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INFANT AND CHILD MORTALITY IN THREE CULTURALLY CONTRASTING STATES OF INDIA

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Summary. Using cross-sectional, individual-level survey data from Maharashtra, Tamil Nadu and Uttar Pradesh collected under the Indian National Family Health Survey programme of 1992–93, statistical modelling was used to analyse the impact of a range of variables on the survival status of children during their first 2 years of life. Attention was focused on the potential impact of the mother's autonomy. The strongest predictors of mortality were demographic and biological factors, breast-feeding behaviour, and use and knowledge of health services. Variables that can be interpreted as being related to maternal autonomy, such as the presence of a mother-in-law in the household, did not have a significant direct effect on child survival at the individual level, and their indirect effects were very limited.

Introduction

The aim of this paper is to examine the survival status of infants and young children in three culturally contrasting states of India using the Indian National Family Health Survey (NFHS) of 1992–93. Previous work has stressed the importance of the Indian household for mortality since it is the unit providing food, shelter and health care. Dyson & Moore (1983) were among the first to find that, at an aggregate, or societal, level mortality and health outcomes in India can be linked to household composition, kinship and power structures within the home. They argued that the higher mortality in the north of the country compared with the south is associated with regional differences in female status. The aim of this study was to determine whether Dyson and Moore's societal-level argument applies also at the level of the individual household. Covariates that measure aspects of household structure and female autonomy were therefore included in the analysis, along with a range of demographic, biological and socioeconomic factors.

Data from three states were analysed. Maharashtra is in west-central India, Tamil Nadu is on the south-east coast, and Uttar Pradesh is in the north-east.

Table 1. Characteristics of the states of Tamil Nadu, Maharashtra and Uttar Pradesh

Characteristic	Tamil Nadu	Maharashtra	Uttar Pradesh
Population (millions)	56	79	139
Infant mortality rate 1989–92 (per 1000 live births)	58	51	100
Total fertility rate, 1990–92	2·2	2·9	4·8
Percentage of females literate	51	56	31
Percentage of males literate	74	79	64
Percentage of females employed	47	49	13
Singulate mean age at marriage for females	20·5	19·3	18·6
Male life expectancy at birth, 1991 (years)	61	62	54
Female life expectancy at birth, 1991 (years)	61	63	50
Percentage of population urban	34	39	20

Source: 1992–93 Indian National Family Health Survey.

Table 1 gives some basic demographic indicators for each state. Uttar Pradesh is less demographically developed and urbanized than the other two states: demographic and socioeconomic conditions for women there are less favourable compared with those for men than they are in Tamil Nadu and Maharashtra.

Marriage systems, household structure and female autonomy

Maharashtra, Tamil Nadu and Utter Pradesh have different marriage systems, which Dyson and Moore (1983) suggested were related to the level of female autonomy found in each of the states. Uttar Pradesh exhibits the north Indian patrilocal exogamous system of marriage, which results in many husbands and wives being neither related in blood nor born in the same locality. Females are often secluded and married at a young age to protect their sexuality. Natal kin expect little benefit from daughters after marriage, which results in a strong son preference. The autonomy of the young female is also reduced because of her marriage into an unfamiliar household, the senior members of which ensure that she is socialized according to the rules of the new family. This often results in older female members of the household, for example her mother-in-law, appropriating a young woman's power to make decisions. According to Dyson and Moore, this reduced maternal autonomy is associated with higher levels of infant and child mortality. In contrast, the endogamous marriage system of the southern states is, in parts of the population, characterized by matrilineal kinship and/or matrilocal marriages. Women have greater freedom of movement, increased autonomy and continued attachment to their natal kin. This results in a less marked preference for sons and is associated with lower infant and child mortality.

Dyson and Moore use kinship as a close (though not perfect) proxy for female autonomy: 'One can only map kinship variables rather than the degree of female autonomy, the variable for which kinship is here taken as a close proxy. Exactly how close it is one cannot at present say' (Dyson & Moore, 1983, p. 46). They further

suggest that household structure might be another proxy that is available to researchers. The cross-sectional survey data about women of childbearing age collected under the Indian NFHS programme of 1992–93 (International Institute for Population Sciences, 1994a) contain only limited information about kinship or household structure, but it is possible to identify whether a household contains a mother-in-law/daughter-in-law dyad. The existence of such a dyad is a simple, albeit rather crude, method of identifying patrilineal households in which the presence of a woman's mother-in-law might reduce the degree of autonomy she possesses.

Table 2 shows the distribution of different types of household in Maharashtra, Tamil Nadu and Uttar Pradesh in the NFHS data sample. Households were classified using the relationship of each household member to the head of household. Those containing a husband and at least one wife residing with or without children and with no other family members or non-relatives were classified as 'nuclear households' (a few cases of male or female household heads without spouse but with children were also included, provided that no other family members or non-relatives were present). 'Extended households with mother-in-law' contain a head of household with at least one spouse and other relations, including a mother-in-law/daughter-in-law dyad, and no non-relatives. 'Other extended households' are those containing a head of household living with other related members, with or without unmarried children, but with no mother-in-law/daughter-in-law dyad. These may (but need not be) matrilineal, or the products of endogamous marriages.

