Southampton Statistical Sciences Research Institute
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S[3]RI Applications Working Paper A03/14

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A tale of two continents: Infant death clustering in India and sub-Saharan Africa

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Introduction

Although childhood mortality has declined in the past four decades in almost all countries, the declines have been faster and in percentage terms greater, in relatively rich countries (Ahmad, Lopez, and Inoue 2000). In recent years, the decline in child mortality levels has slowed down and in some countries reversals are recorded. For example, evidence from the demographic and health surveys (DHS) suggests that infant mortality in Zambia and Zimbabwe is increasing, while in India infant mortality is decreasing very slowly (Claeson et al. 2000). Within regions and countries overall declines in infant mortality mask a stagnant situation for poor subgroups, thus it is important to examine infant mortality differentials within populations (Wagstaff 2000; Victora et al. 2003). Understanding the determinants of death clustering within families and communities is important for those who work to reduce inequalities in health.

An interesting comparison in this respect exists between the states of India and the countries of sub-Saharan Africa. Infant mortality in India is much lower than in sub-Saharan Africa but just over 30 per cent of African children are malnourished as measured by children's weight-for-age in comparison with 50 per cent in south Asia (Ramalingaswami, Jonsoon and Rohde 1996). Further, about a quarter of babies in India are born of low birth weight compared with about 12 per cent in sub-Saharan Africa (UNICEF 2003). Although a secular decline in infant and child mortality has occurred in both continents, differentials exist between and within each of the regions. In some states of India, notably the more northern states, mortality levels for infants and children are higher than in some sub-Saharan countries. Aggregate levels of income are higher in India but female literacy is lower than in Africa.

Madise, Matthews, and Margetts (1999), after examining data on nutritional status in six African countries, speculated that the underlying reasons for the clustering of child health outcomes could be linked with a nation's health indicators and levels of social and economic development. This paper tests this hypothesis with reference to infant mortality, using data from 16 states of India and 18 countries in sub-Saharan Africa. Specifically, the paper will quantify the degree of clustering of infant mortality at family level while controlling for a range of bio-demographic and socio-economic variables as well as community clustering of deaths. Secondly, the paper will explore the association between levels of death clustering and country or state-level factors such as the level of mortality, use of health services, and economic and social development indicators.

Literature review

Infant mortality is often used as an indicator of the development of a country since infants, more than any other age-group of a population depend heavily on the socio-economic conditions of their environmental for survival. Thus, the level of infant mortality presents a measure of how well a society meets the needs of its people (Bicego and Ahmad 1996). Many researchers have, using data from demographic and health surveys, documented evidence of associations between infant mortality and socio-economic and demographic factors. Although there are some similarities (for example, the length of preceding birth intervals) there are also differences of which determinants are important for predicting mortality and which are not. These differences suggest that the determinants of infant mortality are not static, but that they vary with geographical location.

Child-level demographic factors such as birth order, the length of the preceding birth interval, and the survival status of the preceding child are strongly associated with child mortality in Africa as well as Asia (Cleland and Sathar 1984; Koenig et al. 1990; Boerma and Bicego 1992; Curtis et al. 1993; Madise and Diamond 1995; Rutstein 2000; Whitworth and Stephenson 2002). Many studies report higher mortality risks among first and higher order births, those born after birth intervals of less than two years, and those whose previous sibling has died. A relationship has also been observed between the sex of the child and childhood mortality but there are differences between India and the rest of the developed world. In India, girls are about 30 per cent more likely to die before their fifth birthday than boys. A plausible reason for this may be son preference, which is manifest in lower spending on health for girls and higher prevalence of immunization among boys (Timæus, Harris and Fairbarn 1998; Claeson et al. 2000; Victora et al. 2003). In the rest of the less developed world, lower mortality risks are reported for girls, at least in the first few months of life, and this is thought to be a result of male biological disadvantage in infancy (Sastry 1997; Curtis and Steele 1996).

An association has been observed between maternal age and infant mortality, with elevated risks of child loss for teenage and older mothers (Bicego and Ahmad 1996; Manda 1998). A plausible explanation for this association is that very young mothers tend to be socially and economically disadvantaged and they use antenatal services less frequently (Geronimus and Korenman 1993). Elevated mortality risks for births to older mothers are thought to be a result of complications associated with high parity and low use of obstetric services (Magadi et al. 2000).

Studies have found that levels of parental education, the socio-economic status of a family, and parental occupation are associated with infant mortality (Bicego and Boerma 1993; Curtis and Steele 1996). Desai and Alva (1998) used data from 22 countries participating in the first round of the DHS programme. They found that infant mortality was lower among educated women and that although this effect attenuated with the inclusion of socio-economic factors, it remained significant. Environmental factors and sanitation are important for the health of young children. Studies demonstrate lower infant mortality risks among children of households where toilets exist (Da Vanzo et al. 1983; Gubhaju et al. 1991), and where piped water is used (Brockerhoff 1990; Brockerhoff and Derose 1996).

The evidence for death clustering within families and communities is now well documented. After accounting for demographic, socio-economic, and environmental differences, studies demonstrate that some families have a higher propensity to lose a child than others. Das Gupta (1990), in her study of child mortality in rural Punjab, estimated that four per cent of the families in her sample accounted for 23 per cent of all deaths. Similarly, other authors show significant correlation of mortality risks between siblings (Zenger 1993; Curtis et al. 1993 and also 1996; Madise and Diamond 1995; Ronsmans 1995; Sastry 1997). One of the suggestions put forward to explain the clustering of child deaths within families is genetic factors. An early study by Bakketeig, Hoffman and Harley (1979) found that there was a tendency for some women to repeat pre-term deliveries and low birth weights in subsequent pregnancies. This work provided some evidence of genetic patterns leading to increased likelihood of multiple child loss in some families. More recently, Magadi et al. (2001) found a significant tendency for Kenyan women to repeat high-risk birth outcomes such as premature deliveries and low birth weight.

The pace of childbearing has also been shown to be a contributory factor to family death clustering (Ronsmans 1995; Sastry 1997). Short birth intervals are not only associated with increased risk of mortality for the index child but they may increase the mortality risks for all the children in the family because of larger sibling sizes leading to competition for parental attention and resources. Larger sibling sizes may increase exposure to childhood infections also. Other explanations for death clustering within families are: parenting competence (Das Gupta 1997; Pebley and Goldman 1996); feeding practices (Madise and Mpoma 1997) including breastfeeding patterns (Sastry 1997); and the use of health services (Steele et al. 1996; Matthews and Diamond 1997).

A major limitation of most of the studies cited above is that they are based on the analysis of single datasets from one country or one region. While it is acknowledged that the results from these studies are valid and offer significant contribution to our understanding of the determinants of infant deaths and death clustering, it is important to document evidence from many countries so that persistently significant associations can be identified and studied further. The distinction between multi-polar effects and those that are context-specific may shed light into the potential causal factors for infant mortality and death clustering. In addition, to assess the importance of national-level factors on infant mortality requires multi-country comparisons. The availability of data from the DHS programme and country-level data from national statistical offices and United Nations agencies offers an opportunity for such comparisons.

