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Household Environmental Factors and their Effects on Infant Mortality in Mewat Region of Haryana State, India

Introduction

HIGH MORBIDITY and mortality rates in infancy and childhood in the developing countries are often considered to be largely due to poor environmental conditions. Diarrhoea, a disease highly influenced by poor environmental sanitation including water and sanitation facilities (Stephens, Mason and Isely, 1985), is one of the major killers of children in developing countries (UNICEF, 1988). The World Health Organisation (WHO) (WHO, 1995) estimates that each year in developing countries acute respiratory infections primarily pneumonia, are responsible for 4.1 million deaths of children under the age of five years. The major causes of these deaths are environmental factors such as crowding and indoor air pollution (Pio, Leowski and Ten Dam, 1984, Miller, 1985). In Mosley and Chen's (1984) model household environmental contamination variables are one of the five sets of proximate variables through which socioeconomic factors operate to influence child survival. Household environmental contamination variables are the direct causal variables that influence infant and child mortality (Merrick, 1985). The quality of the immediate physical environment strongly influences the child's risk of exposure to infectious diseases and to injury (Puffer and Serrano, 1973). The higher the quality of the physical environment, the smaller the burden of daily cooperation of individual household members to minimise the risk of exposure (Tekce and Shorter, 1984).

Several studies have considered the relationship between environmental conditions and infant and child health and survival (Da Vanzo, Butz and Habicht, 1983; Trussell

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and Hammerslough, 1983; Jain, 1985; Merrick, 1985; Rahman *et al.,* 1985; Esrey and Habicht, 1986; Victora *et al.,* 1988; Barrera, 1990; Gubhaju, Streatfield and Majumder, 1991). Still relatively little is known about the relationship between environmental factors and child survival in many areas of the developing world, including India. Moreover, knowledge about the consistency of findings across countries, over different periods, and for different indicators of child survival is extremely limited. A number of studies that have been conducted in India, mainly deal with demographic and socio-economic determinants of infant and child mortality (see, Jatrana (1999) for a detailed literature review on infant and child mortality). Little attention has been paid to environmental variables of infant and child mortality. There are only a few studies on the influence of environmental factors on infant and child mortality (Pandey *et al.,* 1998). Even in these studies environmental factors have not been considered as major factors of interest or only a few environmental indicators are included. Information on the effect of environmental factors is important, however, in designing effective intervention strategies for reducing child mortality. There is a growing recognition of the importance on environmental conditions affecting infant mortality. It has become apparent that any strategies that intend to deal with child care, including 'child survival' must recognize the impact of environmental conditions (Satterthwaite *et al.,* 1996). This paper will try to fill this gap in knowledge by examining the role of household environmental contamination factors in explaining differentials in infant mortality in Mewat region of Haryana State, India.

The majority of the Mewat region falls in Haryana which is a State of the northern region of the Indian Union. Haryana State as a whole is fairly well developed and it has the second highest per capita income in India (Government of India, 1998) but Mewat has remained a backward region even after Independence. The area lags behind the rest of Haryana on almost every yardstick of development index, even though the farthest point of Mewat is no further than 145 kilometres from Delhi, the national capital. The overall literacy rate in Mewat is 23.1 percent, whereas for Haryana as a whole the literacy rate is 55.3 percent (Mewat Development Agency, 1994, 1995b). The Infant Mortality Rate (IMR) in Mewat is 91 (Jatrana, 1999) while for Haryana State as a whole the IMR is 68 (Registrar General of India, 1997). Mewat is predominantly rural, covering an area of 1874 sq km with 491 villages and 5 towns (Mewat Development Agency, 1995a). A large part of around 7 hundred thousand inhabitants of this region have agriculture as its main occupation.

Methods

The data employed in this study were obtained by conducting a field survey between April 1996 to February 1997 of factors affecting infant and child survival in the Mewat region of Haryana State. The study was conducted in the Nuh and Taoru blocks of the

Mewat region. Three villages with 500-3000 population were selected from each block on the basis of simple random sampling. This was done to eliminate villages that were too small or too large. In the sampled villages, all those households were visited which had experienced a live birth during three years preceding the survey (Holi festival 1993-Holi festival 1996). A reference to Holi, an important festival in India, was expected to facilitate recall and thus, reporting of births and deaths. Children born during this period formed the universe of the study. Of 950 children thus identified, 83 had died during infancy and the remaining 867 had either survived beyond their birthday or were censored by the survey date. In the survey, a mother who had a live birth during the reference period was considered as a respondenl. If there were more than one woman in the household who had a live birth during the reference period, all were selected for the survey.

