Environment, Access to Health Care, and Other Factors Affecting Infant and Child Survival Among the African and Coloured Populations of South Africa, 1989–94

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Some maintain that environmental factors are unimportant for infant and child survival once mother's education and other characteristics have been taken into account. However, an analysis of survival of African and Coloured children based on the 1994 October Household Survey supports the importance of environmental factors in relatively high mortality populations. Among African households, the source of domestic water is important, but for Coloured households, almost all of which have safe water, the type of sanitation is important. If safe drinking water is available, the type of sanitation influences survival; if safe drinking water is not available, sanitation seems to matter little.

KEY WORDS: safe water; sanitation; infant mortality; less developed countries.

INTRODUCTION

Infant and child survival is important to families, communities and countries. In high mortality settings, infant and child mortality typically de-

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clines at an earlier date than mortality at older ages. The most common indicator of infant and child survival is the infant mortality rate (IMR), which is the number of children dying within the first year of life out of 1000 births. A society whose IMR is low is viewed as being healthier than one in which the IMR is high. The IMR is also frequently used as an indicator of a society's level of socioeconomic development, with a lower IMR being associated with a higher level of socioeconomic development.

Three kinds of explanations have been put forth for factors related to the level of infant mortality: socioeconomic characteristics, access to and use of health care and environmental conditions.

Socioeconomic characteristics have increasingly been believed to be important for infant and child survival. Prime among the household characteristics is the educational level of the mother, with higher maternal education contributing to higher rates of infant survival (Caldwell, 1979; Caldwell & McDonald, 1982; Hobcraft, 1993; Morelos, 1996; Sufian, 1990; United Nations, 1985). Infant mortality is also associated with the place of residence of the parents, with urban settings having lower rates than rural settings.

There has long been a controversy about the role of medical care in mortality. McKeown (1976) argued that mortality decline in England and Wales in the 18th and 19th centuries was mainly related to improvement in the overall standard of living and was little affected by most medical care. In developing countries, there has been consideration of the role of preventive versus curative medical care, with most credit for mortality decline resting with preventive care, such as vaccination programs. While it has been argued that access to health services is important (Frankenberg, 1995; Jain, 1985; Lalou & LeGrand, 1995; Niraula, 1994; Sandiford et al., 1991), it has sometimes been unclear whether availability of health care by itself will affect infant and child survival or whether other factors, such as mother's education, dominate. The argument is that mothers with a relatively high level of education will be likely to perceive the need for such care and act on it (Mason, 1984).

Environmental conditions have long been considered to be significant influences on mortality. John Snow's (1855) work on a specific water pump in London as the source of a cholera outbreak is noted as the prime example of the value of geographic epidemiology and of the salience of the environment. However, the difficulty of disentangling environmental factors from other influences has led some scholars and policy advisors to support improvements in water supply and in sanitation, while being frustrated by their inability to attribute mortality differentials directly to these sources (Churchill, 1987). Further, some recent assessments of Snow's work

have questioned whether shutting off the water from the Bank Street pump actually led to the ending of the cholera epidemic or whether the epidemic had already abated before that (McLeod, 2000; Sandler, 2000). Other research has supported the importance of environmental factors in infant mortality (Burger & Esrey, 1995; Hammerslough, 1990; Merrick, 1985; Pant, 1991; Rajna et al., 1998; Timaeus & Lush, 1995). Still others claim that safe water is necessary but not sufficient for infant and child survival and suggest that safe water will not be important unless sanitation is also good (Esrey & Habicht, 1985). Yet others have argued that the effects both of water supply and of sanitation are greatly diminished or disappear when household socioeconomic characteristics are taken into account (United Nations, 1985; van Poppell & van der Heijden, 1997; Woldemicael, 1998).

This paper investigates the role of these three kinds of factors in infant and child survival among the African and Coloured populations of South Africa for the period 1989–1994. Under apartheid these populations were severely disadvantaged, and many of these disadvantages persist. This analysis provides a baseline for the determinants of infant and child death in the new South African state, which was established in 1994.

POPULATION GROUPS IN SOUTH AFRICA

Under apartheid in South Africa people were classified into four official population groups: Whites, Asians, Coloureds and Africans. There were separate educational and health systems for each group, and the rights and privileges for each group differed greatly. White institutions and systems had the greatest resources and the African systems had the least resources. Apartheid laws were largely abolished by 1990 and the first democratic non-racial elections in South Africa were held in 1994.

Under apartheid the vast majority of Africans were not allowed to be permanent residents in urban areas and could only have legal residence in "homelands." These homelands comprised 13% of the land area of South Africa although Africans comprised 74% of the total population of South Africa.