Data and methods

The data are from 16 states of India which participated in the 1998/99 National Family Health Survey (NFHS) and from 18 DHS data from sub-Saharan African. The 16 states of India were chosen on the basis of availability of state-level indicators and consequently are biased in favour of the major states. The African countries were selected arbitrarily from those countries with a DHS survey conducted in 1995 or later and where macro-level data were available (see Table 1 for the list of states and countries). Surveys conducted under the DHS programme contain birth histories from nationally representative samples of at least 4,000 women of childbearing age thus they are useful for measuring infant mortality and identifying the determinants associated with it. Infant mortality is usually defined as death before the end of the first year of life, but due to age heaping at twelve months by DHS respondents, the analysis includes deaths up to thirteen months of age. To reduce recall bias, only births born 0–10 years before the survey are included in this study.

The data structure for DHS and NFHS surveys are hierarchical in that births are nested within families and families within communities. In this study 'communities' are defined from the clusters used in survey sampling process. In the majority of the countries participating in the DHS programme, these clusters are derived from census enumeration areas. A key feature of such clusters is that households and individuals within a cluster are geographically close such that health outcomes may be related because of a shared environment and similar health care access. For multi-country comparisons, another level of hierarchy is the state or country.

The analysis was carried out in three parts. In the first stage, significant determinants of infant mortality were identified in all of the chosen settings including an estimation of the level of clustering of deaths at both family and community level. This was achieved by applying multilevel discrete-time hazard models to individual-level data. Five exposure periods were defined in the discrete-time hazards models: 0, 1– 4, 5–8, 9–11, and 12–13 months. The range of individual child and family variables (also known as 'micro' variables) is shown in Table 2.

The death of the previous child has been shown to be associated with the mortality risk of the index child. However, this effect can be confounded with the overall death clustering effect within a family (Curtis et al. 1993; Madise and Diamond 1995). To avoid ambiguity, the death of the previous sibling is not included in this paper and the random effect at the family level is allowed to capture the correlation of death clustering between all siblings of a family.

Another variable that is excluded from the analysis is breastfeeding since such information is recorded for births in the last three years in many of the surveys used in the study. If breastfeeding was included, the samples would have been reduced considerably.

The intra-family correlation coefficients were calculated using the formula proposed by Goldstein (1995)

$$\frac{\sigma_k^2 + \sigma_u^2}{\sigma_k^2 + \sigma_u^2 + \sigma_e^2}$$

where σ_k^2 is the community-level variance, σ_u^2 is the family-level variance, and σ_e^2 is the individual-level variance. Similarly, the intra-community correlations coefficients are calculated using the formula

$$\frac{\sigma_k^2}{\sigma_k^2 + \sigma_u^2 + \sigma_e^2}.$$

Since the data include births born as far back as ten years before the survey, the range of household socio-economic factors has been limited to parental education and maternal occupation since these are thought to change little between the onset of childbearing and the survey date.

The second part of the analysis sought to explain the levels of clustering found from the first stage, by regressing the intra-family correlation coefficients with country- or state-level factors under the following aspects of socio-economic wellbeing: development and economic; health; social welfare; gender equity; demography; and prevalence of HIV. These data were obtained from the Human Development Report produced by the United Nations and the equivalent publication from the Indian National Planning Commission (UNDP 1999; Indian Planning Commission 2000). The time period for the chosen indicators was roughly the same period as the survey date in each country or state. There are some minor differences in the way the human development index (HDI) was calculated by the United Nations and by the Indian government but these differences are unlikely to affect the comparisons in this paper too much. A list of the country- or state-level variables (referred to as ‘macro’ variables) is shown in Table 3. Box plots of selected indicators for the 16 Indian states and 18 African countries are shown in Figure 1.

The third stage of the analysis comprised the fitting of regional ‘supermodels’ in which all of the data from the 16 Indian states were pooled and a similar dataset created for the African countries. Because of the hugeness of the data sets, only two exposure durations were used: less than five months, and 5-13 months. For each regional supermodel a multilevel discrete-time hazards model with micro variables only was fitted (SM1). In this model the country, community, and family level variances were estimated. The second supermodel (SM2) extended SM1 by the addition of the macro variables in the fixed part of the model. The differences between the country, community, and family level variances from SM1 to SM2 were attributed to the inclusion of the macro variables.

Results

Table 1 gives some information about the number of births and levels of infant mortality in the 16 Indian states of India and 18 African countries. As one would expect, the average number of births per African family is higher since fertility is higher than in India. The average number of children per community is roughly the same. Overall levels of infant mortality are higher in the African countries than in the Indian states. The box plots in Figure 1 show slightly higher levels of human development in India than in Africa but with wider variation between the Indian states. Female-to-male literacy is slightly higher in Africa than in India. As expected, HIV prevalence is much higher in Africa than in India, infant mortality is lower in India but under-nutrition among children is higher.

[Figure 1 about here]

Stage One: Determinants of infant mortality

Tables 4a, 4b, are a summary of the significant determinants of infant mortality for the Indian states, and Tables 5a and 5b give the corresponding results for the African models. For easier presentation, only those determinants that were significant at a five per cent level or lower are included in the tables. These results concur with previous work in that they confirm the widespread risks of multiple births, and of births born after birth intervals of 23 months or less. Multiple births have, on average, eight times the risks of infant death in India compared with singleton births. The corresponding factor for Africa is about four. Children born after birth intervals of 23 months or less have about double the risks of dying in both regions compared with children born after intervals of between 24 and 35 months. Preceding birth intervals of three years or more are associated with about 30 per cent lower risks of dying in infancy compared with birth intervals of between two and three years. On average, first births have about 50 per cent higher risks of dying than higher-order births but there is wide variation in the relative risks ranging from 1.02 in Assam to 1.94 in Madhya Pradesh.

In the Indian states of Karnataka and Maharashtra there was evidence of declining infant mortality since births born 5–10 years before survey had higher mortality compared with the period 0–4 years before the survey. In Assam state infant mortality was higher in the more recent period. For Africa, there is evidence of declining infant mortality in six countries and increasing infant mortality in Nigeria and Zimbabwe. In Haryana and Punjab states of India, males have about 25 per cent lower risks of dying than females while in Karnataka, males are at higher risk compared with females. In the rest of the Indian states, the sex differential is not significant at five per cent level. In twelve of the 18 African countries, the sex of the child is significant and shows higher mortality for males.

[Tables 4a, 4b, 5a, and 5b about here]

The relationship between maternal age at birth and the risk of infant death is significant in fourteen African countries, and in nine Indian states. For both regions, the risks of dying for infants born to teenage mothers are elevated by about 30 per cent compared with infants born to mothers aged between 20 and 34 years. For births to older mothers (35 years or more), mortality risks are, on average, much higher among Indian infants those born in Africa. A J–shaped association between maternal age and infant mortality is evident in the Indian states while in Africa higher mortality risks are observed for births to teenage mothers only (see Figure 2).

[Figure 2 about here]

Socioeconomic determinants such as maternal and paternal education were significantly associated with infant mortality in some of the models. Maternal education is significant in 12 Indian states and 13 African countries. The association is in the expected direction: lower mortality risks for infants of mothers with secondary or higher education. The pattern of association between maternal occupation and infant mortality varies between the regions. In the three Indian states where this variable is significant, mortality risks are highest for births to mothers in non-agricultural occupations. In Africa, the direction of the association is inconsistent. In Kenya, Nigeria, Tanzania, and Zambia, the highest mortality risks are observed for births to women in agricultural occupations. However in Burkina Faso, Malaŵi, Niger, and Togo, births to women who were not working had the highest mortality risks. Urban residence is significant in three of the Indian states and in ten of the African models. In both regions, mortality is higher in rural than in urban areas.