This classification, though crude, does suggest that at the aggregate level the three states illustrate the regional pattern of household structures outlined by Dyson & Moore (1983). The biggest difference is in the proportion of 'extended with mother-in-law' (or patrilineal) households, with Tamil Nadu displaying approximately half of the proportion found in Uttar Pradesh, and Maharashtra occupying an intermediate position rather closer to Tamil Nadu than Uttar Pradesh. Tamil Nadu has the highest proportion of 'other extended' and 'nuclear' households, followed by Maharashtra and Uttar Pradesh.

Data

Dyson and Moore's argument associating marriage systems with female autonomy and infant mortality is worked out at the societal level. This study asked whether this association also applies at the individual level within states. That is, do women living in patrilineal households have less autonomy, and their children a greater risk of death, than those living in other household types, even within the same state?

Female autonomy is a difficult concept to measure and involves a number of key factors including physical mobility, authority, aspiration, prestige, power and access to control over resources (Amin *et al*., 1994; Mason, 1986). Bloom, Wypij & Das Gupta (1998) identified the distance of women from their natal kin and the frequency of contact between women and their blood families as important indicators of autonomy in the study of maternal health care utilization, but unfortunately the NFHS does not provide data on these. However, there is information on three variables that are often considered to be related to female autonomy: whether a woman watches television at least once in a week, her knowledge of the minimum

Table 2. Household types and distribution of three proxies for female autonomy by household type in Maharashtra, Tamil Nadu and Uttar Pradesh

	State	Nuclear households	Other extended households	Extended households with mother-in-law	All households
Number of households	Uttar Pradesh	4396	1936	3410	10,110
	Maharashtra	1840	846	1217	4063
	Tamil Nadu	2248	967	844	4287
Number of respondents	Uttar Pradesh	3813	2186	5261	11,438
	Maharashtra	1529	893	1622	4106
	Tamil Nadu	1839	997	1035	3948
Percentage of respondents watching television at least once a week	Uttar Pradesh	19·6	20·8	19·6	20·2
	Maharashtra	47·0	50·3	43·1	46·4
	Tamil Nadu	45·9	54·7	53·3	50·4
Percentage of respondents knowing the correct minimum legal age at marriage for women	Uttar Pradesh	28·0	28·1	27·8	28·2
	Maharashtra	49·6	51·5	47·2	49·1
	Tamil Nadu	35·7	40·6	42·2	38·9
Percentage of married respondents who were related to their husbands before marriage	Uttar Pradesh	9·7	11·6	10·1	10·2
	Maharashtra	25·8	32·2	29·0	29·2
	Tamil Nadu	46·7	47·4	51·6	46·8

Notes: The figures in the right-hand column include 378 households (178 respondents) in Uttar Pradesh, 160 households (62 respondents) in Maharashtra and 228 housholds (77 respondents) in Tamil Nadu that could not be classified into one of the three main types.
Source: 1992–93 Indian National Family Health Survey.

legal age of marriage for females in India, and whether or not she was related to her husband before marriage. The distribution of these variables among NFHS respondents by state and household type is also shown in Table 2.

Respondents living in Uttar Pradesh were much less likely to watch television once a week than their counterparts in Maharashtra and Tamil Nadu, confirming the societal-level effect. They were also less likely to know correctly the minimum legal age of marriage for females than were respondents in the other two states. Finally, only one respondent in ten in Uttar Pradesh was related to her husband before

Table 3. Measures of infant and child mortality for Maharashtra, Tamil Nadu and Uttar Pradesh

State	Neonatal mortality (per 1000 births)	Postneonatal mortality (per 1000 births)	Child mortality (deaths under 5 years per 1000 children attaining the age of 1 year)	Crude death rate (per 1000)
Maharashtra	36·4	14·0	20·9	7·7
Tamil Nadu	46·2	21·5	20·1	9·7
Uttar Pradesh	59·9	40·0	46·0	11·9
India	48·6	29·9	33·4	9·7

Note: Crude death rates are based on the annual number of deaths recorded for the *de jure* population during the 2 years prior to the survey.
Source: International Institute for Population Sciences (1994a, pp. 208 and 221).

marriage, compared with more than one in four in Maharashtra and almost one in two in Tamil Nadu. Within each state, however, there is little difference by household type in the distribution of the three 'autonomy' variables. This suggests either that these variables are not, after all, closely related to female autonomy and/or that women living in patrilineal households do not have less autonomy at the individual level than women in other types of household.

Table 3 shows neonatal, postneonatal and early childhood mortality rates for Maharashtra, Tamil Nadu and Uttar Pradesh. Uttar Pradesh has the highest level of mortality. The rates in Maharashtra are lower than those in Tamil Nadu. Maharashtra is the most urbanized state in India and enjoys better overall provision of health care services.

A wide range of factors that might be associated with infant and child mortality were examined. Most of these are fairly standard in analyses based on Mosley & Chen's (1984) analytical framework for the study of child survival in developing countries, and may be grouped into demographic factors (such as the age of the mother and the length of the preceding birth interval), biological factors and breast-feeding behaviour, and factors measuring the mother's knowledge and use of health care services. A full list is given in the Appendix. The remaining covariates are either attempts to measure female autonomy, or socioeconomic factors (including some that also measure access to health services).