The Coloured are primarily located in the Cape Town region. They are a mixture of Dutch, Malay, Khoikhoi and other groups. The Khoikhoi are an African group traditionally located in the Cape Town area. Intermarriage among these groups dates to the 17th century. While the Coloured under apartheid were subject to substantial discrimination, they were allowed legal residence in cities. Asians are primarily those of Indian background but also include Chinese. Asians are concentrated in the Natal region. While

they have done well in socioeconomic terms, there also was substantial legal discrimination against Asians under apartheid.[1]

The variation in the IMR among population subgroups is striking. The estimated IMR of 46 for *circa* 1990 bears little relation to the IMR for the major population groups for that period: 51 for the African population, 29 for the Coloured population, 10 for the Asian population and 9 for the White population (Hofmeyer et al., 1997; Mostert & Hofmeyer, 1997).

These wide variations are a product of the particular social, economic and political history of South Africa not only since the establishment of apartheid in the 1950s, but throughout South African history, especially since the early twentieth century. The effects of this system are still present today, with the result that South Africa may be viewed as a nation containing two parallel societies. One, composed of the White and Asian populations, exhibits most of the characteristics of the developed world. The second, composed of the African and Coloured populations, presents many of the problems found in the developing world. This paper concentrates on factors related to infant and child mortality among the African and Coloured populations of South Africa.

PRELIMINARY WORK SUGGESTING IMPORTANCE OF ENVIRONMENTAL CONDITIONS

Inspection of published aggregate data from the South African 1988–92 Demographic and Health Survey showed that in Gauteng Province, which includes the cities of Johannesburg and Pretoria, educational attainment, medical attendance at birth and use of prenatal care among African and Coloured mothers were almost identical, although the infant mortality rate for the African population was much higher than for the Coloured population (34 for the African population vs. 9 for the Coloured population). The most noticeable difference in the situation of African and Coloured infants was the greater access of Coloured than African households to safe water (Rossouw & Jordaan, 1997). This observation led to a focus on environmental conditions in the research reported in this paper.

1994 OCTOBER HOUSEHOLD SURVEY OF SOUTH AFRICA

The data used in this paper are from the 1994 October Household Survey of South Africa, which was conducted by the Central Statistical Services of South Africa. This was the second in a series of annual surveys,

begun in 1993, designed to collect a broad range of social, economic and demographic information about the population of South Africa. The 1994 survey is the first October Household Survey for which the kind of analysis presented in this paper can be conducted. Also, it is the first October Household Survey that included all of the geographic areas presently included in South Africa.[2] This project plans to extend the analysis to the data in later October Household Surveys, which continued on an annual basis through 1999.

The data in the 1994 survey were from a multistage random sample. Thus, the proportions included in the sample by geographic location within the country and by other characteristics were not representative. The analysis in this paper uses weighted data to make the sample representative of the African and the Coloured populations in South Africa as a whole.

We wanted to examine differences in infant and child survival among groups, but we did not want to place an excessive reliance on the exact reported age at death. Thus, our cases are children born to women in the sampled households since the beginning of 1989. The decision to include all births that occurred since the beginning of 1989 was a trade-off between wanting to only include recent births, in order to maximize the quality of reported data, and wanting to include as many births as possible, in order to have a sufficient number of births and deaths to make multivariate statistical analysis worthwhile.

In the unweighted data, there were 10,008 African children and 2,919 Coloured children born since 1989 in the data set, and among these, there were 147 deaths of African children and 43 deaths of Coloured children. In the tables, the unit of analysis is a child (surviving or not) born in 1989 or later. Our indicator of infant and child mortality is whether a child born since 1989 died before the survey date.

The analysis presented in the tables is based on the weighted data. When the weights were applied, it was done so that the number of weighted cases and the number of unweighted cases for each group (African children and Coloured children) was equal. This was a fair way to treat the data for the significance tests. When the unweighted number of births divides the unweighted number of infant and child deaths, the probability of dying for African children and for Coloured children is identical. When the weighted data are used the probabilities of dying reported in the paper are obtained.

Infant and child deaths were certainly underreported. However, as we shall see, the pattern of relationships between socioeconomic characteristics and the chance of an infant or child death is what would be expected if there were not severe bias in the reporting related to important independent

variables. This pattern supports the plausibility of the results of the micro-data analyses. Thus, although we do not accept the overall level of infant and child mortality implied by these data, we think that the data are useful for examining factors related to the relative chance of infant or child death according to the characteristics of the child and of the household into which he or she was born.

