UN) Population Division. The URPAS data are compiled using national population censuses (both samples and full count) and population registers, and undergo thorough evaluation before UN publication. Thirty-nine percent of countries in the URPAS data had no data available by age and sex requiring imputation of sub-regional proportions by age and sex on the basis of countries with available data. While many countries lacking rural and urban population data by age and sex are LMICs, the list also includes European states such as Italy and Germany. Overall, nearly a third of the countries without such data are in Africa, while 45% are very small countries or islands, and disaggregated data is also not available for China. We test for sensitivity of our results by excluding countries for which data was imputed and find marginal differences (see Figure A1 in Appendix). The population within each rural/urban sector are computed over five year periods between 1980-2015, to reflect the national data source, while also guaranteeing that the total estimates are consistent with the UN World Urbanisation Prospects (WUP) aggregates and the UN World Population Prospects (WPP) by sex and age (United Nations 2014a).

We use the URPAS data for 112 low- and middle-income countries with populations over 400,000 in 2015 to estimate rural/urban differentials in sex ratios by five-year age groups. It is important to note that the URPAS data are based on each country's own definition of "urban", making cross-national comparisons and regional aggregations fairly limited (Buettner 2014; Cohen 2004; Satterthwaite 2010). Generally, three criteria are used to define settlements as urban. The first is a population threshold, such as localities with over 5,000 residents as in Jordan and Mali. The second is an administrative definition, for instance centres of all districts, as in Malawi and Togo. The third criterion is based on functionality, such as services of piped water, electricity and waste removal being provided by a local council, as used in South Africa. Often, a combination of these criteria are used in defining urban. For example, in Vietnam a settlement is urban is it has a population of at least 2,000 and over half of them work outside of agriculture. While these definitions are quite disparate, they reflect the context of each country (United Nations 2014b). In other words, the meaning of urban has the advantage of reflecting the nature of what is considered urban within each country (Potts 2017). We do not (and cannot) standardise the sex ratios to a universal definition.

According to the URPAS data, less than a quarter of countries across all regions in 2015 have urban proportions below 30% and just under a third of countries are over 60% urban. South-east Africa is the least urban region of the world (34% urban) and Latin American and

Caribbean the most urban (68%). At the national level, the 2015 urbanisation levels range from 8% in Trinidad and Tobago to 98% in Guadeloupe. The urban proportions have shifted notably over time: the percentage of countries across all regions that fall below 30% urban having declined from 31% in 1980 to 21% by 2015. We focus on 2015, the most recent and policy relevant data. Comparisons between 2015 and 1980 using age-standardised rural and urban sex ratio do not suggest systematic shifts in rural/urban sex ratios over this 35-year period (see Appendix Figure A2).

*Methods for Comparison of Rural-Urban Sex Ratio Gaps across Countries*

Sex ratios are our principle instrument for exploring variation in age- and sex- specific patterns across rural and urban sectors. Sex ratios are measured as the ratio of men to women, calculated separately for each five-year age group by rural/urban sector. A ratio above one indicates more men than women. Given our focus on countries as units of analysis, mean sex ratios are not weighted by national population size. We also use age-standardised sex ratios to adjust for variability in age structures across sectors and countries in a given period. In standardising the sex ratios, we adopt the convention of using the mean population composition (of all LMICs included in our sample, unweighted) as a standard age structure (Preston et al. 2001). We tested our findings for sensitivity to the choice of standard. We found

that whether we used the mean HIC age structure (reflecting an older population) or the mean age structure of sub-Saharan Africa (reflecting a younger population) had little qualitative impact on our main results. Comparison of the standardised sex ratios and non-standardised total sex ratios (Appendix Figure A3) suggests standardisation has a relatively minor effect – but offers a convenient approach to account for variation in age structures.

We use the URPAS data to examine the sex ratios for the rural and urban sectors and consider how differences shift over age. We are limited to cross-sectional analysis of sex ratios, rather than longitudinal, which would be more suited for a life-course perspective. However, while we address sex ratios at all ages, we do not follow sex ratios of cohorts. A cohort analysis would require detailed data following cohorts or individual level data for a much longer time frame than is available. Considering that individuals may move between sectors (or emigrate), a cohort perspective could help tease out the contribution of migration to rural/urban sex ratio differences. With the period data we have, we examine variability in rural and urban sex ratios within each age category while considering regional diversity. We then explore if and how rural and urban sex ratio differences vary by regions and consider the role of urbanization in these patterns. For this part of the analysis we rely on visualisation, considering our sample is small (112 countries), by using scatterplots of sex ratios by proportions urban, and differentiating between regions. These plots also include linear fitted lines, to assist in describing trends.

*Methods for the Estimation of Sex Ratio Determinants: Internal Migration and Mortality*

A final step in our analysis examines the relationship between two of the four primary factors determining rural and urban sex ratios: rural/urban age- and sex-specific mortality, and age- and sex-specific internal migration flows. We do not examine the role of sex ratios at birth since variation between sex ratios of 0-4 year olds (a crude proxy for sex ratios at birth) are quite small between the sectors and rather stable over time (see Appendix Figure A4), and to our knowledge there is no systematic data available on sex ratios at birth by rural/urban sector across LMICs.

We also do not examine the role of international migration, although we do believe separate efforts in this direction would be valued. There are three principal explanations for why we do not include international migration flows in this analysis. The most important is that available age-and sex-specific data by rural/urban sector (mostly from censuses) captures immigration information, if at all, and rarely emigration. It is common to capture immigration through data on foreign birth places, but this means we cannot estimate age-specific patterns without overly courageous assumptions. Because censuses are only collected periodically, we would be highly limited in what countries could be examined in 2015. In addition, we expect that the net effect of international migration will be modest in comparison to internal migration both because a relatively small proportion of roughly 0.6% of the world's population crosses national borders (Abel and Sander 2014) as well as because these migrants may end up in either rural or urban environments.

Net migration flows capture the balance of in- and out-migration (whether aggregated or by age) and therefore are useful in evaluating where more men or women move to/from overall. Net internal migration is estimated with the URPAS data using the residual method (also known as the census survival ratio method) (Preston 1979), with some modifications (Menashe-Oren and Stecklov 2018). Migration is estimated by comparing sector-specific populations between two periods of time (five years in our data), with predicted populations in the later period based on the assumption of 25% higher rural mortality. Earlier testing of this assumption indicates that the results are robust to variations in the mortality difference and that population age structures are more sensitive to fertility differentials than to mortality (Menashe-Oren and Stecklov 2018). With this method, the difference between the predicted and actual populations is considered internal net migration (and reclassification and international migration to a lesser extent).

Rural/urban mortality estimates by age and sex for all the countries in our analysis do not exist. Instead, we focus on a select number of countries in Latin America and the Caribbean that include the necessary data to estimate adult mortality using data from the Demographic and Health Surveys (DHS) (ICF International 2021). Relying on the DHS samples limits the number of countries and time periods in our study. However, it offers a considerable advantage, in comparison to relying on census data, in that the DHS employ broadly consistent methods across countries helping to reduce variability in our estimates. We estimate the probability of dying between ages 15-59 ($_{45}q_{15}$) based on sibling survival, using the *demogsurv* package in *R*

(Eaton and Masquelier 2020). These estimates rely on respondents' (women of reproductive ages) reports on the survival status of siblings. Data on location of the sibling are not collected and therefore we assume that siblings are located within the same rural/urban sector as respondents. Possible bias due to misclassification of residence in rural/urban adult mortality estimates has previously been noted as insignificant (Menashe-Oren and Masquelier 2022). All the same, considering the DHS surveys cover a wide time period, we are cautious in our interpretation of the adult mortality rates.