The intra-family and intra-community correlation coefficients are calculated from the random variances after controlling for the individual and family characteristics as described above. These coefficients are presented in Table 6. Death clustering is higher and significant in more African countries than in India; the average intra-family correlation coefficient in Africa is about five per cent compared with one per cent in India. In Kenya and Côte d'Ivoire the intra-family correlation coefficient is about eleven per cent, while the highest for India is four per cent in Andhra Pradesh and Tamil Nadu. Death clustering within communities in Africa is slightly lower than within families. To illustrate the differences in death clustering between India and Africa, shaded maps have been constructed (see Figure 3). Clustering is defined as 'high' if the coefficient is at least one standard deviation above the mean, and defined as 'low' if equal to or below one standard deviation below the mean.

[Table 6 about here]

[Figure 3 about here]

Stage Two – Regression of intra-family correlation coefficients

Figure 4 shows scatter plots of the intra-family correlation coefficients for the 34 states/countries by selected macro variables and Table 7 shows the corresponding linear regression results. From Figure 4, it can be seen that Kenya and Côte d'Ivoire stand out with much higher death clustering than the rest. Similarly, Zimbabwe's HIV prevalence is significantly higher than the rest. Table 7 shows that countries or states with a larger proportion of the population who is poor have higher within-family death clustering (R^2 = 0.18). In terms of aggregate wealth, a negative association (after excluding Kenya and Côte d'Ivoire) is observed suggesting that death clustering is higher in those countries with lower average gross national incomes. The association between death clustering within families and HDI (which includes longevity, educational attainment, and gross income) is not significant.

Both the overall infant mortality and vulnerability to early death (measured by the per cent of the population not expected to live beyond 40 years) are positively associated with infant death. Thus, in high mortality countries, infant deaths are more concentrated within some families. Death clustering is higher in those countries where fertility is high ($R^2 = 0.16$). Lower death clustering is observed in those states or countries where under nutrition among children is higher.

[Figure 4 about here]

[Table 7 about here]

The HIV prevalence of a country or state has a positive and significant association with death clustering at a family level ($R^2 = 0.3$). When Zimbabwe is excluded, the association is stronger ($R^2 = 0.46$). Thus, deaths appear to be concentrated in some families in those countries where HIV prevalence is high. The ratio of female-to-male literacy is significant in the Indian states and does suggest that where large gender inequalities in literacy exist, death clustering within families is higher. To identify the most significant macro variable associated with death clustering, stepwise regression was performed, which showed that HIV prevalence was the most significant.

Stage Three – Regional models

The results from the final part of the analysis are presented in Table 8. For each region, two multilevel discrete-time hazards models were fitted: with micro variables only (SM1); and with micro and macro variables (SM2). The estimates for the micro variables from the pooled data are very close to the averages from the individual state models presented in Tables 4a–5b. For the African models, the macro variables that are significant are: the per cent of the population who is poor, gross national income, the level of under–nutrition among children, urbanisation, and the level of the human development index. Children from countries where a larger proportion of the population is classed as ‘poor’ have higher risks of infant death. The association between gross national income and infant death is such that children from countries with average gross incomes of less than U$200 have about 7 per cent higher risks of dying than infants from countries with higher average incomes.

Negative associations of infant death with the level of under-nutrition among children, the per cent urbanised, and human development were observed. For these African countries, a unit increase in the per cent of children who are underweight is associated with a one per cent decrease in the risks of dying. Similarly, a one per cent increase in the population who are urbanised is associated with a one per cent decrease in the risks of infant death. The association between infant death and HDI is very strong and suggests a reduction of 84 per cent in the risks of dying in infancy for every percentage increase in HDI.

[Table 8 about here]

For the Indian models, the macro variables that are significant are: poverty, the per cent of the population not expected to live beyond 40 years, and the ratio of female-to-male literacy. The relation between poverty and the probability of dying is opposite to that observed in the African pooled data. In India, lower levels of poverty at state level are associated with higher risks of dying in infancy. An association is observed between a child’s risk of infant mortality and the population’s overall vulnerability to death. A percentage increase in the proportion not expected to live beyond 40 years is associated with a four per cent increase in the risks of dying in infancy. The direction of association between female-to-male literacy and infant mortality was expected; on average, a one percentage increase in the ratio is associated with a reduction of about 56 per cent in the risks of dying in infancy. This suggests that children residing in states where the gap between female and male literacy is narrow have lower mortality risks compared with children who live in states where the gap is wider.

To turn to the changes in the random variances, a comparison of African supermodel SM1 with SM2 shows that the variance estimates at country and family levels reduce by about 90 per cent. The corresponding reduction for the community variance is about eight per cent. Similarly for the Indian supermodels (SM1 and SM2), the variance reduction is over 90 per cent for the state and family variances, and about eleven per cent for the community level variance. This suggests that part of the variation in infant mortality between children of different nations can be explained by levels of poverty, human development, and levels of under-nutrition in Africa. In India, female literacy, poverty, and vulnerability to mortality explain some of the differences in mortality risks between children of different families. Surprisingly HIV prevalence is not associated with individual children's risks of infant death in the supermodels. The intra-family correlation coefficient from the pooled Indian data (Model SM2) is two per cent and that for Africa is about four per cent. These values are similar to the averages obtained from the individual models.

Discussion

This study has provided interesting findings of the determinants of infant mortality and death clustering in sub-Saharan Africa and India. Using a range of different approaches, the study confirms the findings from many studies—for example, in all the 34 states/countries, the study has found that short birth intervals and multiple births are associated with higher infant mortality and this finding is preserved using pooled and individual-country analyses. Similarly the association between maternal education and infant mortality appears quite robust and is in the expected direction. A significant contribution of this study is the identification of correlates of infant mortality that have not been studied much. Examples of these include: gender inequality in literacy, poverty, human development and levels of under-nutrition among children. Further, the study has found significant associations of infant death clustering with health and economic variables at country level.

One interesting finding is the different pattern of association between infant mortality and the age of the mother at birth between the two regions. It would appear that regional patterns of fertility behaviour have a bearing on infant mortality differentials. In India, childbearing starts and stops very early, such that women who give birth after the age of 35 years may be ‘high risk’ women (for example, women with high parity or those with previous foetal loss). Thus it is not surprising to find elevated mortality risks for births to such older women. In contrast, African women have higher fertility, spread throughout their reproductive life. Higher infant mortality risks are apparent for teenage mothers but not for older mothers.

Gender differentials in infant mortality also portray the regional divide between Africa and India. Higher male mortality is observed in the African countries and confirms the theory of male biological disadvantage in early life (Waldron 1998). In India, the differential is inconsistent and less significant. Griffiths et al. (2003), who examined child nutrition in India and Africa and found similar results, argue that the fact that sex differentials are insignificant when male disadvantage is expected is in itself a sign of male preference in India.