CHARACTERISTICS OF AFRICAN AND COLOURED HOUSEHOLDS IN SOUTH AFRICA

Table 1 shows characteristics of the households in which the children lived. The variables shown in Table 1 are those used in the subsequent analysis. They fall into the three areas of explanations of infant and child mortality discussed earlier. Whether the mother of the child was age forty or older at the time the child was born is included to control for mother's age.[3] Unlike in many other settings of the world, there was no evidence of excess female infant and child mortality.

The differences in the overall conditions of life of African and Coloured children are striking. In every area, Coloured children live in a better off and healthier setting than African children.

ANALYSIS OF VARIANCE OF INDIVIDUAL VARIABLES IN RELATION TO INFANT AND CHILD MORTALITY

Based simply on the differences in the distributions on education and other factors in the above table, one could argue that high infant and child mortality in the African population is likely a product of low maternal education coupled with rural residence, lack of sanitary facilities and only limited medical assistance at birth. A critical question, however, is what kind of program of action would be most effective in reducing infant and child mortality. In an era of limited resources, it is essential that interventions be focused on those areas that can bring about the most significant changes. The identification of such optimal strategies requires first an analysis of the factors involved and the influence each appears to have on infant and child mortality of the population group concerned. It is to this task that we now turn.

In this section, we perform an analysis of variance of the relation of each of the variables shown in Table 1 to infant and child mortality. This is done separately for African and Coloured children. We want to know

TABLE 1

Distribution of Characteristics of Households of Children Born 1989–94 in 1994 October Household Survey of South Africa

	African	Coloured
Household Socioeconomic Characteristics		
Education of mother		
No education	11%	5%
Through Standard 5	35	31
Standard 6 through Standard 8	30	39
Standard 9 or higher	23	24
Total	99%	99%
% Living in rural areas	69%	17%
% With mother age 40+ at birth	14%	8%
Access To and Use of Health Care		
Distance to health facility		
Less than 1 kilometer	25%	51%
1 kilometer - 5 kilometers	33	36
5 kilometers +	43	14
Total	101%	101%
% Born in hospital or clinic	83%	95%
Environmental Conditions		
Type of sanitation		
Flush or chemical toilet	26%	85%
Pit toilet or pit latrine	53	8
Bucket toilet or none	20	7
Total	100%	100%
Main source of domestic water		
Running tap in dwelling or onsite	42%	93%
Water carrier/tanker or public tap	21	4
Borehole or rainwater tank	14	1
Stream, non-borehole well, or other	23	2
Total	100%	100%

whether for each group the different categories of each variable are significantly related to infant and child mortality. We would be surprised if these variables did not have the expected relation to infant and child mortality. Emergence of expected patterns also increases confidence in the quality of the data and can point at the relative importance of various factors, which will be investigated in more detail through multivariate analysis.

In Table 2 the proportion of children born in 1989 or later which was

TABLE 2

Analysis of Variance of Factors Related to Infant and Child Death

	African	Coloured
Household Socioeconomic Characteristics		
Education of mother		
1 No education	.02084	.02124
2 Through Standard 5	.01458	.01690
3 Standard 6 through Standard 8	.01642	.00664
4 Standard 9 or higher	.00940	.00593
Significance of F from ANOVA	.044	.054
Rural-Urban Residence		
0 Urban	.01100	.00689
1 Rural	.01614	.02612
Significance of F from ANOVA	.048	<.001
Age of mother at birth of child		
0 Less than age 40	.01380	.00813
1 Age 40 or older	.01945	.03419
Significance of F from ANOVA	.106	<.001
Access to and Use of Health Care		
Distance to health facility		
1 < 1 km	.01229	.00667
2 1–5 km	.01182	.00873
3 5 km+	.01798	.02673
Significance of F from ANOVA	.048	.002
Medical facility at birth		
0 Not hospital or clinic	.02584	.05482
1 Hospital or clinic	.01230	.00773
Significance of F from ANOVA	<.001	<.001
Environmental Conditions		
Type of sanitation		
1 Flush or chemical toilet	.01349	.00634
2 Pit toilet or pit latrine	.01314	.02901
3 Bucket toilet or none	.01970	.03460
Significance of F from ANOVA	.096	<.001
Main source of domestic water		
1 Running tap in dwelling or onsite	.01107	.00992
2 Water carrier/tanker or public tap	.00944	.00452
3 Borehole or rainwater tank	.02173	.01798
4 Stream, non-borehole well, or other	.02135	.02712
Significance of F from ANOVA	<.001	.522

Note: Values are the proportion of children born since 1989 who had died by the survey date. Coefficients for the ANOVA are underlined if $p < .05$ Numbers in the left-hand column are the codes used in the logistic regressions in Table 3.

reported dead by the survey date is shown for each category of each variable. For each group for each variable considered, the significance of the F statistic for the analysis of variance (ANOVA) is shown. If the p value for the F statistic is less than .05, the value is underlined.