Information on sociodemographic, housing and environment factors of the household was collected by questioning the mothers through a structured questionnaire. Where appropriate their replies were confirmed or supplemented by observation of the house and its surrounding. The household environmental contamination variables used in the following analysis are the source of drinking water, the presence of latrines, the type of house, the number of persons per room, the presence of separate kitchen, the presence of separate bathroom, the type of cooking fuel, refuse in the courtyard, and whether there were animals inside the courtyard (Table 1).

The variable 'source of drinking water' is classified into two categories: piped water or non-piped water that the household uses for drinking purpose. Although the Mewat survey collected information on type of toilet facility, there is not much variation in toilet type[1]. Therefore, the variable 'presence of toilet' identifies whether the household has a toilet regardless of type. Type of house is classified *into pukka* house if it is made of fired bricks throughout (including roof, wall and floor) and *kachcha* if a house is made of unfired bricks. The category *kachcha* also includes *semi-pukka* houses which are made of both types of bricks. Room density (crowding) was calculated by dividing the total number of persons living in the house by the total number of rooms in the house (excluding kitchen, bathroom). This continuous variable was divided into two categories by taking the median of the distribution (less than or equal to three persons per room).

The variables relating to presence of separate kitchen and bathroom denote whether the household has a separate place designated as kitchen and bathroom. The various cooking fuels were grouped into two categories—cleaner fuels (coal/coke/lignite, charcoal, kerosene, electricity, liquid petroleum gas, biogas) and biomass fuels (wood or dung). Mishra and Retherford (1997) also used a similar classification of cooking fuel. The variable refuse in the courtyard denotes that refuse was disposed of inside

1. Ninety percent of the infants belong to household which defecate in open. Other 10 percent use some sort of toilet facility: 4.6% flush toilet and the remaining 5.4% pit toilet.

TABLE 1: DISTRIBUTION OF LIVE BIRTHS BY CATEGORIES OF INDEPENDENT ENVIRONMENTAL VARIABLES, MEWAT, 1996

Variables	*Live births*	*Infant deaths*
Source of drinking water		
Piped	318 (34)	17
Non-piped	632 (66)	66
Presence of latrines		
Yes	95 (10)	7
No	855 (90)	76
Types of house		
Pukka/cemented	214(23)	12
Kachcha/not cemented	736 (77)	71
Persons per room		
3 or less	446 (47)	17
More than 3	504 (53)	66
Presence of separate kitchen		
Yes	312 (33)	18
No	638 (67)	65
Presence of separate bathroom		
Yes	281 (30)	21
No	669 (70)	62
Type of cooking fuel		
Cleaner fuels (Kerosene, coal, gas)	65 (7)	4
Biomass fuel (cow dung cakes, wood)	885 (93)	79
Refuse in the courtyard		
No	306 (32)	13
Yes	642 (68)	70
Animals in the courtyard		
No	640 (67)	49
Yes	310 (33)	34

Source: Mewat field data, 1996.
Notes: Figures in parentheses are percentages.

the courtyard in the open. The variable animals in the courtyard means that the household does not have a separate cattleshed and the animals are tethered inside in the courtyard. As suggested by Mosley and Chen (1984), levels of environmental contamination reflecting the various routes of spread of diseases, are measured by a series of simple physical indexes that are known to be strongly correlated to the levels of biological contamination of environment. Crowding (persons per room), domestic smoke (type of fuel used for cooking) and cooking in the living room (presence of separate kitchen) is an approximation for contamination and the risk of contact-acquired respiratory infections. Water contamination is related to the source of drinking water supply (piped or non-piped) and potential faecal contamination to the presence of latrine or toilets. Other housing environmental characteristics such as type of house (cemented or non-cemented), refuse disposal (refuse in the courtyard or otherwise) and presence of animals inside the courtyard are expected to exert an impact on mortality because these conditions are closely related to the risk of exposure to infectious agents.

The categorisation of the independent variables was based on theoretical grounds, as well as on the basis of the distribution of births with respect to the different variables. A partitioning of the sample according to various background characteristics of its members produces such small sub-groups that estimates are unstable and the interpretation of results difficult. Hence, distribution of various variables is collapsed into two broader categories in order to alleviate the problem of excessively small cell size. All the independent variables included in the regression analysis were dummy coded.