To turn to death clustering, this study has found lower levels of death clustering in India than in Africa. One explanation for lower death clustering in India compared with Africa is the lower fertility and lower infant mortality in India which means that the numbers of births and deaths with which to estimate death clustering are smaller. This explanation is consistent with the positive association observed between death clustering and total fertility and also with infant mortality in Table 7. Infant death clustering is highest in Kenya and Côte d'Ivoire but it is not apparent why this is so. An examination of the macro-level variables such as aggregate income, urbanisation, and sanitation did not show peculiar features in these countries. Certainly HIV prevalence is high in these two countries but the levels are not the highest among the countries studied. It is possible that other inequalities that are not included in our study contribute to the concentration of deaths within particular families in these two countries.

The explanations for death clustering have centred on childcare practices, use of health services and personal attributes of mothers (Das Gupta 1990; Curtis et al. 1993; Pebley et al. 1996; Sastry 1997). The results from our study suggest that the economic and social development of the countries in which children live may influence their survival as well as the distribution of deaths across families. A high proportion of the population who are below the poverty line is an indicator not only of corporate poverty but also of inequalities in the distribution of resources. A positive association between this indicator and death clustering is consistent with the hypothesis that in resource-poor, non-egalitarian nations, the poorest families may have not have access to adequate health care thereby resulting in a concentration of deaths within these sub-groups (Madise et al.,1999). The finding of higher mortality risks for individual children in those Indian states where there are lower proportions of the population who are classed as 'poor' is surprising but it does suggest that wealth indicators alone may not be sufficient in predicting infant mortality in India (Das Gupta 1997; Claeson et al. 2000).

A strong negative association is observed between the probability of dying in infancy and the level of HDI of the African country that a child lives in. Human development, which includes indicators of health as well as achievements in education, is a better measure of welfare than mere economic indicators. As a nation develops its human resource, mortality for individual children will also reduce since improving human development requires investments in health and social wellbeing across the population.

Higher ratios of female-to-male literacy in India are associated with lower infant mortality and this is in addition to the negative association between a child's mortality risks and its mother's level of education. In addition this measure of gender inequality in literacy is negatively associated with death clustering, suggesting that in the states where the gap between women's and men's literacy is wide, there is a concentration of death in fewer families. At a household or family level, explanations for the positive benefit of education on child survival include better childcare practices, higher use of health services, and access to higher incomes among the more educated mothers (Das Gupta 1990; Steele et al. 1996; Desai and Alva 1998). When it comes to aggregate literacy rates, nations that invest in female education may be more progressive and therefore also more likely to invest in child health. Higher female literacy rates may also encourage diffusion of innovative ideas on childcare and use of health services, thereby reducing inequalities in child survival.

This study has found a positive association between levels of mortality and death clustering. Countries with high mortality levels often have poor social indicators, poor environmental conditions, and less investment in public health. The synergy between these factors can create inequalities in health outcomes to the extent that some families become more vulnerable to multiple child losses than others (Ahmad et al 2000; Wagstaff 2000).

The HIV prevalence of the country appears not to have a strong association with the mortality risks of individual children. Adetunji (2000) who examined mortality levels in countries with different adult HIV prevalence rates found weak associations between the two variables, except in countries with very high HIV prevalence (greater than 5 per cent). The strong association between infant death and the HIV status of mothers is clear from longitudinal studies (Crampin et al. 2003). However, with cross-sectional surveys such as those conducted by the DHS programme, there are difficulties in measuring infant mortality accurately since births to mothers who have died are often not recorded in these surveys (Ahmad 2000). In such cases, the mortality risks of births to HIV-positive mothers may be under-reported and the link between HIV and infant mortality would appear weaker.

A very strong and positive link between HIV prevalence and death clustering is observed however. Of all the macro variables, HIV prevalence emerged as the most important predictor of death clustering. This association might be even stronger if measurement problems indicated above were overcome. The association between the HIV prevalence and the degree of death clustering implies that a country with a high proportion of its population who are HIV positive can expect to see more concentration of infant deaths in particular families. Given the high risk of mother–to–child transmission of the HIV virus, it is not surprising that death clustering is stronger in high prevalent nations. The link between death clustering and HIV prevalence appears less influenced by economic prosperity. Indeed the HIV rates for the 34 states and countries in the study have a weak association with gross national income ($r = -0.24$, $p\text{-value} > 0.16$).

Conclusions

The study has compared levels of death clustering in India and Africa, after controlling for known socio-economic and demographic determinants of infant mortality. The study has highlighted interesting similarities and differences between the two regions. For example, the relationship between child survival and the sex of the child appears to be region-specific, with no evidence of male disadvantage in India while the findings in Africa are consistent with the universal finding of higher male mortality in infancy. The relationship between infant mortality and the length of preceding birth intervals however, is consistent regardless of location.

The explanations for death clustering within families have so far focused on genetic traits, parental competence in childcare, and on the use of health services. This study has provided, using data from Africa and India, evidence that the distribution of infant deaths among families is also influenced by the wider environment into which children are born. Levels of mortality, economic and social development, and prevalence of communicable diseases such as HIV appear to contribute to the propensity of some families to lose their children more than others. While some associations found in the study are easier to explain, for example HIV prevalence and death clustering, others are more complex. This suggests that there is need to find better ways of teasing out the components of death clustering and perhaps taking into consideration other global and national factors that may explain the huge inequalities in infant mortality that are present in our world.

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Table 1 Indian NFHS and African DHS surveys used in the study showing, the year of survey, number of births and infant mortality.

Country	Year of of Survey	Total births 0-10 years to survey	Average number of births Family	 Community	IMR[a]
Africa					
Benin	2001	10,395	2.31	86.62	89
Burkina Faso	1999	11,743	2.41	116.18	105
Cameroon	1998	7,859	2.12	83.61	77
Côte d'Ivoire	1998/99	3,884	1.96	61.65	112
Ghana	1998	6,555	1.93	34.50	57
Guinea	1999	12,011	2.27	81.16	98
Kenya	1998	11,193	2.05	45.31	74
Madagascar	1997	11,399	2.27	86.36	96
Malaŵi	2000	21,894	2.19	79.91	104
Mozambique	1997	13,440	2.07	71.11	135
Niger	1998	15,333	2.63	114.43	123
Nigeria	1999	12,408	2.26	67.43	75
Rwanda	2000	14,755	2.29	69.37	107
Tanzania	1999	6,151	2.16	73.23	99
Togo	1998	14,056	2.27	97.67	80
Uganda	1995	13,056	2.44	96.71	81
Zambia	1996	13,162	2.26	84.37	109
Zimbabwe	1999	6,923	1.73	62.37	65
Average for Africa		*11,457*	*2.20*	*78.43*	*94*
India					
Andhra Pradesh	1999	4,222	1.48	63.97	66
Assam	1999	4,329	1.69	88.35	78
Bihar	1999	11,170	1.96	97.13	67
Delhi	1999	2,966	1.57	59.32	35
Gujarat	1999	4,423	1.57	67.02	64
Haryana	1999	3,894	1.68	79.47	69
Karnataka	1999	4,779	1.54	71.33	58
Kerala	1999	2,385	1.31	48.67	16
Madhya Pradesh	1999	10,690	1.92	93.77	97
Maharasthra	1999	5,936	1.52	54.46	49
Orissa	1999	5,507	1.63	83.44	98
Punjab	1999	3,281	1.56	66.96	54
Rajasthan	1999	10,858	1.96	94.42	83
Tamil Nadu	1999	4,438	1.39	56.18	53
Uttar Pradesh	1999	15,709	2.07	95.79	85
West Bengal	1999	4,519	1.47	57.94	53
Average for India		*6,194*	*1.65*	*73.64*	*64*

[a] Relates to 0-4 years before DHS/NFHS Survey.