**Results**

Country-level sex ratios generally follow a declining pattern from birth, as men die earlier than women at nearly every age, albeit with varying gaps between the sexes at different ages, leading to an increase in the proportion of women by age (Dyson 2012). Similarly, using the URPAS data, median national sex ratios across LMICs for ages 0-4 are 1.04 but fall to 0.67 by age 80+. While subsequent analyses explore variation in sex ratios for individual countries and regions, Figure 1 illustrates how the mean sex ratios by age vary between sectors across all countries in the URPAS data. On average across the 112 countries, the rural and urban sector sex ratios both start above one and then diminish rapidly over the age of 60. However, the general trends over age between birth and age 60 differ rather sharply between the sectors.

The broad empirical patterns seen in Figure 1 of rural and urban sex ratios are also robust to alternative and finer categorizations of urbanicity. In considering a gradient of urbanicity, we examine data from a limited subset of DHS countries (see Appendix Figure A6). While the analysis shows that substantial diversity in settlement types is lost by the rural/urban dichotomy, rural and urban sex ratios appear effective at capturing meaningful differences across the two sectors. Despite increased noise in these data related to sampling error, a more limited number of countries, and aggregation over a broad temporal window, the survey data reinforce rather than upend the impression from the URPAS data, and suggest broadly similar age patterns and sectoral heterogeneity. The rural and main city sex ratios capture the extremes, while town and smaller cities appear to mostly fall in between.

*(Figure 1 here)*

According to Figure 1, sex ratios at birth (ages 0-4) and up to ages 5-9 are quite similar across sectors. On average, the male advantage among children is evident in both rural and urban sectors, and is consistent with national sex ratios at birth averaging 1.05 (Tafuro and Guilmoto 2020). Although these mean sectoral sex ratios hide impressive diversity between countries – partly due to national variation in sex ratios at birth (Garenne 2002; Guilmoto 2009; Tafuro and Guilmoto 2020) – the under-five year old sex ratios suggest that the mechanisms

driving sex ratios at birth tend to balance each other out by sector. The similarity across sectors in the child sex ratios is suggestive that sex ratios at birth play a relatively modest role in driving overall differences. While sex ratios remain above one and slightly increase in the urban sector, rural sex ratios decline through to age 19. From ages 20-24, there is a crossover, as sex ratios increase in the urban sector and decline in the rural. This reversal of trends continues with rural sex ratios falling below urban for the remaining working ages, and a surplus of males in the urban sector in comparison to a deficit in the rural. For both rural and urban sectors over age 60 there is a sharp and unsurprising drop in sex ratios, apparently driven by a relative excess in male mortality (Wingard et al. 1989; Oksuzyan et al. 2008; Rogers et al. 2010).

*Heterogeneous Sex Ratios in Older Ages Contrasts Similar Rural/Urban Sex Ratios among Children*

In Figure 2, we consider each stage of the life course examining four discrete age groups: under-15-year olds, 15-29 year-olds, 30-59 year-olds and over age 60. While these cut-offs are imprecise and highly heterogeneous, they do offer a useful approach to compare sectors, emphasizing how variability between sectors may shift differently with age. Amongst children aged 0-14, the distribution of sex ratios is relatively clustered, close to the diagonal and centred near 1.0 for both rural and urban sectors, indicating relatively similar ratios and modest sectoral

differences. The points primarily lie along but slightly below the diagonal, indicating that urban sex ratios tend to fall slightly below those in the rural sector but sex ratios tend to be balanced - not surprising given that sex ratios at these youngest ages are driven in part by sex ratios at birth, which may be affected by many of the same cultural patterns in both rural and urban areas. Even where gender preferences are strong, the mechanisms that drive higher sex ratios may counterbalance each other across sectors and produce relatively small sex ratios gaps. For example, because fertility is generally higher in the rural sector (Shapiro and Tambashe 1999; Lerch 2017; Garenne 2017), son preference may be accentuated in rural populations at higher parity births (Pebley and Amin 1991; Muhuri and Preston 1991; Das Gupta 2005; Chung and Das Gupta 2007). At the same time, lower fertility in the urban sector may also put pressure on urban parents to achieved their desired sex structure with fewer children using readily available prenatal sex determination technology. Thus, whether in countries with especially high, or low, sex ratios at birth, the gap between the sectors is relatively small, as in Azerbaijan (with sex ratios among 0-4 year olds at 1.15 rural and 1.13 urban), and Zimbabwe (with sex ratios among 0-4 year olds at 1.01 in both sectors), as seen in Appendix Figure A4.

There are also some important exceptions to the balanced young sex ratios and small rural-urban differences. Armenia is also notable with higher sex ratios in both sectors, indicating a deficit of girls nationally, partly driven by a strong son preference throughout the country

(Duthé et al. 2012). Two additional exceptions in the Pacific islands offer examples where we see substantially higher urban sex ratios in combination with rural sex ratios near unity. This appears to be at least partly due to the very small population sizes of these island nations, and with the URPAS population data, provided in thousands, occasionally leading to skewed sex ratios when the URPAS population numbers are rounded.

*(Figure 2 here)*

In the youngest ages (0-14), regional gaps are notable with most urban values in sub-Saharan Africa lower than rural sex ratios. Considering that gender preferences in sub-Saharan Africa do not tend to be as strong as in Asia (Fuse 2010), it is not surprising that sex ratios in this age group are low. The higher rural sex ratios may be explained by patterns of rural to urban migration among girls for school, as domestic help for relatives, early marriage, or perhaps a combination (Isiugo-Abanihe 1985; Beegle and Poulin 2013; Awumbila al. 2017). In other regions, the values in this youngest age category are quite similar across the sectors, as countries mostly lie along the diagonal.

At young adult ages (15-29), dispersion in sex ratios increases: on the one hand we see higher rural sex ratios combined with lower urban sex ratios, and on the other hand higher urban sex ratios with lower rural sex ratios. This increasing divergence along an axis

perpendicular to the main diagonal suggests the population of 15-29 year-olds is redistributed across sectors within countries, rather than shifts in sex ratios along the diagonal which would tend to suggest overall changes in national sex ratios. Generally, urban 15-29 year-old sex ratios are concentrated between a minimum of 0.81 in Zimbabwe and maximum of 1.29 in Yemen. The rural sex ratios of 15-29 year-olds are a bit more widely distributed, ranging between 0.84 in Nepal to 1.54 in Uruguay. Interestingly, pronounced regional differences in the rural and urban sex ratio gap emerge in this age range. In Latin America and the Caribbean, we see higher sex ratios in the rural sector across most countries, with urban sex ratios near unity and rural sex ratios averaging 1.09 and in some countries with considerably higher values. One possible explanation involves higher urban risk-taking and violence among men, leading to higher mortality by injury in this age group (Murray and Lopez 1997), especially common in Latin America and the Caribbean (Patton et al. 2009). In contrast, sub-Saharan African sex ratios are predominantly above unity in the urban sector but much more narrowly constrained around 1.0 in the rural sector. This pattern would appear to highlight the strength of male migration flows to cities, of young adults primarily moving for work and marriage (Bernard et al. 2014), evident across much of sub-Saharan Africa (Montgomery et al. 2003; Menashe-Oren and Stecklov 2018), typically lowering the sex ratios in the rural sector and increasing them in the urban sector (see more below). In North Africa and Central-West Asia, the patterns are considerably more diffuse.