As the unit of analysis, children born three years preceding the survey were selected as the study population for the analysis of infant mortality. A dichotomous dependent variable, child's survival status through infancy, has been given a value of 1.00 if the child failed to survive through infancy and zero otherwise. The Cox proportional hazard regression model (Cox, 1972) was fitted to determine the effect of each variable and to investigate the partial effects of multiple factors on infant mortality. Both univariate and multivariate models are fitted. The results in the univariate model describe the gross effect, while the results in the multivariate model describe the net effects, that is the effects after controlling for the effects of other variables in the model. A variable was considered significantly associated with mortality when its/? value was below 0.10. This relatively high significant level was chosen instead of the usual 0.05 in order not to miss any possible variables associated with infant mortality.

The results of the proportional hazards models including values of exp(p) and regression coefficient p are presented in Tables 2, 3 and 4. Exp(P) represents the risk of dying associated with each covariate, relative to the risk for the reference category. The reference category was preferably the category with theoretically the lowest risk of mortality. The relative risk for the reference category of each covariate is unity. Values greater than unity indicate that the relative risk of dying is greater for this group, compared with the reference group, whereas values less than unity indicate a decrease in the risk (Pebley and Stupp, 1987; Santow and Bracher, 1994). The regression coefficient P in the hazard model indicates the relationship between the independent variable and the hazard of dying (the force of mortality). A positive coefficient indicates that the variable is associated with an increased hazard of dying and has a negative relationship with survival.

One important limitation of this kind of study is that the deaths of children are related to characteristics of the family at the time of survey. Because the household and socioeconomic covariates are available only for the time of the interview and the living standard of the family may change during the period, it is likely that a child born in the most distant past was exposed to the risk of death under a different set of socioeconomic conditions than those recorded in the survey. Thus, to reduce the time differentials between the two variables, the sample has been limited to births in the last three years. Moreover, there is no documented evidence which suggests that the living standards have changed rapidly in Mewat. Another limitation is that some mothers may have omitted information on the birth and death of their children. In general, such problems would tend to underestimate the true magnitude of any differentials.

The principal weakness of these data is the small number of deaths on which they are based, relative to the inferences I desire to make. The total sample used in this analysis contains 950 singleton'births, of which 83 had died in infancy by the time of the survey. Since the primary focus of this study is differential mortality and not the overall levels of infant and child mortality, these numbers are adequate for studying the determinants of infant mortality. Moreover, the underlying purpose of this survey design was the maximisation of the quality of the information while at the same time obtaining a sample size large enough for mutivariate analysis. The fixed budget of time and money necessitated a choice between quality and quantity. Quality of information was generally favoured over the size of the sample. With this in mind, sample villages were visited several times before interviews were conducted.

Results

Results from the proportional hazards regression analysis are presented in three separate model specifications. Model 1 (Table 2) which is a univariate model, estimates the gross effects of each environmental variable listed in Table 1, on infant survival. Model 2 (Table 3) which is a multivariate Model, estimates the net effects of each environmental variable by controlling for other environmental factors in the model. Model 3 (Table 4) expands on Model 2 by introducing socioeconomic variables into the model. The objective of Models 2 and 3 is to determine whether the estimates of Model 1 change if these control factors are included and to find out which of the environmental factors are significant predictors of infant mortality.

Results based on model 1 (Table 2) show that the variables that are significantly associated with infant mortality in the univariate analysis are the source of drinking water, the type of house, the room density, the presence of separate kitchen, the place for refuse disposal and whether there were animals in the courtyard. Table 2 indicates that infants born to households with piped drinking water experienced significantly lower mortality during infancy compared with infants in houses using other water sources. Infants with low risk of mortality are those who live in less crowded households (households with less than or equal to 3 persons per room), cemented houses with separate kitchens and in households where refuse is not disposed of in the courtyard and animals are not kept inside the courtyard.