Table 2 Micro-level variables used in the models and their codings

Individual child level	
Sex	Coded as 1 = male, 0 = female.
Birth cohort	Coded as 0 = born 0-4 years before the survey; 1 = born 5-10 years before the survey.
Birth order	Coded as 1 = first birth; 0 = 2-5; 2 = 6+.
Multiple birth	Whether child is singleton or multiple birth.
Preceding birth interval	Coded as 1 = < 24 months; 0 = 24-47 months; 2 =48 or more months.
Maternal age at birth	Coded as 1= < 20 years; 0 = 20-34 years; 2 = 35 years or above.
Family- level	
Maternal education	Coded as 0 = none; 1= primary; 2 = secondary or higher.
Paternal education	Educational level of current partner of the mother. Coded as 0 = none or no partner; 1 = primary; 2 = secondary or higher.
Maternal occupation	Coded as 0 = housewife; 1 = agricultural; 2 = other.
Community level	
Urban residence	Coded 1 = urban; 0 =rural

Table 3 Macro-level explanatory variables used in Stage 2 analyses

Development and economic indicators
Gross national income per capita (US$)
Human development index — a composite index incorporating longevity, educational attainment and aggregate wealth
Population below poverty line (1$ per day)
Urbanisation (percentage of the population who live in urban areas)

Health indicators
Infant mortality
Under-five mortality
Percentage of the population not expected to live beyond 40 years
Percentage of under-five children who are underweight
Percentage of women/pregnant women who are underweight
Average energy consumption (in kilo calories)
Percentage of birth attended by skilled health professionals
Maternal mortality ratio

Social welfare indicators
Adult, male and female literacy
Population with access to safe water
Population with access to sanitation

Gender equity indicators
Ratio of female-to-male life expectancy
Female-to-male literacy rate

Demographic indicators
Total fertility
Contraceptive prevalence
Crude birth rate
Crude death rate

Prevalence of communicable diseases
HIV prevalence

Sources: The Human Development Report, 1997- 1999 from the United Nations and the 2000 Indian Human Development Report.

Table 4a Average relative risks of infant death by background characteristics in selected Indian states

Relative risks	Andhra Pradesh	Assam	Bihar	Delhi	Gujarat	Haryana	Karnataka	Kerala	*Mean*
Exposure period									
0 months	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
1-4 months	0.32	0.46	0.30	0.43	0.21	0.36	0.23	0.12	*0.31*
5-8 months	0.13	0.14	0.17	0.21	0.23	0.25	0.11	0.19	*0.18*
9-11 months	0.06	0.07	0.07	0.10	0.12	0.14	0.06	0.06	*0.09*
12-13 months	0.09	0.07	0.12	0.18	0.10	0.27	0.06	0.06	*0.13*
Multiple birth	5.02	3.25	8.76	16.28	8.96	11.05	10.89	9.22	*8.16*
Preceding birth interval									
< 24 months	2.00	1.61	2.05	1.50	2.01	2.18	2.28	2.29	*2.01*
24-35 months	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
36+ months	0.55	0.66	0.70	0.53	0.68	0.96	0.81	0.73	*0.73*
First birth	1.50	1.02	1.34	1.13	1.42	1.74	1.60	1.94	*1.50*
Higher birth order									
2-5		1.00							*1.00*
6+		1.44							*1.46*
Birth cohort 5-10 yrs		0.73					1.40		*1.14*
Sex of child-male						0.72	1.29		*0.92*
Maternal age									
<20 years		1.39	1.27	1.79				1.00	*1.34*
20-34		1.00	1.00	1.00				1.00	*1.00*
35+		2.03	1.86	1.00				7.80	*2.31*
Maternal education									
None		1.00	1.00	1.00	1.00	1.00			*1.00*
Primary		0.94	0.79	0.72	0.93	0.60			*0.84*
Secondary +		0.71	0.64	0.63	0.57	0.52			*0.57*
Paternal education									
None	1.00		1.00	1.00	1.00		1.00		*1.00*
Primary	0.84		0.95	0.65	0.73		0.83		*0.88*
Secondary+	0.49		0.80	0.44	0.63		0.49		*0.64*
Maternal occupation									
Not working			1.00			1.00			*1.00*
Agricultural			1.07			1.00			*1.07*
Non-agricultural			1.30			1.66			*1.42*
Urban residence									*0.61*

Table 4b Average relative risks of infant death by background characteristics in selected Indian states

Relative risks	Madhya Pradesh	Mahara-Shtra	Orissa	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	West Bengal	*Mean*
Exposure period									
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
1-4	0.32	0.23	0.40	0.36	0.31	0.19	0.30	0.37	*0.31*
5-8	0.21	0.15	0.18	0.12	0.22	0.17	0.20	0.13	*0.18*
9-11	0.10	0.07	0.07	0.14	0.13	0.08	0.08	0.06	*0.09*
12-13	0.24	0.08	0.12	0.12	0.24	0.04	0.20	0.11	*0.13*
Multiple birth	9.78	10.80	6.89	5.23	5.24	7.63	6.69	4.90	*8.16*
Preceding birth interval									
< 24 months	2.07	2.05	1.86	2.51	2.12	2.08	1.92	1.78	*2.01*
24-35 months	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
36+ months	0.78	1.03	0.72	0.66	0.72	1.00	0.59	0.56	*0.73*
First birth	1.77	1.39	1.27	1.76	1.78	1.06	1.37	1.46	*1.50*
Higher birth order									
2-5				1.00	1.00		1.00		*1.00*
6+				1.84	1.26		1.30		*1.46*
Birth cohort 5-10 yrs		1.27							*1.14*
Sex of child-male				0.76					*0.92*
Maternal age at birth									
<20 years	1.33	1.32	1.35			1.30	1.27		*1.34*
20-34	1.00	1.00	1.00			1.00	1.00		*1.00*
35+	1.23	2.14	1.00			2.49	1.22		*2.31*
Maternal education									
None	1.00		1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
Primary	0.77		0.80	0.83	1.01	0.98	0.81	0.84	*0.84*
Secondary or higher	0.59		0.57	0.54	0.53	0.57	0.65	0.41	*0.58*
Paternal education									
None		1.00	1.00		1.00		1.00		*1.00*
Primary		0.77	1.21		1.00		1.00		*0.89*
Secondary or higher		0.60	0.71		0.77		0.84		*0.64*
Maternal occupation									
Not working							1.00		*1.00*
Agricultural							1.15		*1.07*
Non-agricultural							1.31		*1.42*
Urban residence	0.64	0.46					0.76		*0.62*

Table 5a Average relative risks of infant death by background characteristics in selected Africa countries