The pattern shown in Figure 2 for the older working age adults, aged 30-59, suggests a continued expansion and widening of the diversity that is first seen for 15-29 year-olds. Urban sex ratios in sub-Saharan Africa are consistently higher than rural, and range from 0.9 to about 1.5, while the variation in the rural sector is much narrower and all below 1.0. Latin American and Caribbean countries follow nearly the opposite pattern, with rural sex ratios ranging from 0.8 to 1.5, while urban sex ratios are nearly all below 1.0. The pattern for Southeast Asia and Pacific emphasizes a notable shift from the earlier age group. Here, we see urban sex ratios surpass those in the rural sector in many countries, though the values are relatively spread out and the urban mean sex ratio is 1.07 (compared to 0.98 in the rural). One explanation for this may be higher rates of rural to urban migration among men, though subsequent analyses (see below) are not supportive of this reasoning. Another explanation may be more male deaths from non-communicable diseases such as cardiovascular illnesses, which tend to be more common in the urban sector because of lifestyle choices (Amuna and Zotor 2008; Kolcic 2012). Finally, the North Africa and Central-West Asian patterns remain rather narrow with little variation between rural and urban sectors.

The sharp shift observed for the oldest age highlights the intertwined nature of demographic and geographic processes. It is clear that sex ratios decline in the oldest ages as women are more likely to survive. But, it is less appreciated how these processes tend to create

a rebalancing of sex ratio differences across sectors. With aging, females begin to outnumber men at the national level – witness the large increase in points along the diagonal but at sex ratios far below 1.0. However, this feminization of older age is not balanced and urban sector sex ratios are seen not only falling considerably below 1.0 in almost all countries, but also tending well below rural sex ratios across most countries outside of sub-Saharan Africa. Return migration of elderly men from the urban to rural sectors– a pattern identified in sub-Saharan Africa (Clark et al. 2007; Levira et al. 2014; Lankoandé et al. 2018) – or the movement of elderly women to cities to assist with the care of grandchildren, are both potential factors that may underlie this pattern. In contrast, rural sex ratios in Latin America and the Caribbean remain surprisingly high, probably through cohort effects as high rural sex ratios from earlier adult ages being maintained into older ages. That said, data at these higher ages are less reliable and must be interpreted with caution.

Wider urban-rural sex ratio gaps at older ages, and greater diversity across countries in later stages of the life course, suggests that the determinants of sex ratios – notably mortality and migration – are especially variable among older adults. Of course, sex ratios at these older ages are simultaneously a product of age-related factors as well as factors that impacted sex ratios at younger ages for these same cohorts in the past. The determinants change as countries develop and urbanise: life expectancy increases and the female survival advantage into older

ages shrinks (Hollingshaus et al. 2019); international migration flows increase and contribute to city growth (Lerch 2020); and rural to urban migration rises and falls over the urban transition (Rees et al. 2017, Menashe-Oren and Bocquier 2021). Alongside this descriptive evidence in the cross-section, it is important to determine whether the gaps between rural and urban sex ratios are linked to core processes associated with development and the urban transition.

*How Urbanisation is Related to Rural/Urban Sex Ratio Gaps*

As a first step, we consider how rural/urban sex ratios are distributed by age when countries are divided into three categories by level of urbanization (see Appendix Table A1): low (<30%, 22 countries), medium (30-60%, 54 countries including Nigeria, India and China) and high (above 60%, 36 countries) (Figure 3). In the least urbanized countries, such as Burkina Faso and Nepal, urban sex ratios between ages 25 and 59 are strikingly high. The high urban sex ratios at these ages create substantial gaps with rural sex ratios. The situation is reversed in countries with urbanization levels above 60% (Figure 3). In this highly urbanized category, rural sex ratios exceed urban ratios from age five and above with rural sex ratios remaining above unity till age 70. The sharp contrast in the age-specific rural-urban sex ratios when comparing low and high urbanization contexts points to a potentially strong role for urbanisation. At the same time, the levels of urbanisation actually consist of *relatively* distinct trends in rural-urban gaps that exist

across regions (Appendix Figure A6). The geographic nature of these groupings begs the question of whether it is urbanization per se that is driving these differences or whether it is alternative underlying conditions and historical contextual factors within these regions that matter.

*(Figure 3 here)*

To further unpack the role of urbanisation while reducing the impact of existing age-structural differences between rural and urban sex ratios across societies, we consider age-standardised aggregate sex ratios. Figure 4 shows the age-standardised total sex ratios for rural and urban sectors by urbanisation level for 2015. We primarily build here on visualization methods given the small sample sizes (see Appendix Table A2 for statistical analyses that corroborate our qualitative findings): scatter plots and linear fitted lines. In countries below 30% urban, mostly in sub-Saharan Africa and Southeast Asia and Pacific, urban sex ratios tend to be considerably higher than rural, and higher than urban sex ratios in other regions. In contrast, countries over 60% urban, primarily in Latin America and the Caribbean, and North Africa and Central-West Asia, demonstrate less variance in sectoral sex ratios. In many of these high urbanization settings rural sex ratios appear to be equal to or exceed urban sex ratios. According to the fitted lines in Figure 4, the gap in urban-rural sex ratios is largest for countries

at low levels of urbanisation, when urban sex ratios are higher than rural. The gap is smallest for countries between 40-60 percent urban and then widens again with rural sex ratios exceeding urban ratios at levels of urbanization above 60 percent.

*(Figure 4 here)*

One interpretation of Figure 4 is that sex ratios gaps are large at low levels of urbanization, with urban sex ratios greatly exceeding rural, and then reversing course with rural sex ratios exceeding urban sex ratios at high levels of urbanization. This developmental interpretation is appealing but is not supported by further examination. Figure 5 presents the standardised urban-rural sex ratio gaps and their change over time for each country as urbanization levels change, while also presenting the overall averages for each geographic region. The evidence from Figure 5 shows that countries at lower levels of urbanization appear to have higher urban sex ratios, and countries at higher urbanization levels relatively higher rural sex ratios. However, when examining the entire 35-year period, we see little evidence of clear country-level or regional trends with the lines being most flat. Thus, alongside a very modest negative slope overall there is limited variation in how each country shifts over the 35-year period with this "within-country" visualization. At most there are generally weak patterns identifiable for individual countries as shifting urbanization is shown to have little association

with changing rural-urban sex ratio gaps over time. In contrast, strong cross-country differences are abundantly clear that with countries at low levels of urbanization showing large gaps and countries at high levels tending to show small sex ratio gaps across sectors.

*(Figure 5 here)*

These results highlight a reality where rural/urban sex ratio gaps are not related to changing levels of urbanisation, but are more likely related to each country's, and each region's, distinctive background. Contextual socio-economic and demographic histories for each country likely explain why some countries have relatively high sex ratios in the urban sector along with low levels of urbanization or relatively high rural sex ratios at high levels of urbanization. Part of the explanation may be due to the period in which countries made large advances in their urban transition. Countries which experienced urbanization processes decades earlier, have seen changes that contributed to greater similarity in urban and rural sex ratios. These findings would seem to reinforce the salience of timing – how a country's level of urbanization at a particular period in history may have long-lasting impacts and it offers a further reminder of the perils of "reading history sideways" (Thornton 2001).