Dyson and Moore's definition of female autonomy stresses a woman's power within the household. A justification for this approach is provided by the fact that the household is the unit that generates decisions on accessing health care services in India (Chatterjee, 1989; Basu, 1992; Khan *et al.*, 1989; Mosley & Chen, 1984; Das Gupta, 1987). The outcomes of such decisions are influenced by the familial power structure and the relationship between the decision-maker and the affected party (Khan *et al.*, 1989; Behrman, 1998). Caldwell *et al.* (1983) point out that a child's

mother is the person most likely to notice problems with a child's health because of her role as the primary carer, and she is therefore likely to be in the best position to make health care choices. Yet in northern India, where women are likely to live in extended families with their mother-in-law, health care decisions may often be made by the woman's mother-in-law, rather than the woman herself. The low status afforded to a young mother in the north, and the lack of natal kin living within the vicinity, make it difficult for a daughter-in-law to challenge any decisions her mother-in-law makes. In view of this, the presence of a woman's mother-in-law in the household, and whether the mother was related to her husband prior to marriage, were included as covariates in the models. The two other variables tabulated in Table 2 were also included.

As well as household decision-making processes, household resources are likely to influence the health and mortality of infants and children. Household production determines the capability of the household to purchase health goods and services (Chatterjee, 1989; Doan & Bisharat, 1990; Berman, Kendall & Bhattacharya, 1994; Behrman, 1998). Basu (1987) found that a mother's ability to make her decision-making count was limited by the resources available to the household. It has also been argued that, while the nuclear household may create more initiative to access health services, the joint household offers a better social security system for dependants and is therefore more likely to provide the necessary resources for seeking health treatment (Chekki, 1974; Caldwell, Reddy & Caldwell, 1996; Murthy *et al.*, 1985). Beenstock & Sturdy (1990) found that lack of access for the household to sanitation services and other social/medical services plus crowded housing conditions led to higher morbidity and mortality rates. The way in which household resources affect mortality can be tested using variables in the NFHS about the socioeconomic status of the household (see Appendix).

Methods

Statistical regression techniques were used to model neonatal (under 1 month), early postneonatal (1–8 months) and early childhood (9–23 months) mortality. The three age ranges were analysed separately where possible to reflect the changing determinants of mortality throughout early childhood. Only children who were born between 1 month and 5 years of the survey date were included in the analysis. One reason for this is that information on immunization, breast-feeding and health care was only collected for children born within this period. Another reason is that the models include covariates that are measured at the time of the survey, but which are subject to change over time (for example the presence in the household of a mother-in-law). Later childhood was not considered because of the small number of deaths occurring after the age of 2 years.

Neonatal mortality

This was modelled using a logistic model of the form:

$$\ln\left(\frac{P_i}{1-\mathrm{P_i}}\right) = x_i'\,\beta$$

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where P_i is the probability that the i^{th} child died, x_i is a vector of characteristics of the child and its mother, and β is a vector of parameter estimates. To control for right-censoring of the data caused by the survey, children who had not been exposed to the risk of death for a complete month were excluded. An attempt was made to fit multi-level models to the data for neonatal mortality in order to measure death clustering within families. However, no significant death clustering was found (possibly because there were not enough data available for the effect to be identified), and so this was not pursued further.

Early postneonatal and early childhood mortality

Because the data for Uttar Pradesh contain many deaths (323 in total), it was possible to use a discrete-time hazard model (Allison, 1982; Yamaguchi, 1991) to analyse mortality at ages 1–8 months. Hazard modelling has the advantage that censored observations can be included. The hazard rate h_{it} is the number of deaths to children aged t divided by the number exposed to risk at that age. In other words, it is the conditional probability that a child dies at age t, given that the child is still alive just prior to that age.

If the hazard rate for individual i at time t is h_{it}, then the model may be written

$$\log(h_{it}/[1 - h_{it}]) = \alpha_t + x_{it}' \beta$$

where α_t is some function of time, x_{it} is a vector of covariates and β is a vector of model parameters. As Allison (1982, p. 72) states, the logistic specification of this model, which expresses the odds of the hazard rate as a function of a set of covariates, is 'a somewhat arbitrary choice' but it has the virtues of constraining h_{it} to lie between 0 and 1 and of being computationally convenient.

The discrete-time approach is used because of the nature of the way in which the data were collected in the NFHS. A continuous-time model would require the time at death to be measured on a continuous scale. Of course, death does occur on such a scale, but as the survey recorded age at death to the nearest month, the data are 'grouped continuous', with many ties in the reported ages at death, and it is more appropriate to use a discrete-time model. The model was estimated using a data file containing a separate line for each child-month of exposure. Each line included a binary variable taking the value 0 if the child did not die in that month, and 1 if the child did die. A duration variable was included to measure changes in mortality with age.

An examination of the age at death data for Uttar Pradesh showed that there was a problem with heaping in the reported age at death at 12 months, and smaller heaps at 6 and 18 months. This meant that it was impossible to state the true rate of mortality for the months immediately preceding 12 months and those just after it, as mothers had clearly reported an approximate age at death despite the probing questions asked by the interviewers when the survey was conducted. Because of its sensitivity to inaccurately recorded ages at death, it was felt that a discrete-time hazard model would not be appropriate for modelling mortality in Uttar Pradesh at ages 9 months or above. Instead, all deaths at ages 9–23 months were grouped and modelled using a logistic regression model similar to the one used for neonatal mortality.