For example, the risk of infant mortality in households which did not have piped drinking water was twice as high as for those which did have piped drinking water. The

TABLE 2: SUMMARY RESULTS[3] FROM COX PROPORTIONAL HAZARDS MODEL FOR THE EFFECT OF ENVIRONMENTAL FACTORS ON INFANT MORTALITY: MODEL 1 (UNIVARIATE MODEL), MEWAT, 1996

Covariates	*Regression coefficient* P	£xp(P)	*SE*	95% *confidence interval*
Source of drinking water				
Piped	0.0000	1.0000		
Non-piped	0.6983***	2.0104	0.2720	1.1797-3.4261
Presence of latrines				
Yes	0.0000	1.0000		
No	0.1834	1.2013	0.3950	0.5539 - 2.6054
Type of house				
Pukka/ cemented	0.0000	1.0000		
Kachcha/not cemented	0.5577*	1.7467	0.3121	0.9474 - 3.2203
Persons per room				
3 or less	0.0000	1.0000		
More than 3	1.2652***	3.5439	0.2720	2.0794 - 6.0397
Presence of separate kitchen				
Yes	0.0000	1.0000		
No	0.5771**	1.7808	0.2663	1.0566-3.0014
Presence of separate bathroom				
Yes	0.0000	1.0000		
No	0.2219	1.2485	0.2525	0.7611 -2.0479
Type of cooking fuel				
Cleaner fuels (kerosene, coal, gas)	0.0000	1.0000		
Biomass fuel (cow dung cakes, wood)	0.3777	1.4589	0.5125	0.5343 - 3.9836
Refuse in the courtyard				
No	0.0000	1.0000		
Yes	0.9772***	2.6569	0.3020	1.4699-4.8025
Animals in the courtyard				
No	0.0000	1.0000		
Yes	0.3788*	1.4605	0.2322	0.9430 - 2.2620

Source: Mewat field data 1996.
Note: [a]Results based on a total of 950 cases: 83 died during the interval; 867 either survived the infancy period or were censored at survey date.
*$p<0.10$
**$p < 0.05$
***$p < 0.01$

risk of infant death was 1.7 times higher in *kachcha* houses and without a separate kitchen than those *of pukka* houses and with a separate kitchen. Infants born in relatively crowded houses (more than 3 persons per room) appear to have 3.5 times higher risk of mortality than that of children in less crowded houses (3 or less than three persons per room). The risk of infant mortality was 2.5 times as high if the refuse was dumped in the courtyard compared to households, which did not do so. The presence of animals

TABLE 3: SUMMARY RESULTS[a] FROM COX PROPORTIONAL HAZARDS MODEL FOR THE EFFECT OF ENVIRONMENTAL FACTORS ON INFANT MORTALITY: MODEL 2[b] (MULTIVARIATE MODEL), MEWAT, 1996

Covariates	*Regression coefficient* (ß	Exp(P)	*SE*	*95% confidence interval*
Source of drinking water				
Piped	0.0000	1.0000		
Non-piped	0.4138	1.5125	0.3290	0.7937 - 2.8821
Type of house				
Pakka/cemented	0.0000	1.0000		
Kachcha/not cemented	-0.4028	0.6684	0.3856	0.3140 - 1.4231
Persons per room				
3 or less	0.0000	1.0000		
More than 3	1.1299***	3.0955	0.3002	1.7187-5.5753
Presence of separate kitchen				
Yes	0.0000	1.0000		
No	0.2560	1.2918	0.2855	0.7382 - 2.2607
Refuse in the courtyard				
No	0.0000	1.0000		
Yes	0.8622***	2.3683	0.3095	1.2911 - 4.3442
Animals in the courtyard				
No	0.0000	1.0000		
Yes	0.4889**	1.6306	0.2274	1.0442-2.5461

Source: Mewat field data 1996.

Note: [a]Results based on a total of 950 cases: 83 died during the interval; 867 either survived the infancy period or were censored at survey date.

[b]Model contained all covariates listed in Table 2 that were significantly associated ($p < 0.10$) with infant mortality.

**$p < 0.05$

***$p < 0.01$

in the courtyard also increases the risk of dying during infancy. The risk was one and a half times higher for households which keep animals inside the courtyard than those which donot.

The results were not altered greatly by adding the controls for other environmental covariates (Table 3) except that the association of mortality with the source of drinking water, the type of house and the presence of separate kitchen were eliminated by adjusting for other environmental factors. Hazard analysis suggest that crowding, refuse disposal and location of cattleshed are important correlates of infant mortality,. Because the environmental variables are associated with each other and also with poverty, the more informative analyses are those in which the adjustments were made for the effects of socioeconomic status (education of father and mother and ownership of land) and the other environmental variables (Table 4). When these adjustments were made the variables that remained statistically significant were room density, and the disposal of refuse.