Relative risks	Benin	Burkina Faso	Cameroon	Cote d' Ivoire	Ghana	Guinea	Kenya	Madagascar	Malaŵi	*Mean*
Exposure period										
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
1-4	0.47	0.79	0.46	0.48	0.52	0.60	0.71	0.68	0.61	*0.61*
5-8	0.55	0.47	0.32	0.38	0.40	0.43	0.64	0.59	0.57	*0.53*
9-11	0.36	0.35	0.24	0.18	0.16	0.13	0.23	0.28	0.33	*0.29*
12-13	0.33	0.66	0.35	0.21	0.33	0.51	0.32	0.28	0.47	*0.40*
Multiple birth	4.75	3.35	4.16	3.16	5.75	3.44	4.45	3.56	3.94	*4.00*
Preceding birth interval										
< 24 months	1.90	1.77	1.85	1.91	2.39	1.28	1.51	2.05	1.93	*1.90*
24-35 months	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
36+ months	0.88	0.53	0.61	0.58	0.78	0.46	0.71	0.63	0.82	*0.73*
First birth	1.34	1.79	1.22	1.43	1.88	1.26	1.06	1.43	1.58	*1.46*
Higher birth order										
2-5	1.00	1.00					1.00	1.00		*1.00*
6+	1.21	1.17					1.27	1.32		*1.26*
Birth cohort 5-10 yrs						1.12			1.16	*1.07*
Sex of child-male		1.11		1.33		1.13		1.22	1.08	*1.18*
Maternal age										
<20 years	1.30		1.30	1.42		1.00	1.40	1.22	1.27	*1.27*
20-34	1.00		1.00	1.00		1.00	1.00	1.00	1.00	*1.00*
35+	1.10		0.98	1.05		1.20	1.05	1.03	1.09	*1.09*
Maternal education										
None			1.00	1.00		1.00	1.00	1.00	1.00	*1.00*
Primary			0.82	0.80		0.84	0.93	0.88	0.95	*0.88*
Secondary or higher			0.51	0.64		0.73	0.66	0.54	0.58	*0.58*
Paternal education										
None	1.00		1.00		1.00	1.00			1.00	*1.00*
Primary	0.98		0.62		0.96	0.95			0.95	*0.90*
Secondary or higher	0.65		0.73		0.73	0.79			0.80	*0.71*
Maternal occupation										
Not working		1.00				1.00	1.00		1.00	*1.00*
Agricultural		0.93				1.02	1.20		0.88	*1.07*
Non-agricultural		0.86				0.83	1.01		0.89	*0.95*
Urban residence	0.78	0.58		0.70	0.64	0.81			0.72	*0.71*

Table 5b Average relative risks of infant death by background characteristics in selected Africa countries

Relative risks	Mozambique	Niger	Nigeria	Rwanda	Tanzania	Togo	Uganda	Zambia	Zimbabwe	***Mean***
Exposure period										
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***1.00***
1-4	0.62	0.56	0.49	0.59	0.68	0.44	0.71	0.87	0.78	***0.61***
5-8	0.56	0.72	0.40	0.57	0.61	0.40	0.75	0.80	0.33	***0.53***
9-11	0.26	0.55	0.19	0.31	0.27	0.25	0.39	0.53	0.27	***0.29***
12-13	0.34	0.52	0.53	0.34	0.32	0.36	0.43	0.52	0.42	***0.40***
Multiple birth	3.99	4.20	3.18	3.97	3.45	3.80	4.10	4.01	4.65	***4.00***
Preceding birth interval										
< 24 months	1.69	1.54	1.77	1.98	1.45	2.50	1.88	1.95	2.87	***1.90***
24-35 months	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	***1.00***
36+ months	0.45	0.66	0.86	0.61	0.90	0.82	0.74	0.90	1.14	***0.73***
First birth	1.54	1.34	1.45	1.37	1.54	1.46	1.67	1.27	1.68	***1.46***
Higher birth order										
2-5	1.00		1.00							***1.00***
6+	1.16		1.42							***1.26***
Birth cohort 5-10 yrs	1.17	1.23	0.84	1.14			1.12		0.77	***1.07***
Sex of child-male	1.10	1.10		1.13		1.29	1.12	1.21	1.25	***1.18***
Maternal age										
<20 years		1.32	1.25	1.11	1.30	1.25	1.21	1.45		***1.27***
20-34		1.00	1.00	1.00	1.00	1.00	1.00	1.00		***1.00***
35+		1.12	1.39	1.19	1.00	1.19	0.91	0.96		***1.09***
Maternal education										
None	1.00			1.00	1.00	1.00	1.00	1.00	1.00	***1.00***
Primary	1.12			0.87	0.91	0.87	0.88	0.80	0.74	***0.88***
Secondary or higher	0.46			0.48	0.43	0.76	0.58	0.61	0.56	***0.58***
Paternal education										
None	1.00	1.00	1.00	1.00		1.00	1.00			***1.00***
Primary	0.89	0.80	0.90	0.90		0.86	1.07			***0.90***
Secondary or higher	0.67	0.46	0.65	0.73		0.80	0.77			***0.71***
Maternal occupation										
Not working		1.00	1.00		1.00	1.00		1.00		***1.00***
Agricultural		0.90	1.40		1.30	0.77		1.22		***1.07***
Non-agricultural		0.90	1.14		1.10	0.76		1.14		***0.95***
Urban residence	0.64	0.61		0.82		0.83				***0.71***

Table 6 Death clustering correlation coefficients for selected Indian States and African countries

	Level	
	Family	Community
Africa		
Benin	NS	NS
Burkina Faso	0.05	0.01
Cameroon	0.03	0.03
Côte d'Ivoire	0.11	0.02
Ghana	0.04	0.04
Guinea	0.02	0.02
Kenya	0.11	0.11
Madagascar	0.03	0.03
Malaŵi	0.06	0.02
Mozambique	0.05	0.05
Niger	0.02	0.02
Nigeria	0.05	0.05
Rwanda	0.02	0.02
Tanzania	0.02	0.02
Togo	0.06	0.01
Uganda	0.06	0.02
Zambia	0.06	0.02
Zimbabwe	0.05	0.05
Average	*0.05*	*0.03*
India		
Andhra Pradesh	0.04	0.04
Assam	NS	NS
Bihar	0.03	0.03
Delhi	NS	NS
Gujarat	0.03	0.03
Haryana	NS	NS
Karnataka	0.02	0.02
Kerala	NS	NS
Madhya Pradesh	0.01	0.01
Maharashtra	NS	NS
Orissa	NS	NS
Punjab	NS	NS
Rajasthan	0.02	0.02
Tamil Nadu	0.04	0.04
Uttar Pradesh	0.02	0.02
West Bengal	NS	NS
Average	*0.01*	*0.01*

NS – not significant at 10% level.