Two specific examples offer interesting contrasts, emphasizing the importance of timing. In Namibia, low proportions urban (24.1% in 1980) were combined with a large gap in the

standardised sex ratios – with urban sex ratios far exceeding rural sex ratios. This gap between sectors were likely driven by the migration of men from rural areas to mining towns (which remain today a large proportion of urban settlements). Uruguay provides a compelling contrast, with proportions urban extremely high (88% in 1980) and a large gap in sex ratios, but with rural sex ratios much higher than urban sex ratios. The proportions urban in Uruguay were already close to 80% in the 1950s (United Nations, 2018), and reached 96% in 2015. Despite this early urban transition, the economy remains largely agricultural, with larger shares of men in agriculture than women, skewing rural sex ratios (1.49 in 2015).

*The Role of Internal Migration and Mortality Differentials in Determining Rural/Urban Sex Ratios*

While our descriptive methods do not point to urbanisation levels themselves as playing a driving force behind shifts in sectoral sex ratio gaps, what is it about these countries with large gaps – notably in sub-Saharan Africa and Latin America and the Caribbean where the rural/urban gaps are more extreme (see Figures 2 and A3) – which may help to explain the observed pattern? The literature on migration and population structure makes clear that internal migration may play a particularly powerful and dis-equilibrating impact on sex ratios and hold a key to this puzzle. Indeed, a weak link between urbanisation and internal migration

(Chen et al. 1998; Stecklov 2008; Menashe-Oren and Bocquier 2021), while important, does not necessarily negate the potential for internal migration to sharply alter sex ratios across sectors.

Figure 6 demonstrates how age- and sex-specific net migration patterns differ by region. The impact of these differential net rural to urban migration patterns may be easy to under-estimate. In fact, they point to potentially powerful forces restructuring the relative age and sex structures of the rural and urban populations. A back-of-the-envelope calculation highlights the dual effect of differential net rural-urban migration rates by sex. Consider a hypothetical birth cohort equally divided between urban and rural sectors and with evenly balanced sex ratios with no sex differences in mortality as they age. Assuming the cohort experiences net rural to urban migration rates of 2% for men and 1.5% for females, the balanced sex ratio across the two sectors will shift within 15 years to an urban sex ratio of nearly 105 males to females and a rural sex ratio below 93 males per 100 females. A modest gap in net rural to urban migration rates by sex of only one-half percent could be sufficient to generate serious disparities in sectoral sex ratios as each additional male that leaves the rural sectors both reduces sex ratios in the rural sector and raises sex ratios in the urban sector. While not meant to be realistic, these migration rates are consistent with those seen in sub-Saharan Africa. Indeed, countries in sub-Saharan Africa are characterised by male dominated migration flows from rural to urban sectors, notable in Figure 6 between ages 15-44, likely explaining a portion of the sex ratio

imbalance across the rural and urban sectors. Internal migration flows in Southeast Asia and the Pacific however, show more complicated and variable migration patterns by age. Up to age 15 boys migrate more than girls, and then from age 15 to 44, women's net migration rates are higher than men's. These migration trends appear less predictive of urban sex ratios in the region which remain above one till age 60. In North Africa and Central-West Asia men and women migrate at very similar rates over all ages (Figure 6), contributing relatively little to sex ratio gaps across the sectors.

The region of Latin America and the Caribbean provides a contrasting scenario to sub-Saharan Africa, with rural sex ratios sharply exceeding those in the urban sector, particularly after early childhood (Appendix Figure A5). The reason for the dominance of females in the urban sector likely reflects multiple causes, including internal migration and mortality. Exploring our available data on internal migration patterns in Latin America and the Caribbean we find overall stronger patterns of net urban migration for women across most of the adult years (Figure 6). Distinctive patterns of female-dominated rural to urban migration is a well-recognized feature of the history and patriarchal structure of many countries in this region (Chant 1998; Rodríguez-Vignoli and Rowe 2018). While more muted than in sub-Saharan Africa given the lower overall rates of net migration in Latin America and the Caribbean, this sex

differential will increase relative female numbers in the urban sector due to the dual effect noted above of differential net internal migration in pushing biased sex ratios across sectors.

*(Figure 6 here)*

Alongside the role of net internal migration, sex-specific mortality patterns and their differences across sectors offer an additional explanation for the rural/urban sex ratio gaps within Latin America and the Caribbean. Differential adult mortality by sex can of course be consequential in all regions, but we focus on Latin America and the Caribbean since the sex-specific net rural-urban migration rates can only explain a modest share of the gap, and sex ratios in the region are imbalanced and in an opposing direction to those in sub-Saharan Africa. Although evidence of rural/urban adult mortality differentials from Latin America and the Caribbean is limited, we consider available data from the DHS for select countries in the region. We do not examine child mortality since the sex ratios among children in rural and urban areas in Latin America and the Caribbean are similar (Appendix Figure A5). In addition, recent evidence suggests no urban penalty in infant mortality in the region (Garcia 2020).

As shown in Figure 7, male adult mortality exceeds female mortality in terms of conditional survival from age 15 to 60 in all sectors except for the rural sector of Peru (which was 76% at time of the survey). The low ratio in rural Peru is likely a reflection of poor quality of

death records in some less developed regions (Piscoya-díaz and Queiroz 2010), and possibly also due to misclassification of female sibling deaths in the rural sector in cases where the sibling migrated to urban areas (Menashe-Oren and Masquelier 2022). More importantly, surplus male mortality patterns are more pronounced in the urban sector, far surpassing those in the rural sector across all five countries, and different periods. These differences in conditional mortality probabilities over the key adult years translate into differential survival probabilities. From this perspective, the average male/female ratio of survival in the urban sector (0.972), versus rural (0.983), would further contribute to a relative abundance of women in the cities. The notable male bias in mortality is consistent with studies that point to high rates of homicide and violent deaths among men in cities noted in Latin America and the Caribbean (Alvarez et al. 2020; Briceño-León et al. 2008). Given that Latin American and Caribbean countries are primarily urban on average, these sectoral mortality patterns likely play an additional role in the relative abundance of women in cities in this region. That said, given that Haiti and Guatemala were less urbanised at time of the surveys (53% and 44% urban respectively), other regional characteristics may be important to consider, and further exploration of rural/urban sex-specific adult mortality in Latin America and the Caribbean is required to confirm what we see here.

*(Figure 8 here)*

## Conclusion

Sex ratios are fascinating not only because they describe a core demographic characteristic of countries or regions, but also because they are both cause and effect for many other demographic, economic and social processes. Most studies to date, however, have considered national level sex ratios and have paid little attention to how sex ratios diverge within countries. Our analysis has highlighted divergence in rural and urban sex ratios across LMICs. We show rural sex ratios on average are higher – men outnumbering women – up till early adult ages and then fall below urban sex ratios. This is followed by a second crossover in older adult ages, back to higher rural sex ratios (though following a declining trend). Moreover, we find that sex ratios for under-15-year-olds are more densely clustered around equity in both rural and urban sectors, while there is far more heterogeneity amongst countries in the rural/urban sex ratio gap at older ages. Importantly, these results are based on period analysis; a cohort perspective may slightly alter our conclusions. We do not expect large differences since sex ratios have not changed dramatically, at least between 1980 to 2015, as shown in Appendix Figures A2 and A4.