TABLE 4: SUMMARY RESULTS" FROM COX PROPORTIONAL HAZARDS MODEL FOR THE EFFECT OF ENVIRONMENTAL FACTORS ON INFANT MORTALITY: MODEL 3[b] (MULTIVARIATE MODEL), ME WAT, 1996

Covariates	*Regression coefficient* (3	*Exp* (P)	*SE*	95% *confidence interval*
Source of drinking water				
Piped	0.0000	1.0000		
Non-piped	0.2851	1.3299	0.3503	0.6693-2.6425
Type of house				
Pukka/cemented	0.0000	1.0000		
Kachcha/not cemented	-0.4313	0.6497	0.4108	0.2904-1.4534
Persons per room				
3 or less	0.0000	1.0000		
More than 3	1.0857***	2.9615	0.3181	1.5877-5.5241
Presence of separate kitchen				
Yes	0.0000	1.0000		
No	0.1924	1.2122	0.3179	0.6501-2.2602
Refuse in the courtyard				
No	0.0000	1.0000		
Yes	0.8600***	2.3631	0.3096	1.2882-4.3350
Animals in the courtyard				
No	0.0000	1.0000		
Yes	0.4732	1.6051	0.2284	1.0259-2.5115
Education of mother				
Some	0.0000	1.0000		
None	0.0452	1.0463	0.3887	0.4884-2.2413
Education of father				
Some	0.0000	1.0000		
None	0.3098	1.3632	0.2934	0.7671-2.4227
Owning land				
Yes	0.0000	1.0000		
No	-0.0068	0.9933	0.2961	0.5559-1.7747

Source: Mewat field data 1996.

Note: [a]Results based on a total of 950 cases: 83 died during the interval; 867 either survived the infancy period or were censored at survey date.

[b]Model contained all covariates listed in Table 2 that were significantly associated $(p < 0.10)$ with infant mortality, with addition of socioeconomic covariates to model (parental education, ownership of land).

$^{**}p < 0.05$

$^{***}p < 0.01$

Although the effect of these two variables is reduced in the final model (Table 4), yet children born in crowded households have nearly three times more risk of dying in infancy as compared to children born in less crowded households. Similarly the risk of infant mortality was 2.4 times as high if the refuse was dumped in the courtyard compared to households, which did not do so.

Discussion

The results of this study provide empirical evidence for an association between household environmental factors and infant mortality. Hazard analysis suggests that crowding, refuse disposal and the presence of animals inside the courtyard are important correlates of infant mortality. The children with low risk of mortality are those who live in less crowded households and who do not dispose of refuse in the courtyard and do not keep the animals inside the courtyard. Sanitation facilities were not found to have a significant effect on infant mortality. These results are in contrast with those found in the Philippines (Martin *et al,* 1983), in Malaysia (Da Vanzo, and Habicht, 1986; Peterson *et al.,* 1986), and in Sri Lanka (Meegama, 1980) which suggest a significant effect of presence of toilet facility on infant and child mortality. This absence of significant results for sanitation facility is consistent with findings from Brazil revealing that household toilet facilities are related very weakly to child mortality risks (Victora, Smith and Vaughan, 1986; Victora *et al.,* 1988) and from Kenya where toilet sanitation is not statistically significant (Anker and Knowles, 1980). Moreover, in Malaysia, sanitation facilities have been found to be more important than water supply in reducing mortality levels (Habicht, Da Vanzo and Butz, 1988). In contrast, this study found rather an association between the availability of piped water supply and infant mortality than between sanitation and infant mortality which is in agreement with findings from Brazil (Victora *et al.,* 1988). There is no clear advantage of having toilet facilities in the house in this study. The presence of toilet may not be a good reflection of household sanitation because a large proportion of children belong to households which did not own latrines (90 %) and those who had it also defecate in the fields. For example, Mohmaddi's mother in Chharroa village in Mewat made the following comments:

> We have a toilet in the hcoise. But we like to defecate in the open field because we are used to the practice and cannot give it up. Moreover, a piece of open land is also nearby and if we defecate in the house it will produce a foul smell which will spoil the clean atmosphere (Field Notes, Mewat, 1996).