Table 7 Linear regression of intra-family death clustering correlation coefficients and significant macro-level variables

Variables	Excluded cases	Standardised Beta coefficients	R^2	p-value
Development and Economic				
Population who are below the poverty line	–	0.42	0.18	0.01
Gross national income (US$)	Kenya and Cote d'Ivoire	-0.39	0.12	0.03
Health and Demographic variables				
Infant mortality	–	0.33	0.11	0.05
Total fertility	–	0.42	0.16	0.01
Crude birth rate	–	0.42	0.15	0.02
Population not expected to live beyond 40 years	–	0.55	0.28	0.001
Children who are underweight	–	-0.47	0.20	0.001
Communicable diseases				
Adult HIV prevalence	Zimbabwe	0.69	0.46	< 0.00
Gender Equity				
Ratio of female-to-male literacy	Africa	-0.52	0.27	0.04

Table 8 Average relative risks of infant death for Indian and Africa pooled supermodels (SM1 = micro variables; SM2= with micro + macro variables)

	Africa supermodels		India supermodels	
Micro variables	Africa SM1	Africa SM2	India SM1	India SM2
Time duration (5-13 months)	0.80	0.79	0.36	0.33
Birth cohort	NS	NS	NS	NS
Multiple birth	4.06	4.01	8.08	7.61
Sex of child-female	1.14	1.14	NS	NS
Maternal age				
< 20 years	1.23	1.24	1.26	1.25
20-34 years	1.00	1.00	1.00	1.00
35+	1.09	1.10	1.34	1.32
Birth order				
First	1.43	1.43	1.54	1.52
2-5	1.00	1.00	1.00	1.00
6+	1.08	1.08	1.23	1.22
Preceding birth interval				
< 24 months	1.82	1.82	1.99	1.97
24-47 months	1.00	1.00	1.00	1.00
48 or more months	0.69	0.69	0.70	0.70
Maternal education				
None	1.00	1.00	1.00	1.00
Primary	0.92	0.92	0.85	0.86
Secondary+	0.66	0.66	0.63	0.63
Paternal education				
None	1.00	1.00	1.00	1.00
Primary	0.92	0.92	0.95	0.96
Secondary+	0.78	0.78	0.79	0.80
Maternal Occupation				
Not working	NS	NS	1.00	1.00
Agricultural			1.03	1.03
Non-agricultural			1.12	1.12
Urban residence	0.77	0.78	0.76	0.76
Macro-level variables				
% below poverty line	–	1.01	–	0.98
Gross national income < 200$	–	1.07	–	
% children underweight	–	0.99	–	NS
Population who are urbanised	–	0.99	–	NS
Human development index	–	0.16	–	NS
Population not expected to live beyond 40 years	–	NS	–	1.04
Female-to male literacy	–	NS	–	0.44
Random variances				
Country/state	0.03**	0.01*	0.06**	0.01**
Community	0.12**	0.11**	0.08**	0.07**
Family	0.28*	0.03	1.31**	0

**Variance at that level are significant at < 0.05 level. * Variance significant at < 0.1 level; NS -not significant.

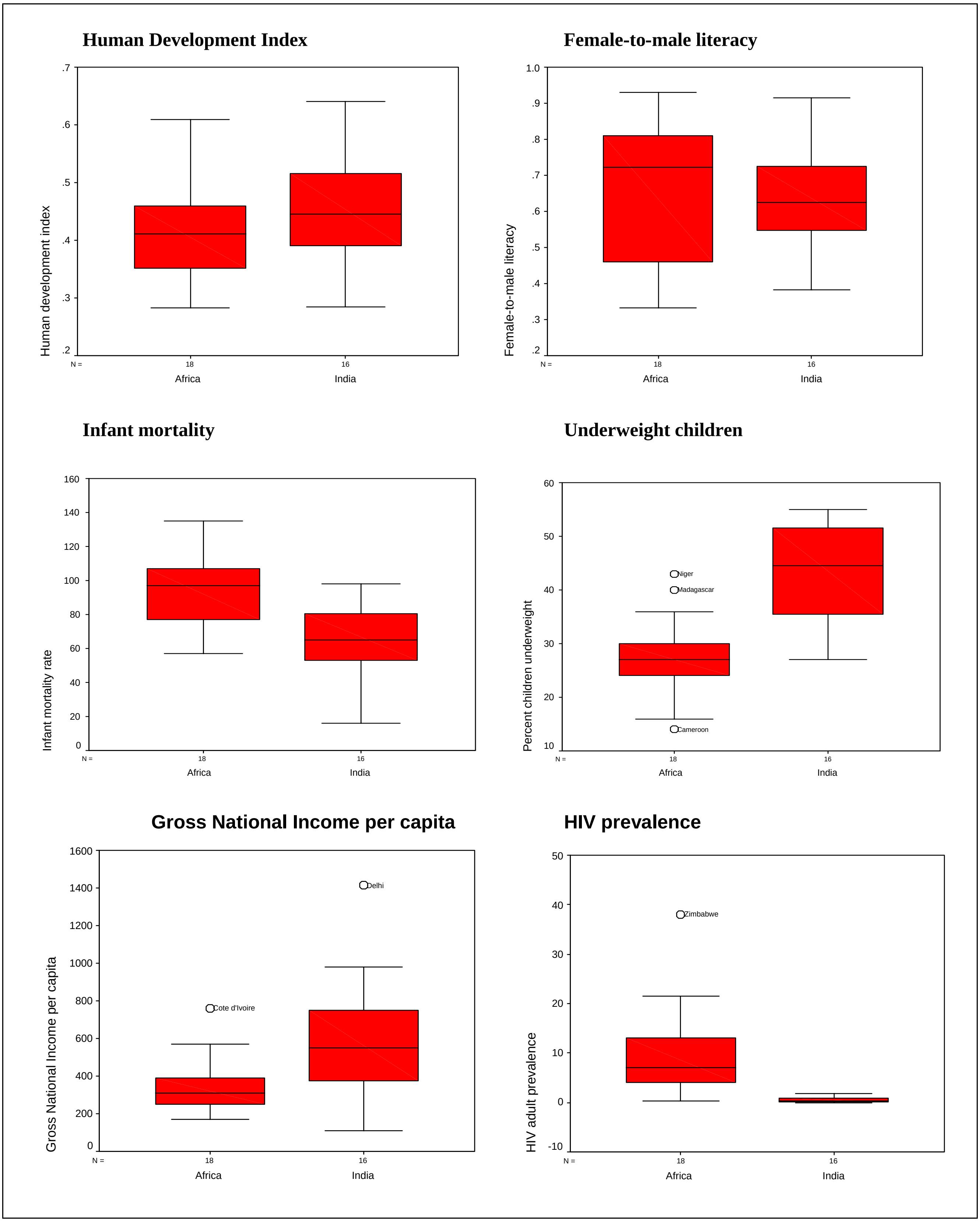

Figure 1 Box plots of selected indicators for 18 African countries and 16 Indian states

Figure 2 Average relative risks of infant death by maternal age at birth for selected Indian states and sub-Saharan African countries