There are important limitations to our analysis. Our focus on urban-rural gaps in sex ratios is directed on this single sub-national division. Other sub-national divisions may be important too in different contexts, with states, provinces or even neighbourhoods and

communities reflecting boundaries across which sex ratios may vary, and this variability may both impact social and demographic life as well as generate important consequences. We concentrate on urban-rural gaps because of their meaning and policy salience in many contexts where urban transitions are ongoing. Countries that are less urban tend to have large gaps in sex ratios between the sectors, with urban sex ratios generally much larger than rural ratios. These gaps are smaller for countries that are around 40-60 percent urban. However, at higher levels of urbanization, above 60 percent, rural sex ratios are found to generally exceed urban sex ratios.

Interestingly, as we have shown, the cross-sectional perspective does not necessarily reflect a clear developmental process. In fact, the general impression from our within-country analyses is of relatively modest changes in the gap in sex ratios between rural and urban sectors as urbanization levels rise. Evidence of regional differences further challenge expectations of similar trends in urban and rural sex ratios emerging as countries urbanize. These regional differences appear to broadly reflect divergent sex-specific internal migration patterns in sub-Saharan Africa and Latin American and Caribbean, and gender differences in mortality in Latin American and Caribbean. International migration flows too could certainly play a role, but more data from LMICs are needed to assess its differential impact on sex ratios in the urban and rural sectors.

According to the UN, future trends in national-level sex ratios in LMICs are expected to decline from 103.2 in 2015 to near equity, 100.5, in 2100 (United Nations 2017). Rural and urban sex ratios are harder to predict, dependent on broader national trends along with rural/urban variability in their determinants. In Asian countries, where half of the population lives in the rural sector as of 2015 (United Nations 2018), national sex ratios are expected to decline to 102.4 in 2100 (from 104.8 in 2015). The higher total sex ratios in the region are driven by particularly high sex ratios at birth, which have declined in some countries like South Korea (Guilmoto 2009; Tafuro and Guilmoto 2020). Lower fertility is likely to spread to the rural sector, reducing pressure of sex selection at higher birth orders. At the same time, rural populations will increasingly gain access to technology for cheap sex determination. Ultimately, the effects will be determined by how son preference in Asia changes in the future in both the rural and urban sectors. Additionally, changes in political systems and policies may close the urban-rural sex ratio gap, such as the relaxation of the one-child policy in China, that was more restrictive on urban fertility (Baochang et al. 2007). All the same, our analysis suggests that sex selective abortion does not play a powerful role in the rural/urban sex ratio gap, and it is unlikely to play a large role in the future.

In Latin American and Caribbean countries, where urbanisation levels are already high, national sex ratios are projected to increase to 99.0 in 2100 (United Nations 2017). Considering

the large proportion of the population already living in the urban sector in the region, these national levels primarily reflect urban sex ratios. If adult male mortality remains especially high in the urban sectors, then national sex ratios will continue to show a relative abundance of women. In contrast, the proportion of the population urban in sub-Saharan Africa is low (United Nations 2018), and although expected to increase, it is possible countries may reach urban saturation (equal rural and urban growth) at low proportions urban (Bocquier 2005). Therefore, while the national sex ratios are predicted to be 98.2 in 2100 (United Nations 2017), rural and urban sex ratios will likely remain divergent in the region. As we have shown, internal migration appears to play a substantial role in shaping rural/urban sex ratios in sub-Saharan Africa. Therefore, if rural to urban migration of young adult men continues, the large gap in sex ratios in these ages is likely to persist.

Clearly, predicting how the urban-rural sex ratio gap will evolve in the future will rely on an understanding of how the principle factors of sex ratios at birth, sex differences in age-specific mortality, and male and female migration will change by sector. Our confidence in interpreting life course patterns in sex ratio gaps must be tempered by our reliance on cross-sectional survey data. Sex ratio gaps that are identified in a given point in time may influenced by shifting cohort behaviours, but this will require different data and methods. For now, we have probed the contribution of factors for which we have limited, available data, and show

how these impact sub-national sex ratio gaps. Notably, internal migration appears to have a more significant role in shaping rural and urban sex ratios than other determinants. Nevertheless, future research is still needed to empirically examine them further, to isolate the effects of each dimension as well as to consider how these sex ratios may vary across other social and political boundaries within countries.