Indeed, the lack of relationship between toilet availability and infant survival is not surprising in the Mewat context where few families have access to a toilet. Moreover presence of a toilet provides no indication about use of the facility or its condition, and whether it works properly and safely disposes of excrement.

Children born in relatively crowded houses (>3 persons per room) appear to experience higher risk of mortality during infancy than children in less crowded houses (< 3 persons per room). The effect is large and statistically significant. This effect is not changed even when other environment and socioeconomic variables are controlled in Table 4. In India, crowding was found to be positively correlated with the IMR (Jain, 1985), in Malaysia it increased the risk of dying in infancy (Da Vanzo, Butz and Habicht, 1983), in Brazil it was identified as one of the risk factors for infants who died from respiratory infections (Victora *et al,* 1989) and in Pakistan it was found to be a risk factor for child mortality from respiratory as well as diarrhoeal infection (D'Souza, 1997a). Van Ginneken (1990) reviewed studies from various developing countries and found crowding as one of the risk factors for acute respiratory infection morbidity. Crowding is known to spread communicable diseases: respiratory diseases in general and tuberculosis, rheumatic heart disease, meningitis, pneumonia and the common cold in particular (Pandey *et al.,* 1989). Crowding is thought to adversely affect health and survival through contagion of respiratory diseases such as tuberculosis and pneumonia (Gorosomov, 1968) and through increased contact and fomites transfer of orally ingested pathogens (Wray, 1971).

Dumping refuse in the courtyard is a common practice in Mewat and was significantly associated with higher risk of infant mortality. The risk of mortality was two and a half times higher if the refuse was dumped in the courtyard in comparison to when it was not dumped in the courtyard. These results are similar to those found in Pakistan (D'Souza, 1997a), in Congo (Mock *et al.,* 1993) and in Bangladesh (Alam, Wojtyniak and Rahman, 1989; Baltazar and Solon, 1989) where refuse disposal was found to be a significant determinant of diarrhoeal disease prevalence. This reflects lack of awareness of hygiene in the household. Accumulation of garbage including faecal material around the house was a common feature observed in this area. In such an environment if an infant starts crawling, he/she is likely to catch infection.

The presence of animals in the courtyard had higher risk of mortality. The presence of animals and the place where they were kept may contribute to the environmental pollution and increase the child's exposure to it; it may also indicate the family's lack of knowledge of hygiene and its effect on the health of the child (D'Souza, 1997b). In the absence of proper drainage and sanitary facilities, animal stools and urine litter the surroundings. When infants and children walk around bare-footed in these surroundings, they are exposed to the risk of hookworms and other parasitic diseases (Khan, 1988).

The type of house and the presence of separate kitchen in the house are other variables which are significantly affecting infant mortality at univariate level. However, controlling for other environmental factors simultaneously not only made the effects of type of house insignificant but also reversed the relationship (Table 3). At the multivariate level the risk of dying for infants from *kachcha* houses was lower than that of infants *from pukka* houses. I could not see any explanation for this except that my small sample size produced unusual results. My field experience suggests that the type of house affects infant mortality mainly through the elements of exposure. The most important health effects of housing conditions on health work through their impact on the incidence of infectious diseases, in particular diarrhoeal diseases. For example non-cemented houses have floors which cannot provide protection from ground water and dampness which increases the incidence of infectious diseases. Particularly problematic are instances where cooking is also done in the living room as many households (67%) do not have a separate kitchen or a designated kitchen area in the housing unit. The situation where a single room is used for day-to-day living, sleeping and also cooking may ultimately produce a health hazard. However, it must also be remembered that the socio-economic conditions of the family are reflected in the type of housing (Khan, 1988). In any case, this issue needs to be resolved with a larger data set.

Domestic smoke pollution, caused in part by cooking, has been identified as a risk factor associated with both the incidence and severity of respiratory diseases (Anderson, 1978; Kossove, 1982; Honicky, Osborne and Akpom, 1985; Samet, Marbury and Spengler, 1987; Chen *et al,* 1990; Ceilings, Sithole and Martin, 1990; Awasthi, Click and Fletcher, 1996). Respiratory diseases are estimated to be responsible for 23 percent of deaths in preschool children in India (Reddiah and Kapoor, 1988). Moreover, pollution increases within the house if cooking is also done in the room (Da Vanzo, 1984; Pandey *et al.,* 1989) and the adverse effects of this pollution are particularly severe for young children who tend to stay indoors and are often carried on their mothers' back or laps while their mothers are cooking (Mishra and Retherford, 1997). Although the variable type of cooking fuel is not statistically significant, the sign of the coefficient implies that cooking fuel is inversely related with infant mortality.