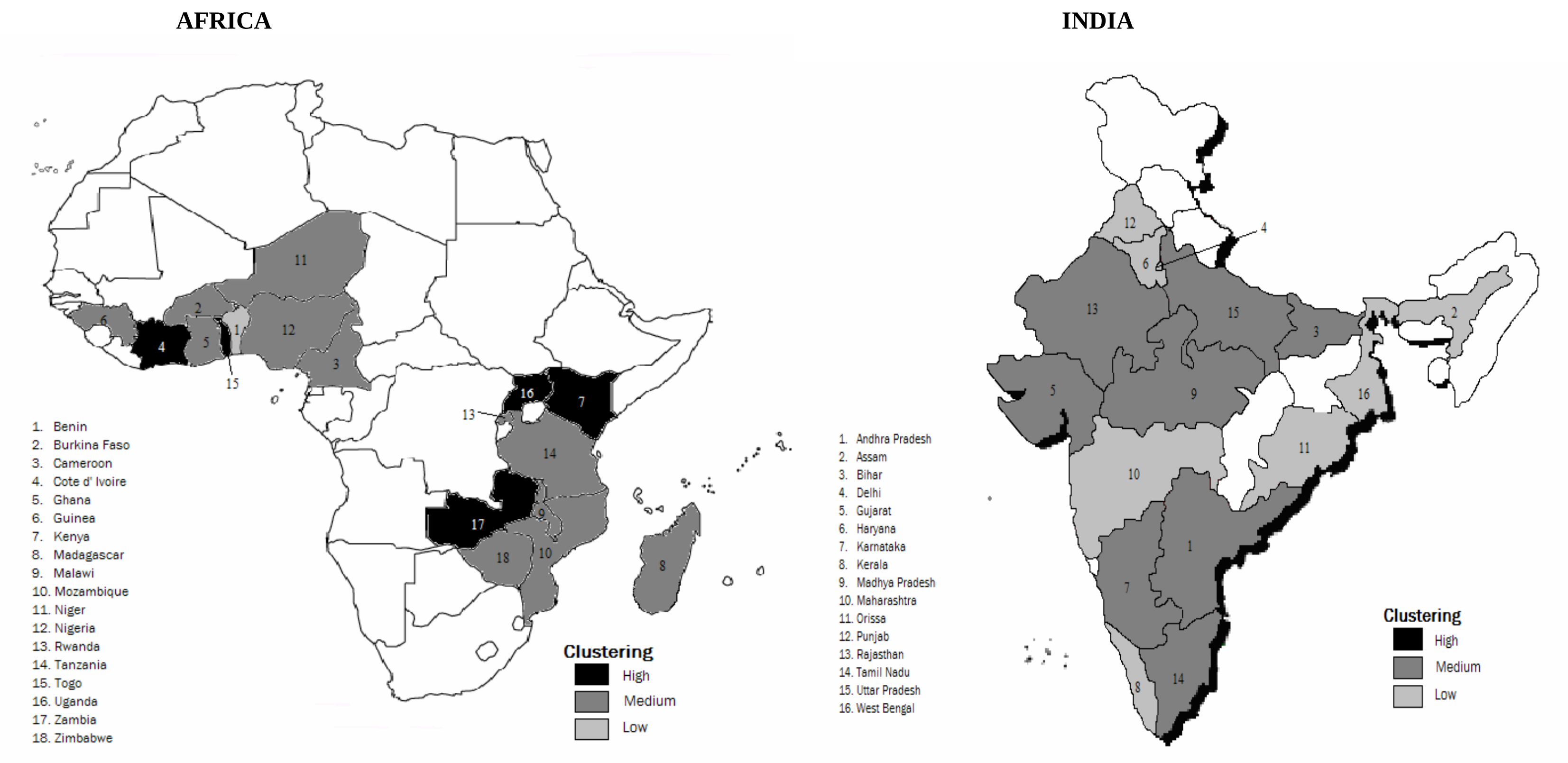

Figure 3 Intra-family correlation coefficients for selected Indian states and African countries

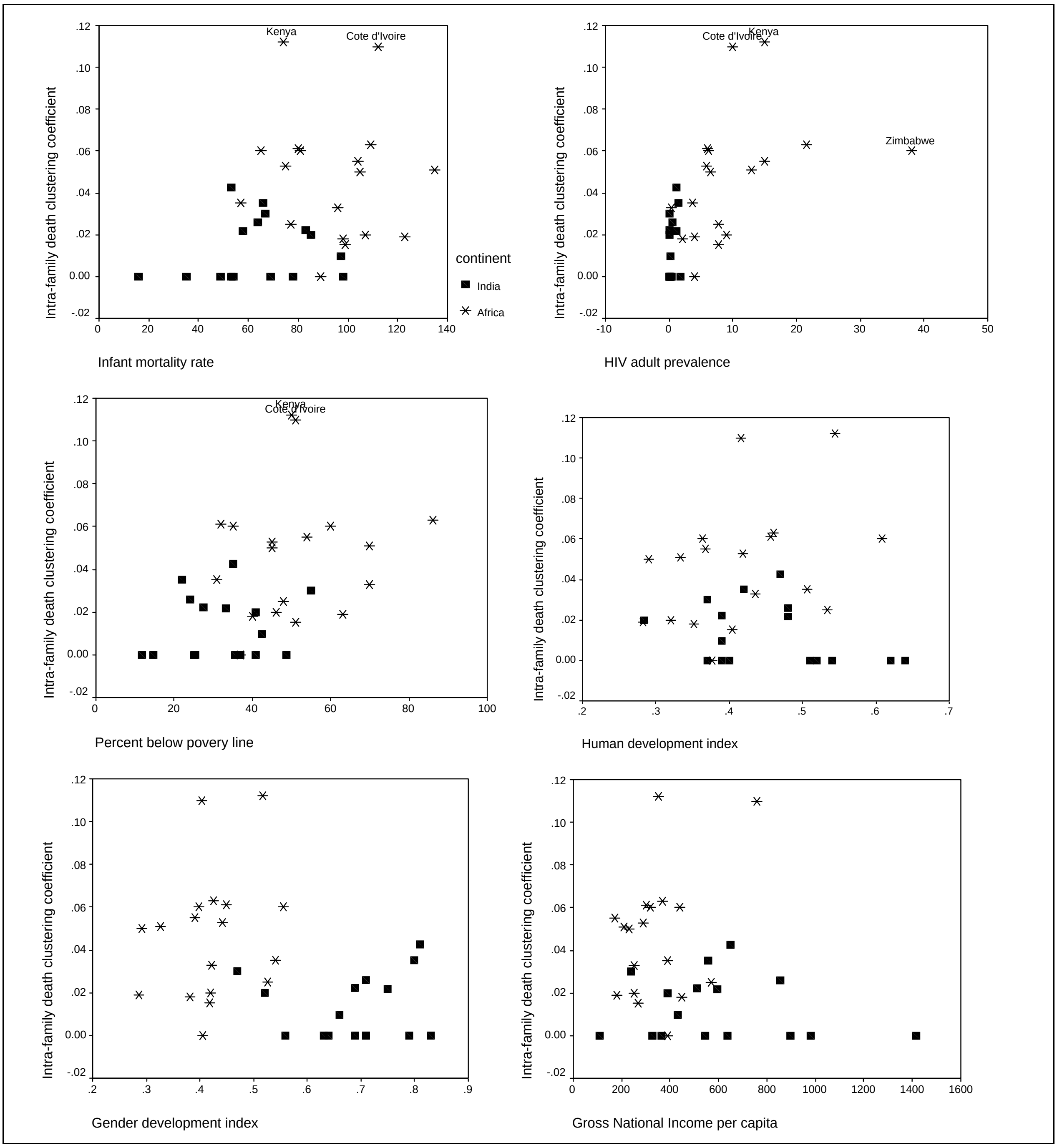

Figure 4 Intra-family correlation coefficients for 16 Indian states and 18 sub-Saharan African countries by selected indicators