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**Figures**

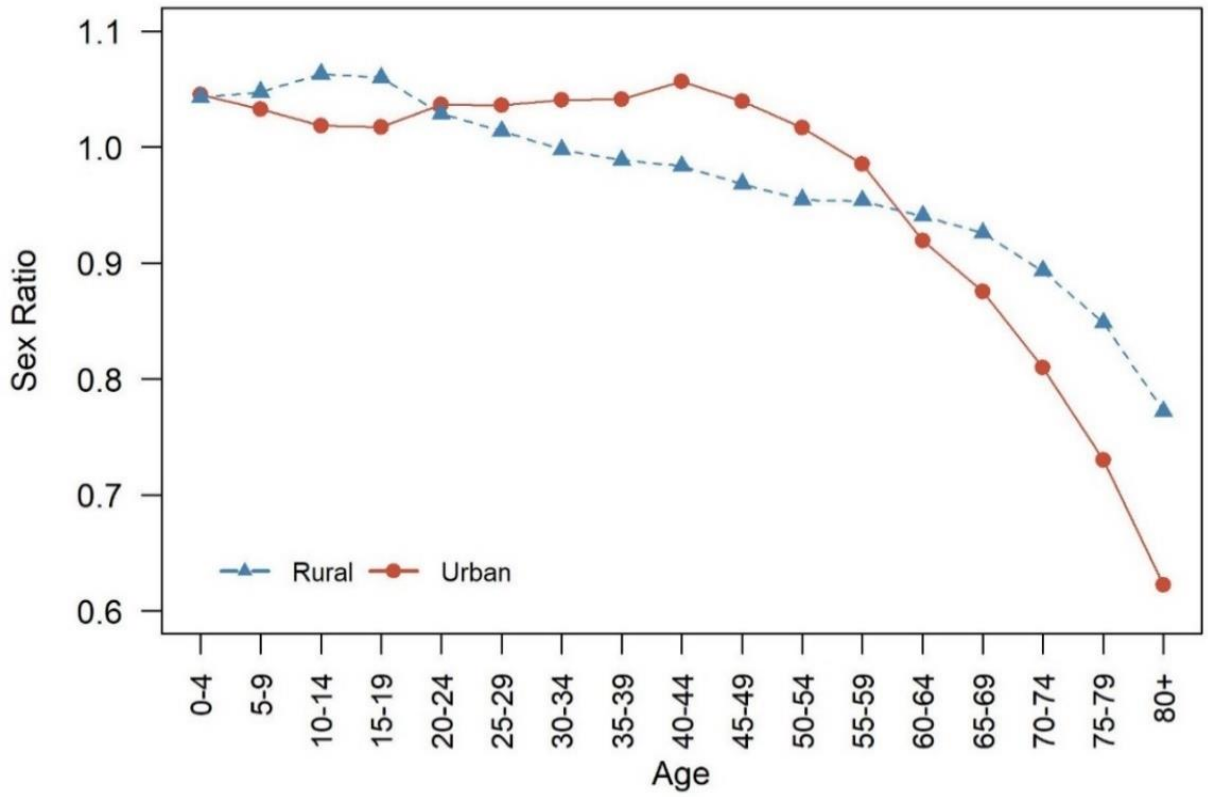


**Figure 1:** Mean rural and urban sex ratios by age for low- and middle-income countries, 2015

*Source*: URPAS, UN

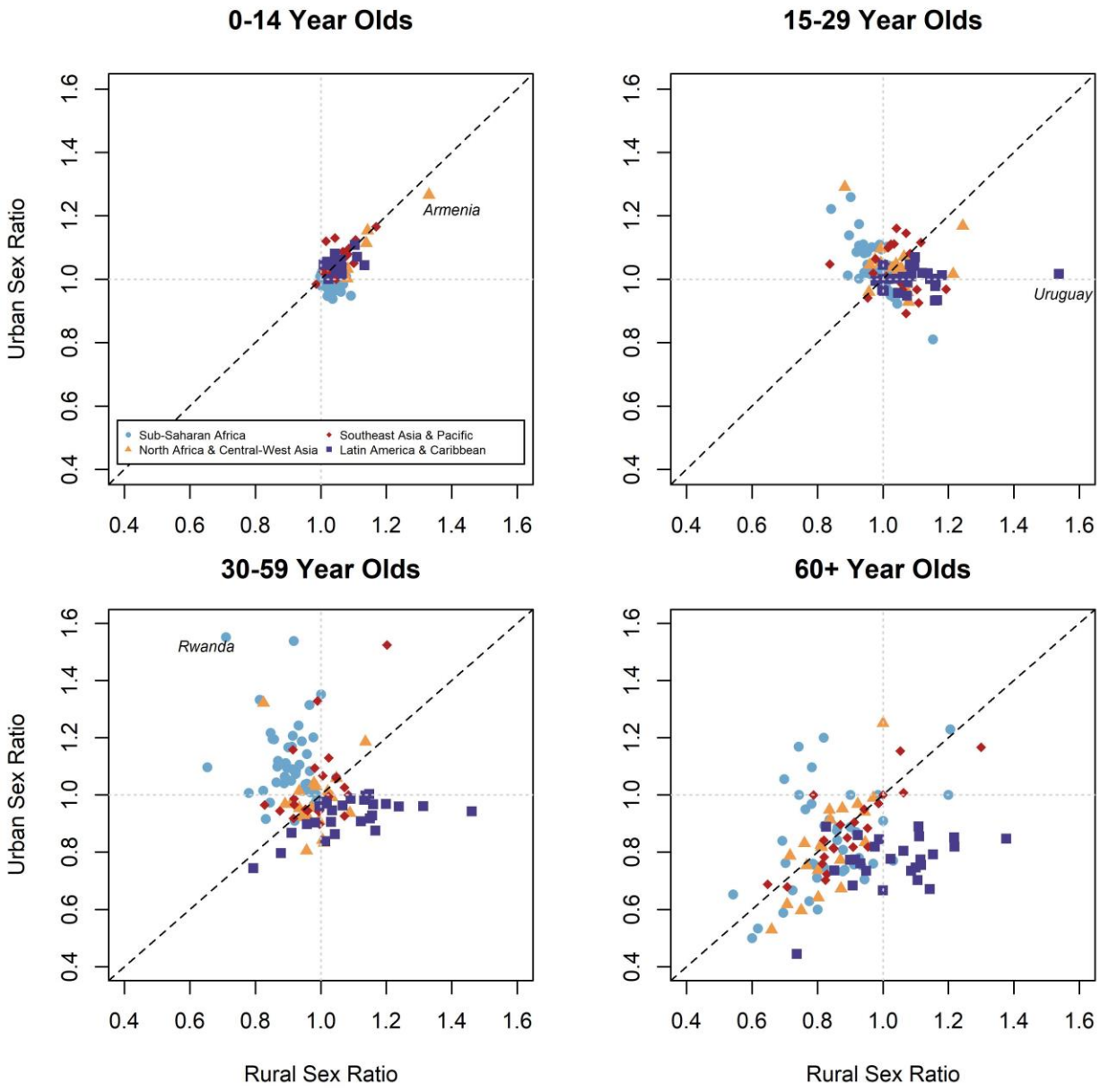


**Figure 2:** Rural and urban sex ratios by age group for low- and middle-income countries, 2015

*Source*: URPAS, UN

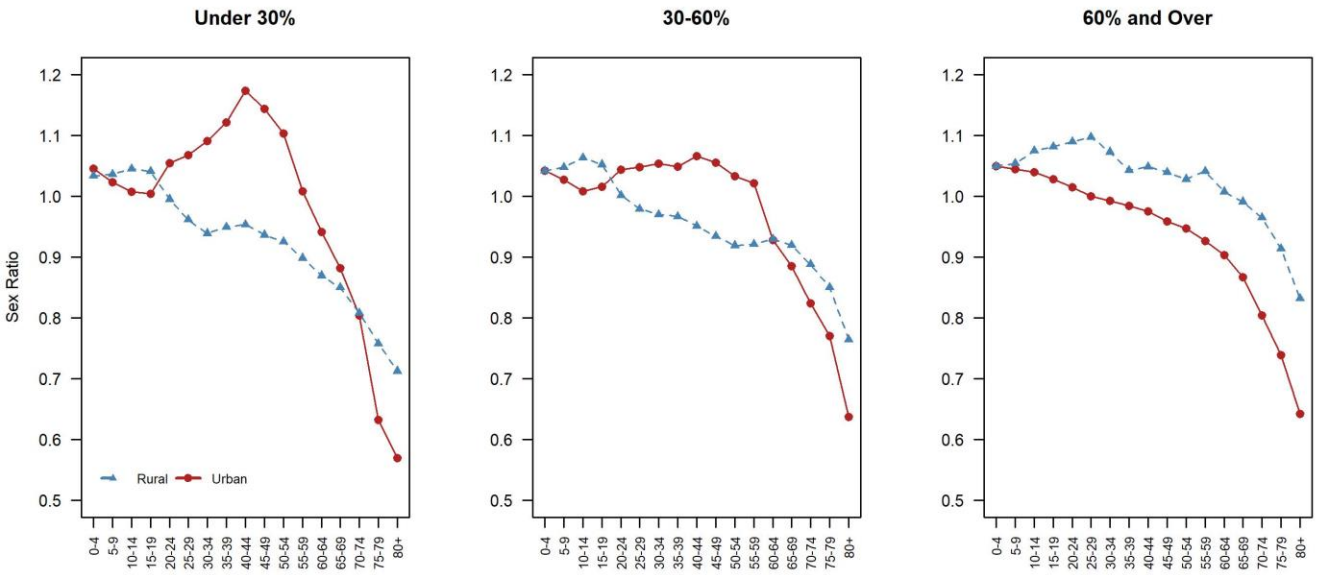


**Figure 3:** Rural and urban sex ratios by age, by urbanisation category, 2015

*Source*: URPAS, UN

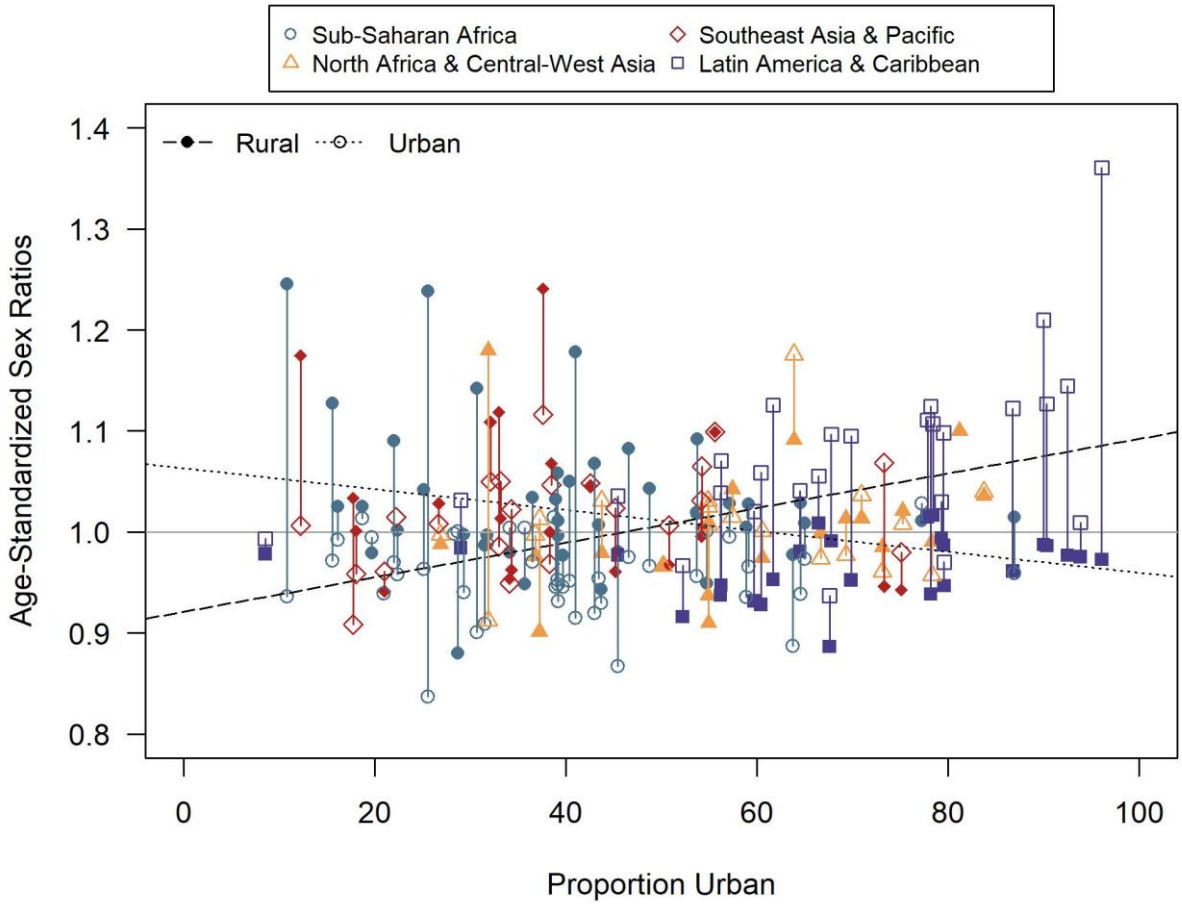


**Figure 4:** Age-standardised rural and urban sex ratios for low- and middle-income countries according to proportion urban, 2015

*Source*: URPAS, UN

*Notes:* The horizontal line at 1.0 indicates equity between rural and urban sex ratios. The dark dashed line is a linear fit to the full markers, indicating the rural trend in sex ratios over