Every variable examined separately has a significant relation to infant and child death, except for education of mother for the Coloured population and sanitation and age of mother for the African population. Even those relations that are not significant show variation across categories of the given variable in the expected direction.

LOGISTIC REGRESSION ANALYSIS

Examination of the results of the analyses of variance for individual variables does not differentiate between possible explanations. The critical question is the relative contribution each of these explanations makes to the chance of infant or child death and the degree to which one or another is more critical in affecting the chance of infant and child survival. It is also important to know whether the set of variables related to a particular explanation, such as access to and use of health care, is significant once the effects of the variables representing household socioeconomic characteristics have been taken into account.

Table 3 shows the results of logistic regression analyses. The codes used for the independent variables are those shown in Table 2. Table 3 shows the results of entering variables in each area as a block. Significance tests are performed to determine whether the set of variables as a whole significantly improves the fit of the model, in addition to the significance tests for individual variables.

For both African and Coloured children, household socioeconomic characteristics are entered first, as shown in Model 1. For both groups, the household socioeconomic variables as a set are significantly related to the chance the infant or child dies. The signs of all the coefficients are in the expected direction. However, only rural residence and age of mother are individually significant and only for the Coloured population.

Model 2 adds the two health care variables to Model 1. For each group, both the χ^2 value for Model 2 as a whole and the χ^2 value for the change from Model 1 to Model 2 were significant. However, for each group, distance to a health facility was not significant, while being born at a hospital or a clinic was significant. This finding suggests that physical ease of access to health care by itself is not important for infant and child survival.

TABLE 3

Logistic Regression Analysis of Factors Related to Infant and Child Death

	African				Coloured			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Household Socioeconomic Characteristics								
Education of mother	−.144	−.075	−.149	−.092	−.215	−.062	−.092	.052
	(.117)	(.424)	(.112)	(.338)	(.373)	(.801)	(.708)	(.837)
Live in a rural place	.317	.157	.038	−.123	1.204	.748	.932	.602
	(.117)	(.473)	(.879)	(.637)	(.003)	(.124)	(.033)	(.234)
Mother age 40 or older at birth of child	.256	.268	.240	.244	1.377	1.361	1.409	1.407
	(.250)	(.229)	(.281)	(.273)	(.002)	(.002)	(.001)	(.002)
Access to and Use of Health Care								
Distance to health facility		.104		.069		.298		.220
		(.381)		(.564)		(.286)		(.445)
Born in hospital or clinic		−.623		−.639		−1.502		−1.426
		(.001)		(<.001)		(.001)		(.002)
Environmental Conditions								
Sanitation			−.063	−.0832			.772	.685
			(.684)	(.227)			(.002)	(.011)
Main source of domestic water			.262	.0669			−.370	−.402
			(.002)	(.001)			(.234)	(.210)

Constant	–4.257	–4.001	–4.2895	–4.025	–4.786	–4.134	–5.590	–4.724
χ^2	8.881	20.104	19.118	29.873	21.712	32.489	29.632	38.453
	(.031)	(.001)	(.002)	(<.001)	(<.001)	(<.001)	(<.001)	(<.001)
χ^2 change from Model 1		11.223	10.237	20.992		10.777	7.919	16.741
Adding to socioeconomic model		(.004)	(.006)	(<.001)		(.005)	(.019)	(.002)
χ^2 change from Model 2				9.769				5.964
Adding to socioeconomic				(.008)				(.051)
χ^2 change from Model 3				10.755				8.822
Adding to socioeconomic and sanitation/water model				(.005)				(.012)
d.f.	3	5	5	7	3	5	5	7
N	9974	9974	9974	9974	2916	2916	2916	2916

Note: p values are in parentheses. Coefficients are underlined if $p < .05$. See Table 2 for categories and coded values for independent variables. Dependent Variable: Whether Child Born in 1989 or later had died by October 1994 (0 = Alive, 1 = Died)

Model 3 adds the environmental variables to Model 1. Again, the χ^2 value for Model 3 as a whole and the χ^2 value for the change from Model 1 to Model 3 were significant for each group. However, while source of drinking water is significant for the African population, type of sanitation is significant for the Coloured population. It is likely that source of drinking water was not significant for the Coloured population because there was very little variation in it—93% of the households of the Coloured children had a running tap in the dwelling or onsite, and 97% had a running tap or obtained water from a tap or a water carrier. However, a lack of variability in type of sanitation is not the explanation for the lack of significance of sanitation for the African population. The large degree of variability in the type of sanitation available to the African population is clear from Table 1.