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In Maharashtra and Tamil Nadu there were too few deaths between the ages of 1 and 23 months (35 deaths in each case) to examine using complex statistical modelling techniques, because of the size of the samples collected and the low mortality rates. Therefore mortality for children aged between 1 and 23 months was examined using the same logistic regression technique as the one used for neonatal mortality. To avoid right-censoring, the model excludes children born within 24 months of the survey date. After this restriction there were only 43 deaths to children aged 1–23 months in Tamil Nadu and Maharashtra combined. The model therefore combines the data for the two states and includes a dummy variable for state. Caution should be exercised in interpreting the results because of the small number of deaths.

Results

Table 4 presents the results of the parsimonious neonatal mortality models. Two-way interaction terms which included the type of household were examined but none was found to be significant. The results are presented as estimated probabilities of dying, calculated by entering the appropriate values for the variable of interest and setting the other covariates to their mean values in the sample for each state. Only for Uttar Pradesh does the household structure (as represented by the presence of a mother-in-law) have a significant effect on neonatal mortality, with a slightly lower probability of death where a mother-in-law is present within the household than where she is not. Other variables that were found to be significant in at least one of the states were crowded living conditions, the previous sibling's survival status, the preceding birth interval, whether or not the birth was premature or multiple, whether the mother received a tetanus injection prior to the birth, complications in delivery, whether the mother squeezed milk from her breast before initiating breast-feeding, the size of the baby at birth, household ownership of a television, caste, whether the child was fed immediately after birth, and whether the mother received antenatal care. The largest effects were found for prematurity, whether the birth was one of a set of multiple births and whether the mother squeezed milk from the breast before initiating breast-feeding. Squeezing milk from the breast deprives the infant of colostrum, which would otherwise confer extra immunity from disease.

The results of the discrete-time hazard modelling of early postneonatal mortality in Uttar Pradesh are presented in Table 5. The risk of dying is greater at ages 1–2 months than at ages 3–8 months. Factors other than age that significantly affect early postneonatal mortality in Uttar Pradesh are an early infant feeding pattern, caste, the mother's age at birth, the mother's knowledge of oral rehydration salts (ORS), the preceding birth interval, whether the child was born prematurely and/or was one of multiple births, the time lived in the place where the child was living, whether the mother squeezed milk from breast before breast-feeding, the size of the baby at birth, and whether the mother received a tetanus injection prior to the birth. The most important of these were the breast-feeding behavioural factors. The World Health Organization recommends that infants begin to be introduced to solid foods between the ages of 4 and 6 months. The 'early feeding' variable identified infants who had been inappropriately fed solid food before the age of 4 months. These had

Table 4. Probabilities of death estimated from a logistic regression model of neonatal mortality: Maharashtra, Tamil Nadu and Uttar Pradesh

Covariate and category	Maharashtra	Tamil Nadu	Uttar Pradesh
Crowding			
0–3 persons per room/missing			0·034
4–5 persons per room			0·024**
6+ persons per room			0·011***
Previous sibling died?			
Yes	0·035	0·039	
No	0·014***	0·014***	
No previous child	0·024**	0·016***	
Preceding birth interval			
<24 months			0·036
24–35 months			0·019***
36–47 months			0·020***
48+ months			0·019**
First births			0·036
Premature birth?			
No	0·017	0·014	0·024
Yes	0·152***	0·297***	0·120***
Multiple birth?			
No	0·017	0·015	0·025
Yes	0·155***	0·143***	0·081***
Respondent received tetanus injection?			
Yes/missing			0·025
No			0·035***
Complication in delivery?			
Yes			0·031
No			0·024***
Mother squeezed milk from breast?			
Yes	0·076	0·068	0·095
No	0·008***	0·008***	0·013***
Missing	0·009***	0·006**	0·012***
Size of baby at birth			
Average/large			0·021
Small			0·071***
Don't know			0·125***
Household owns a TV?			
Yes	0·009		0·015
No	0·021**		0·029***

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Table 4. *Continued*

Covariate and category	Maharashtra	Tamil Nadu	Uttar Pradesh
Caste			
Other caste/scheduled caste			0·025
Scheduled tribe			0·055**
Sex			
Male	0·026	0·021	0·025
Female	0·012***	0·012**	0·026
Child was fed immediately?			
No		0·018	
Yes		0·002***	
Mother received antenatal care?			
No/missing	0·027	0·037	
Yes	0·014*	0·009***	
Mother-in-law in household?			
No	0·020	0·017	0·029
Yes	0·015	0·015	0·022***
Average probability of death	0·009	0·016	0·026

Notes: All probabilities were evaluated using mean values for the other covariates. The first category listed for each covariate is the reference category used in the model. Asterisks denote that the probability of death in the relevant category is significantly different from that in the reference category at the following levels: *$0{\cdot}05 < p \leq 0{\cdot}1$, **$0{\cdot}01 < p \leq 0{\cdot}05$, ***$p \leq 0{\cdot}01$.
Source: 1992–93 Indian National Family Health Survey.

an increased probability of dying in the first 8 months of life compared with those who were recorded as exclusively breast-fed. The presence of a mother-in-law was not significant in this model, nor was watching television or knowledge of the minimum legal age at marriage for women.

Table 6 displays the results of the logistic regression analysis of early childhood deaths to children aged 9–23 months in Uttar Pradesh for the most parsimonious model. The factors that had the greatest impact on mortality were measles immunization, whether the mother received antenatal care during pregnancy, and whether the mother had squeezed milk from the breast before initiating breast-feeding. The mother's age at birth, the preceding birth interval and the sex of the child also had statistically significant associations. Again, neither the presence of the mother-in-law, nor any of the female autonomy variables listed in the Appendix, was significant.