proportions urban, while the light dotted line is a linear fit to the open markers, indicating the urban trend in sex ratios over proportions urban.

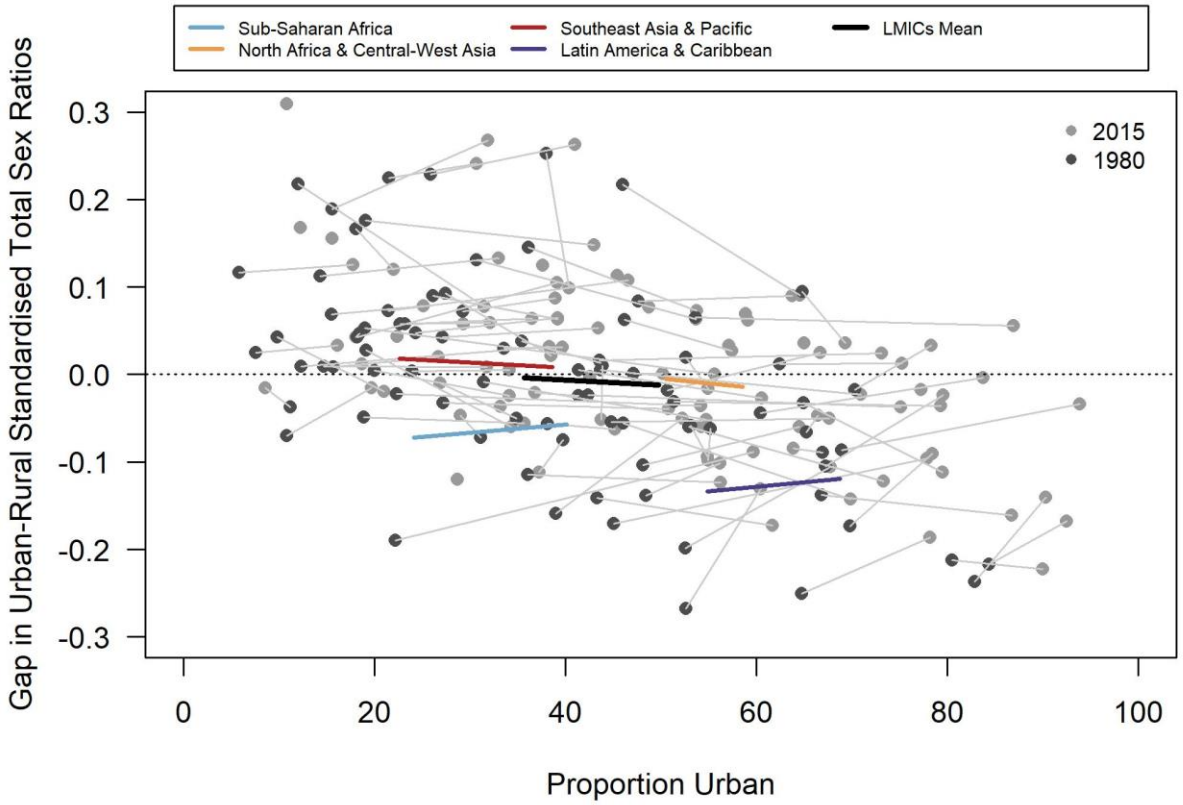


**Figure 5:** Urban-rural gap in standardised total sex ratios for low- and middle-income countries according to proportion urban, 1980 and 2015

*Source*: URPAS, UN

*Note*: Each country is represented by two dots and a line connecting them. The horizontal dotted line at 0.0 indicates no difference in urban and rural sex ratios. The coloured lines indicate mean sex ratio gaps by region, and the thicker black line the mean for all 112 countries. Uruguay is an outlier, with a gap of -0.49 in 1980 at 88% urban, and -0.38 in 2015 at 96% urban, and excluded from this figure for clarity.