The basic explanations of the relative lack of association between the presence of latrine, whether there is a separate bathroom and the type of cooking fuel and infant mortality are: (1) these variables measured only indirectly the quality of environment; and (2) little variability appears to exist in this sample with respect to these variables. Refuse disposal and the presence of cattle inside the courtyard are direct and better measures of environmental hygiene and are significantly related to infant survival.

None of the socioeconomic variables (ownership of land, education of father and mother) was significantly related to infant mortality. This result is in accord with the findings of some studies in rural Bangladesh (Chowdhury, 1982; Phillips and Mazumder, 1984) which stated that socioeconomic characteristics (including maternal education and household economic status) had a non-significant effect on infant mortality. There was no significant variation in infant mortality according to maternal education, paternal status (education and occupation) in Egypt (Casterline, Cooksey and Ismail, 1989, 1992). In Thailand, maternal schooling did not have significant independent or joint effects upon infant survival, once other social variables were controlled (Frenzen and Hogan, 1982). This pattern of insignificant effect of parental education on infant mortality also emerges in other North African and West Asian societies (see Adlakha and Suchindran, 1985).

The absence of any significant influence of maternal education on mortality during infancy in Mewat may be due to the protection given by the almost universal and prolonged breastfeeding by Mewatti women, coupled with the general low level of female education. The female literacy rate in Mewat is only 10.2 percent (Mewat Development Agency, 1995b). It may also be due to small sample size or what Anker and Knowles (1980) call a "threshold" below which increase in education do not affect survival rates. It is also possible that the general level of environmental hygiene in this area is so bad that an individual's education may produce negligible health effects. This interpretation is consistent with the fact that refuse disposal in this sample is associated with infant mortality because refuse disposal is usually correlated with overall environmental hygiene, so it is a better differentiating factor (Mock *et al*, 1993). Moreover, education itself, without resources, may not be important as a factor for lowering infant and child mortality (Pant, 1991) and the positive effects of maternal education are usually greater when accompanied by better hygienic practices and access to potable water and toilets (D'Souza, 1997a).

Although the completion of primary schooling is stressed in many discussions (e.g., Caldwell, 1979, 1986), that does not appear to be the case in Mewat. In the present study the education variable was divided into 'some' education and 'none' education because the percentage of women who had 5 or more years of schooling was very less. Under the prevailing conditions of low female literacy, and when few women continue their studies beyond primary level, it seems that infant mortality was not affected by education of mother to the extent that could produce any significant differences in infant mortality of the two groups of educated and uneducated mothers. The level of educational attainment will have to rise substantially beyond primary levels to achieve a noticeable impact on infant mortality in Mewat.

Owning or having access to land did not affect significantly infant mortality in Mewat, but other variables which are considered proxies for income, such as crowding, and lack of a separate place for cattle were significantly associated with infant mortality. It is likely that under the prevailing conditions when not even half of total cultivated area is under irrigation in Mewat (Mewat Development Agency, 1995a), much less cultivation of owned land was possible. Hence, the effect of amount of land owned could not be shown.

What are the policy implications of these findings? This study suggests that personal hygiene behaviour, poverty and government policies and programmes affect infant mortality. Dumping refuse in the living area reflects lack of awareness of hygiene. Crowding, poor housing, lack of a separate place for cattle and kitchen are the consequences of poverty, while factors such as availability of safe drinking water are conditions arising from government policies and programmes. Water supply being generally the responsibility of the government to be met out of public expenditure: the individual cannot improve them very much on his/her own. The findings of this study suggest that one of the priority areas in planning should be the provision of potable drinking water to rural people. Measures should also be taken to eradicate poverty and improve the socioeconomic conditions of the people. While it may take long time to eradicate poverty, for immediate health benefits, efforts should be directed towards improving household cleanliness by imparting information about personal hygiene practices, sanitary disposal of faeces and disposal of refuse. The study has demonstrated that personal hygiene practices can significantly reduce infant mortality, hence, concludes, that specific hygiene messages should be delivered to motivate people to changes behaviour and habits that can be life threatening.

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