In Maharashtra and Tamil Nadu, possibly because of the small number of cases, mortality between ages 1 and 23 months was only significantly associated with the child being a multiple birth, and the preceding birth interval (Table 7). The presence of the mother-in-law was, once again, not significantly related to child mortality.

Table 5. Results of discrete-time hazard model of early postneonatal mortality (1–8 months) for Uttar Pradesh

Covariate and category	Number of child-months	β	Standard error	Probability of death
Constant***	53,728	−4·52	0·32	0·0016
Breast milk supplementation?				
Yes	11,195	Ref.		0·0063
Partially (extra water given)***	28,827	−1·93	0·19	0·0009
No***	17,706	−1·48	0·18	0·0014
Caste				
Other caste/scheduled tribe	43,958	Ref.		0·0015
Scheduled caste**	9770	0·34	0·16	0·0021
Mother-in-law in household?				
No	27,786	Ref.		0·0015
Yes	25,942	0·17	0·14	0·0017
Mother's age at birth				
20–29 years	32,218	Ref.		0·0013
<20 years	9229	0·22	0·20	0·0016
30–34 years***	7551	0·72	0·20	0·0027
35+ years***	4730	0·82	0·25	0·0029
Mother knows of oral rehydration salts?				
No	39,188	Ref.		0·0018
Yes**	14,540	−0·45	0·19	0·0011
Preceding birth interval				
<24 months	10,649	Ref.		0·0032
24–35 months***	13,580	−0·75	0·19	0·0015
36–47 months***	9336	−0·81	0·22	0·0014
48+ months***	7911	−1·99	0·40	0·0004
First births	12,252	−0·32	0·21	0·0023
Baby was premature				
No	52,724	Ref.		0·0016
Yes**	1004	0·68	0·33	0·0031
Multiple birth?				
No	53,155	Ref.		0·0016
Yes***	573	1·19	0·32	0·0051
Time lived in place				
2+ years	47,197	Ref.		0·0016
<2 years*	1227	0·71	0·40	0·0032
Visitor	5304	0·12	0·25	0·0016

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Table 5. *Continued*

Covariate and category	Number of child-months	β	Standard error	Probability of death
Mother squeezed milk from breast?				
Yes	15,448	Ref.		0·0034
No***	25,669	− 0·99	0·16	0·0013
Missing***	12,611	− 1·25	0·23	0·0064
Size of baby at birth				
Large	43,737	Ref.		0·0014
Small***	9017	0·64	0·15	0·0027
Don't know	974	0·71	0·59	0·0029
Respondent received tetanus injection?				
Yes	23,730	Ref.		0·0012
No***	29,998	0·52	0·17	0·0020
Age of child				
4 months	6792	Ref.		0·0012
1 month***	7436	0·74	0·27	0·0026
2 months**	7222	0·64	0·28	0·0024
3 months	7005	0·07	0·31	0·0013
5 months	6581	0·13	0·31	0·0014
6 months	6394	0·47	0·29	0·0020
7 months	6216	− 0·21	0·34	0·0010
8 months	6082	− 0·02	0·33	0·0012

Notes: All probabilities were evaluated using mean values for the other covariates. Asterisks denote that the hazard of death in the relevant category is significantly different from that in the reference category at the following levels: *$0{\cdot}05 < p \leq 0{\cdot}1$, **$0{\cdot}01 < p \leq 0{\cdot}05$, ***$p \leq 0{\cdot}01$.
Source: 1992–93 Indian National Family Health Survey.

Discussion

The results show that predictors of mortality vary between the three states, although there are a number of key variables that are important in all three. Using the classification of covariates mentioned earlier (see also the Appendix), the most important demographic predictors were a short preceding birth interval, the survival status of the preceding sibling, and the mother's age at birth.

In Tamil Nadu and Maharashtra the death of a previous sibling was found to be significantly associated with an increased risk of mortality during the neonatal period. This is consistent with the findings of Curtis & Steele (1996) who studied neonatal mortality in four different countries. In Uttar Pradesh, however, there was no significant association between the survival status of the previous sibling and the neonate. This might be because the preceding birth interval is capturing much of the influence of the survival status of the previous sibling. A household that loses a child is more likely to produce a child within a short birth interval than a household whose child survives. In Uttar Pradesh contraceptive prevalence is low: only 26% of women

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Table 6. Results of logistic regression model of early childhood mortality (9–23 months) for Uttar Pradesh

Variable	Number of children	β	Standard error	Probability of death
Constant	3441	− 3·09	0·23	0·0123
Uptake of antenatal care				
No	1957	Ref.		0·0182
Yes***	1484	− 0·93	0·31	0·0073
Measles vaccination?				
No	2233	Ref.		0·0196
Yes***	1208	− 1·36	0·41	0·0051
Mother's age at birth				
<35 years	3130	Ref.		0·0113
35+ years***	311	0·89	0·32	0·0273
Preceding birth interval				
<48 months	2220	Ref.		0·0161
48+ months**	455	− 1·08	0·48	0·0055
First births*	766	− 0·59	0·34	0·0090
Mother squeezed milk from breast?				
Yes	2244	Ref.		0·0171
No***	612	− 0·88	0·29	0·0072
Missing	585	− 0·18	0·31	0·0143
Sex				
Male	1808	Ref.		0·0134
Female*	1633	0·43	0·23	0·0203
Mother-in-law in household?				
No	1843	Ref.		0·0101
Yes	1598	0·16	0·23	0·0119