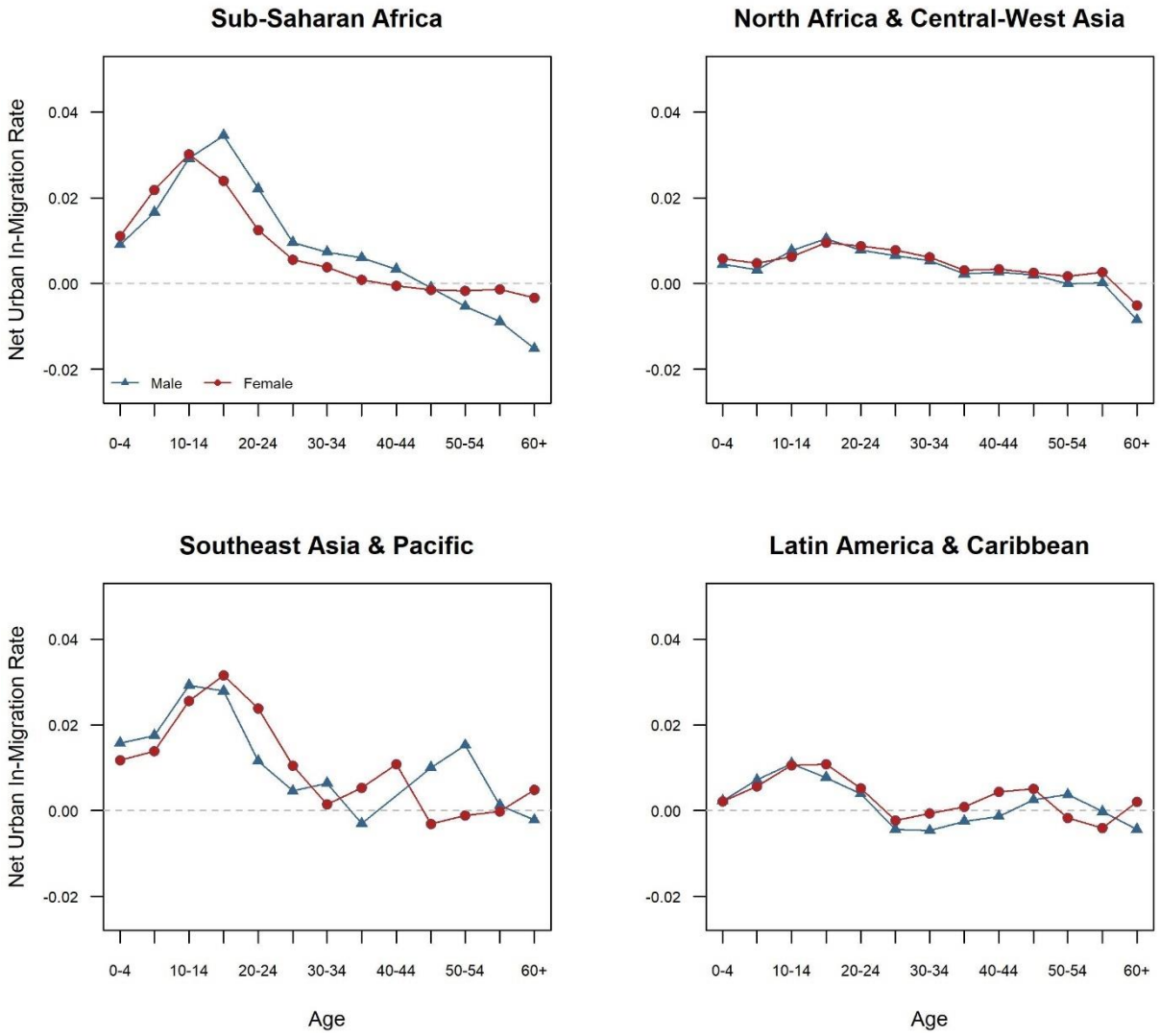


**Figure 6:** Mean net internal migration rates by age and sex across low- and middle-income countries, 2015

*Source*: URPAS, UN

*Note*: Estimates of migration based on census survival method for 112 countries

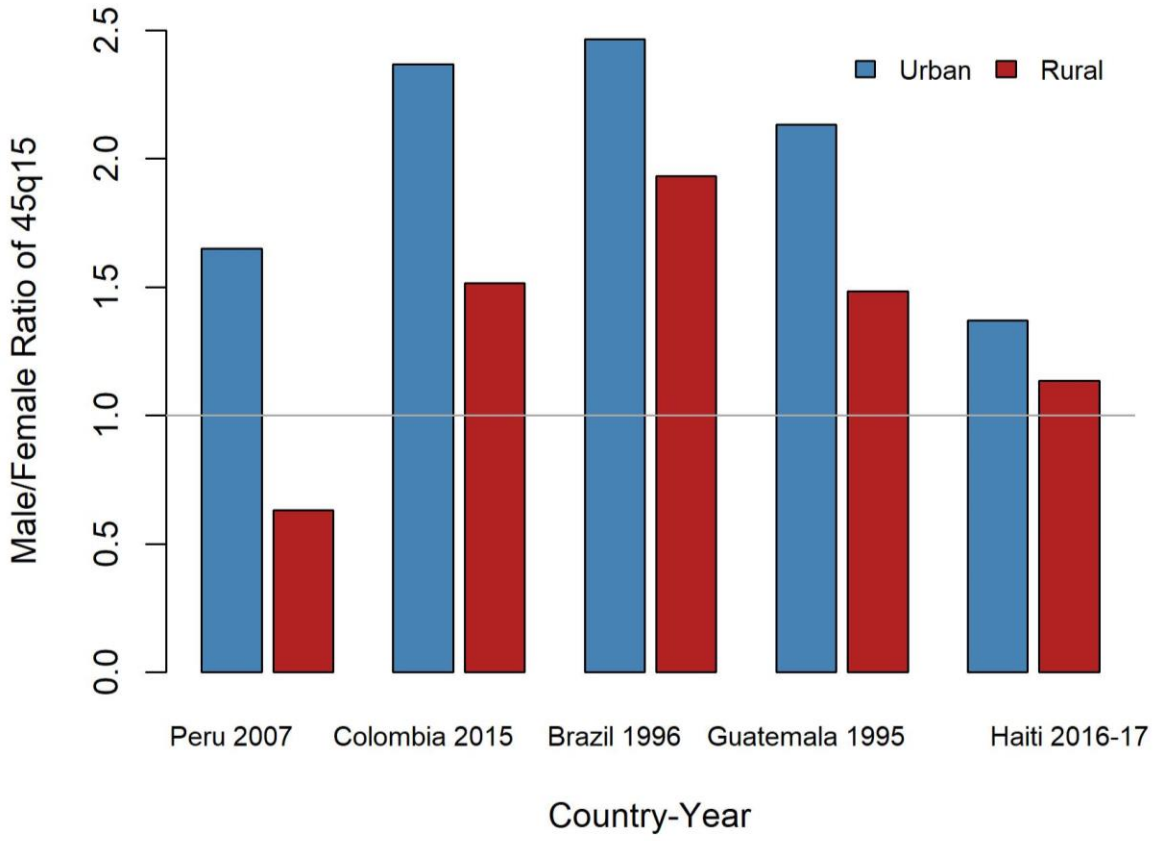


**Figure 7:** The male/female ratio of the probability of dying between ages 15-59 conditional on survival to age 15 ($_{45}q_{15}$)

*Source*: Demographic and Health Surveys with sibling histories in Latin America and the Caribbean