It is also not likely that the lack of significance of type of sanitation for African households is due to a high degree of covariation between source of drinking water and type of sanitation, because a substantial proportion of African households with safe water also had poor sanitation facilities. Twenty percent of the African households overall had a bucket toilet or no toilet facilities. Among the African households with running water in the dwelling or onsite 12% also had a bucket toilet or no toilet facilities, and among the African households who obtained their domestic water from a water carrier or public tap 23% had a bucket toilet or no toilet facilities.

Model 4 includes all the variables considered. Again, the χ^2 value for the overall equation is significant for each group. We can look at Model 4 either as the result of variables being added to Model 2 or as the result of variables being added to Model 3. That is, we can ask whether the environmental variables add significantly to the explanation of infant and child death after the health care variables have been included (by a comparison with Model 2), or we can ask whether the health care variables add significantly to the explanation of infant and child death after the environmental variables have been included (by a comparison with Model 3). For both the African and Coloured population, inclusion of the health care variables significantly increases the χ^2 value, due to the importance of being born in a hospital or a clinic. The source of water remains very important for the African population. The sanitation variable remains statistically significant for the Coloured population, but the environmental variables as a group are not significant for the Coloured population after the health care variables have been included. This finding suggests that the environmental variables covary with the health care and socioeconomic variables sufficiently that they do not make an independent contribution to the chance of infant and child survival for Coloured children. For African children, however, the environmental variables do make a significant independent contribution to

the chance of survival. For both Coloured and African children, health care, especially being born in a medical facility, is significantly related to the chance of survival, even after other factors have been taken into account.

A comparison was also done between the model with the health care and environmental variables included and the full model. That comparison tested whether the household socioeconomic variables significantly improved the fit after the other factors had been included. The socioeconomic variables were significant for the Coloured population ($p = .026$) but not for the African population ($p = .437$).

DISCUSSION AND CONCLUSIONS

Problems of data quality and the large sample size needed to obtain stable results make analysis of factors related to infant and child mortality difficult throughout the developing world. This is especially problematic in South Africa, because during the apartheid era little data were collected for the African population. The 1994 October Household Survey provides a picture of the situation in the late apartheid/early post-apartheid period. Despite understatement of infant and child deaths and limitations in some of the available variables, analysis of the data in this survey yields intriguing and potentially useful results.

The results give some support for all three kinds of factors thought to influence infant and child mortality in moderate and high mortality situations. Overall socioeconomic characteristics play a significant role when analyzed by themselves. However, contrary to some researchers' expectations, their importance is substantially diminished or disappears when health care and environmental variables are taken into account.

Health care, especially the place of birth, retains significance regardless of what other factors are taken into account. Explicit inclusion of whether the mother received prenatal care would be useful. Questions on prenatal care are included in some of the later October Household Surveys.

The most striking finding is the importance of source of domestic water for the African population. The importance of the source of water for infant and child mortality has been thought to operate through duration of breastfeeding and treatment for diarrhea. Some studies have found a relation between safe water and postneonatal mortality but not with neonatal mortality—as long as the child is fed only breast milk, contaminated drinking water has little effect on the child (Ahiadeke, 2000; Woldemichael, 1998). According to results of a survey conducted in South Africa in 1994, among those without access to piped water, 89% did nothing to treat it before

drinking it (Hirshchowitz & Orkin, 1995, p. 140). From surveys conducted in South Africa 1988–92, 46% of African children with diarrhea received neither oral rehydration solution nor any other fluid increase; 20% of diarrheatic children were given a laxative (Roussouw & Jordaan, 1997, p. 41–42). Further analysis of the factors related to treatment of unsafe water and to actions taken when children had diarrhea would be useful.

The results for the African and Coloured populations of South Africa suggest a hierarchy of needs in which without clean water, sanitation matters little. Once clean water is generally available, however, sanitation becomes important in determining the chance that infants and children survive. It will be interesting whether as safe water becomes more available to the African population the significance of sanitation increases, similar to the pattern found in the Coloured population.

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ENDNOTES

1. For a brief discussion of relevant South African history, see Thompson (2001).
2. The 1993 October Household Survey did not include the population in the so-called independent homelands of Traanskei, Bophuthatswana, Venda and Ciskei.
3. Whether the mother was at least age forty is more strongly related to infant and child survival in this data set than more conventional indicators of mother's age, such as a linear function of age or an indicator that the mother was less than twenty years old.

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