Notes: All probabilities were evaluated using mean values for the other covariates. The first category listed for each covariate is the reference category (Ref.) used in the model. Asterisks denote that the probability of death in the relevant category is significantly different from that in the reference category at the following levels: *$0{\cdot}05 < p \leq 0{\cdot}1$, **$0{\cdot}01 < p \leq 0{\cdot}05$, ***$p \leq 0{\cdot}01$.
Source: 1992–93 Indian National Family Health Survey.

who have ever been married have ever used a method (International Institute for Population Sciences, 1994b, p. 92). Because the death of the previous child leads to a reduction in the period of lactational amenorrhoea, sexually active women who are not using contraception are likely to conceive again within a shorter period than if the previous child survives. In Tamil Nadu and Maharashtra the higher contraceptive prevalence weakens this effect.

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Table 7. Results of logistic regression model of postneonatal and early childhood mortality (1–23 months) for Maharashtra and Tamil Nadu

Variable	Number of children	β	Standard error	Probability of death
Constant	1931	− 3·9701	0·32	0·0190
Multiple birth?				
No	1915	Ref.		0·0188
Yes**	16	1·4530	0·80	0·0757
Preceding birth interval				
24+ months	936	Ref.		0·0147
<24 months***	387	1·1915	0·36	0·0467
First births	608	0·0866	0·42	0·0160
State				
Tamil Nadu	863	Ref.		0·0231
Maharashtra	1068	− 0·3609	0·32	0·0162
Mother-in-law in household?				
No	1168	Ref.		0·0200
Yes	763	− 0·1261	0·33	0·0177

Notes: see Table 6.
Source: 1992–93 Indian National Family Health Survey.

Biological factors, such as prematurity, a multiple birth, the size of baby at birth, and complications in delivery were generally important, and their effects on mortality were in the expected direction. Breast-feeding behaviour was also important: squeezing milk before initiating breast-feeding, late initiation of the first feed and early introduction of supplementary foods to the infant's diet were all associated with increased mortality. By contrast, socioeconomic factors were not associated to any great degree with infant and early childhood mortality.

One interesting result that is easy to overlook when considering Tables 4–6 concerns mortality differentials between male and female children. In most populations, male mortality is higher than that of females at (almost) all ages (Waldron, 1985). However, Visaria (1967) highlighted the fact that the opposite was true in many parts of India, particularly the north. The current results suggest that Tamil Nadu and Maharashtra show the normal pattern of mortality in the neonatal period, with males having a greater susceptibility to death. However, in Uttar Pradesh there was no significant difference in the neonatal mortality experience of males and females, suggesting that females are experiencing higher levels of mortality than would be expected, given the level of male mortality. In Maharashtra and Tamil Nadu there were no significant differences in mortality by sex at ages 1–23 months, whereas in Uttar Pradesh females were significantly more likely to die at ages 9–23 months than males (Table 6). This again suggests that females in Uttar Pradesh

are experiencing higher mortality patterns than would be expected given the level of male mortality, after controlling for the other explanatory factors entered into the model.

This excess mortality in the postneonatal and early childhood periods contributes to the unusual population sex ratios found in many areas of India, and is almost certainly related to the low status attached to females (Griffiths *et al.*, 2000). It also confirms reports from other studies that the northern states, such as Uttar Pradesh, have wider sex differentials in mortality than the southern states (see, for example, Dyson & Moore, 1983). Arnold, Choe & Roy (1996) reported preferential treatment of males over females in a study using the NFHS data. They found that male children were more likely than females to be immunized and to be taken for treatment for illness, especially in the northern states. It is possible that this kind of discriminatory behaviour is a cause of the higher mortality of females than males found in this analysis.

A number of variables that measure knowledge of and access to health services were also found to be significant in the models. In the early postneonatal period in Uttar Pradesh, women who knew about ORS were more likely to have surviving children than those who did not. Women who knew of ORS show that they are familiar with the Western health care system and are also more likely to know where to access it and be empowered to use it. Uptake of antenatal care by the mother during pregnancy and at least one dose of tetanus vaccine being administered to the pregnant mother were also associated with increased chances of survival in all of the periods of mortality studied for all three of the states. Measles immunization was also found to be an important predictor of mortality in the early childhood period (9–23 months). Immunization against measles not only reduces the child's vulnerability to catching the disease and hence secondary infections that might cause death, but also shows that the child belongs to a household that is prepared to access Western medical care. This will increase the child's chances of survival (Caldwell, Reddy & Caldwell, 1983).

A proxy for health services available in the village was entered into the models for mortality and was not found to be a significant predictor of survival. It therefore seems that parents who want to approach services for a very sick child will find a way of accessing them regardless of the availability in the particular village in which they are living.

The only mortality outcome that was significantly associated with household type, as measured by the presence of a mother-in-law, was neonatal mortality in Uttar Pradesh, where children living in patrilineal family structures had lower mortality. The hypothesis that the presence of a mother-in-law would lead to worse demographic outcomes for children (through reduced maternal autonomy) is therefore not borne out by the evidence here. One possible explanation is that a household containing a mother-in-law provides an improved support structure – whatever its effect on the mother's autonomy (Caldwell *et al.*, 1996). A mother-in-law may be able to care for other children when a daughter-in-law delivers her baby, meaning that the daughter-in-law will be better able to go to deliver her baby in a health facility and give the newborn infant the constant care that it needs in the early days of life. It may of course be that a mother's autonomy (at the individual level) is an important

determinant of infant and child mortality but that the 'mother-in-law' variable is not a good proxy for it. However, none of the other variables included which might be interpreted as a proxy for female autonomy was significant either. The children of women in endogamous marriages (whose mothers were related to their husbands before marriage) fared no better than the children of women in exogamous marriages.

An interaction between sex and type of household was tested to establish whether patrilineal households had different survival patterns for male and female children in the models for Uttar Pradesh. However, the interaction was found to be insignificant, suggesting that patrilineal households do not have significantly different sex differences in mortality to those found in other types of household in the Uttar Pradeshi population.

These results clearly show that the direct effects of demographic and biological factors, breast-feeding behaviour, and use and knowledge of health services on infant and child mortality are more important than the direct effect of female autonomy. However, autonomy levels and maternal decision-making might still have an important indirect effect, acting through the demographic and biological factors. To test this, models were estimated with the same mortality outcome variables, but with only the 'autonomy' variables as covariates. If indirect effects are operating, then the 'autonomy' variables would be expected to have statistically significant effects in such models. However, the only significant effect observed concerned the variable measuring a mother's knowledge of the minimum legal age at marriage, and even this was not universal. Relative to the children of mothers who gave the correct response (18 years), the children of mothers who gave ages less than 18 years, or who said that they did not know, experienced higher mortality in the neonatal period in Uttar Pradesh and Maharashtra and higher mortality at ages 1–8 months in Uttar Pradesh. Further analysis indicated that the intervening factors through which this variable appeared to be acting were different in each case. This is not considered to be very strong (or easily interpretable) evidence of the indirect effects of maternal autonomy.

Conclusions

Infant and early childhood mortality in Maharashtra and Tamil Nadu have already reached reasonably low levels, although there is still potential for further improvement to reach the levels achieved in most developed countries. In Uttar Pradesh, the rates are still much higher (at ages 1–23 months they are more than double those in Maharashtra and Tamil Nadu).

The evidence presented in this paper suggests that, at the individual level, socioeconomic factors are less important in explaining mortality in the infant and early childhood years than demographic factors (including breast-feeding behaviour), biological factors and mothers' knowledge of and use of health care services.

The magnitude of the association was greatest for breast-feeding behaviour in the models for early mortality and immunization against measles, use of antenatal care and squeezing milk from the breast before initiating breast-feeding in the analysis for mortality of children aged 9–23 months in Uttar Pradesh. Uttar Pradesh also has

higher female child mortality than would be expected, given the level of male mortality found in the population. Some kind of discriminatory behaviour is probably causing this unusual mortality pattern.

From these results, it seems that a direct association between maternal autonomy and infant and child mortality does not operate at the individual level, or that, if it does, its operation is not captured by the 'mother-in-law' variable or any of the other proxies (such as watching television, or knowledge of the minimum legal age at marriage for women) that were tried. In addition, only limited evidence was found of an indirect effect in two of the three states studied. It is acknowledged that the information available for measuring female autonomy in the NFHS data is far from ideal, and further in-depth work is now needed to attempt to measure the impact of inequalities within the household and their association with mortality outcomes. Finally, the apparent lack of any association between the presence of a mother-in-law and mortality at the individual level is not necessarily evidence against Dyson and Moore's argument that there is a chain of causality at the *societal* level from systems of marriage through (say) female autonomy to child mortality outcomes.

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References

Allison, P. D. (1982) Discrete-time methods for the analysis of event histories. In: *Sociological Methodology*, Vol. 13, pp. 61–98. Edited by S. Leinhardt. Jossey-Bass, San Francisco.

Amin, R., Kabir, M., Chowdhury, J., Ahmed, A. U. & Hill, R. B. (1994) Impact of poor women's participation in credit-based self employment on their empowerment, fertility, contraceptive use and fertility desire in rural Bangladesh. Paper presented at the *Annual Meeting of the Population Association of America*, Miami, Florida.

Arnold, F., Choe, M. K. & Roy, T. K. (1996) Son preference, the family-building process and child mortality in India. Paper presented at the *Annual Meeting of the Population Association of America*, New Orleans, Louisiana.

Basu, A. M. (1987) Household influences on childhood mortality: evidence from historical and recent mortality trends. *Social Biol.* **34**, 187–205.

Basu, A. M. (1992) *Culture, the Status of Women and Demographic Behaviour: Illustrated with the Case of India.* Clarendon Press, Oxford.

Beenstock, M. & Sturdy, P. (1990) The determinants of infant mortality in regional India. *Wld Dev.* **18**, 443–453.

Behrman, J. R. (1998) Intra-household allocation of resources: is there a gender bias? In: *Too Young To Die: Genes or Gender?* United Nations, New York.

Berman, P., Kendall, C. & Bhattacharya, K. (1994) The household production of health: integrating social science perspectives on micro-level health determinants. *Social Sci. Med.* **38**, 205–215.

Bloom, S. S., Wypij, D. & Das Gupta, M. (1998) *Dimensions of Women's Autonomy and the Influence on Maternal Health Care Utilisation in a North Indian City*. Working paper, Carolina Population Center, University of North Carolina at Chapel Hill.

Caldwell, J. C., Reddy, P. H. & Caldwell, P. (1983) The social component of mortality decline: an investigation in south India employing alternative methodologies. *Popul. Stud.* **37**, 185–205.

Caldwell, J. C., Reddy, P. H. & Caldwell, P. (1996) The family in south India: past, present and future. *Social Change* **26**, 116–129.

Chatterjee, M. (1989) Competence and care for women: health policy perspectives in the household context. In: *Gender and the Household Domain: Social and Cultural Dimensions. Women and the Household in Asia*, No. 4, pp. 165–190. Edited by M. Krishnaraj & K. Chanana. Sage Publications, London.

Chekki, D. A. (1974) Modernization and social change: the family and kin network in urban India. In: *Family in India: A Regional View. Studies in the Social Sciences*, Vol. 12, pp. 205–231. Edited by G. Kurian. Mouton, Paris.

Curtis, S. L. & Steele, F. (1996) Variations in familial neonatal mortality risks in four countries. *J. biosoc. Sci.* **28**, 95–101.

Das Gupta, M. (1987) Selective discrimination against female children in rural Punjab, India. *Popul. Dev. Rev.* **13**, 77–100.

Doan, R. M. & Bisharat, L. (1990) Female autonomy and child nutritional status: the extended-family residential unit in Amman, Jordan. *Social Sci. Med.* **31**, 783–789.

Dyson, T. & Moore, M. (1983) On kinship structure, female autonomy, and demographic behaviour in India. *Popul. Dev. Rev.* **9**, 35–54.

Griffiths, P., Matthews, Z. & Hinde, A. (2000) Understanding the Indian sex ratio: a simulation approach. *Demography* **37,** 477–488.

International Institute for Population Sciences (1994a) *National Family Health Survey 1992–93. India*. International Institute for Population Sciences, Bombay.

International Institute for Population Sciences (1994b) *National Family Health Survey 1992–93. Uttar Pradesh*. International Institute for Population Sciences, Bombay.

Khan, M. E., Anker, R., Dastidar, S. K. G. & Bairathi, S. (1989) Inequalities between men and women in nutrition and family welfare services: an in-depth enquiry in an Indian village. In: *Selected Readings in the Cultural, Social and Behavioural Determinants of Health. Health Transition Series*, No. 1, pp. 175–199. Edited by J. C. Caldwell & G. Santow. Highland Press, Canberra.

Mason, K. O. (1986) The status of women: conceptual and methodological issues in demographic studies. *Sociol. Forum* **1**, 284–300.

Mosley, W. H. & Chen, L. C. (1984) Child survival: strategies for research. *Popul. Dev. Rev.* **10** (supplement), 25–45.

Murthy, P. S. N., Ramnath, T., Vijayaraghavan, K. & Rao, N. P. (1985) Nutritional profile of joint and nuclear families in rural Andhra Pradesh. *J. Fam. Welfare* **32**, 80–87.

Visaria, P. M. (1967) The sex ratio of the population of India and Pakistan and regional variations during 1901–61. In: *Patterns of Population Change in India 1951–61*, pp. 334–371. Edited by A. Bose. Allied Publishers, Calcutta.

Waldron, I. (1985) What do we know about causes of sex differences in mortality? A review of the literature. *Popul. Bull. United Nations* **18**, 59–76**.**

Yamaguchi, K. (1991) *Event History Analysis*. Sage Publications, London.

Appendix

List of variables entered into the mortality models

Demographic factors

Birth order
Whether previous child had died
Number of births mother had during previous 24 months
Mother's age at birth
Preceding birth interval
Whether child was born prematurely
Whether child was one of multiple births
Sex of child

Biological/breast-feeding factors

Size of child at birth
Timing of initiation of solid foods (infant fed solid foods before 4 months or fed other liquids besides breast milk before 4 months)***
Whether child was fed immediately after birth**
Whether mother squeezed milk from her breast before feeding the child

Socioeconomic factors

Caste
Religion
Whether household used cow dung for cooking***
Whether household had crowded living conditions
Source of drinking water
Type of toilet facility
Type of building materials used for house
Whether household owned a television set
Whether household owned a radio
Geographical locality
Mother's occupation
Mother's partner's occupation
Mother's education
Whether mother's partner had ever attended school
Time lived in current place of residence (years)

Factors measuring knowledge of and use of health care services

Uptake of antenatal care/number of visits
Whether health services were available in the village where the woman lived
Whether child had been immunized against measles*
Mother's knowledge of oral rehydration salts

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Whether mother had received iron or folic acid tablets during pregnancy
Whether mother had received an anti-tetanus injection during pregnancy
Place of delivery**
Whether there were complications in the delivery**

Household structure/female autonomy factors

Whether mother listened to radio at least once per week
Whether mother watched television at least once per week
Mother's knowledge of the legal age at marriage for females
Household type (nuclear, extended with mother-in-law etc)
Whether mother's mother-in-law usually resident in the household
Whether mother was related to her husband other than through marriage

*Only in model of early childhood mortality (9–23 months).
**Only in model of neonatal mortality.
***Only in models of early postneonatal mortality (1–8 months) and early childhood mortality (9–23 months).

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