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On the incidence of diarrhoea among young Indian children

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Abstract

Diarrhoea, claiming over three million young lives in the world every year, is the second biggest killer of children in developing countries. Using data for over 13,000 children in rural India, under the age of 3 years, this paper examines the relative effects of the different factors—*inter alia* the quality of the water supply, mother's literacy, housing conditions, and the level of development of the villages in which the children lived—contributing to diarrhoea. The paper highlights the importance of two factors: that children born to undernourished mothers may be more susceptible to infection than children whose mothers are well nourished, and that good hygienic practices within the home, such as washing hands with soap before feeding a child, can reduce the incidence of diarrhoea. The paper also quantifies the relative strength of the factors that determine whether mothers do so. The results emphasize the importance of mothers being literate, of household affluence and of institutional support (through the availability of trained midwives and mother and child centres in villages) in promoting domestic hygiene.

JEL classification: I10

Keywords: Diarrhoea; India; Mortality; Children

1. Introduction

There are four important facts about diarrhoeal diseases (Curtis et al., 2000). First, they are responsible for about one in five deaths of children in the world (Kosek et al., 2003). Indeed, such diseases are the second-biggest killers of children, ahead of malaria, tuberculosis and AIDS.[1] Second, most of these 2.5 million deaths each year take place in developing

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countries, 80% of them in the first 2 years of their life (Bern et al., 1992). Third, the vast majority of diarrhoeas are caused by infectious pathogens which reside in faeces and which employ a variety of routes to reach new hosts: the pathogen may reach a new host by getting onto fingers and, thereby, into foods and fluids, or the pathogen may enter foods and fluids, without a human intermediary, for example by flies landing on excreta and carrying the pathogen to foods, or by excreta entering the water supply.[2] Fourth, since many transmissions occur in the home, the incidence of such diseases can be reduced by changes in domestic hygiene. While improvements to infrastructure, such as safe drinking water and effective sanitation facilities, contribute to blocking transmission, they are effective only if they are employed in conjunction with good domestic hygiene practices (Cairncross, 1990).

It might also be expected that certain children are more susceptible to infection than others. As Osmani and Sen (2003) point out, the processes that lead to intra-uterine growth retardation, and result in low-weight babies, also induce certain physiological changes in the foetus that impair its immune system. Consequently, there might be a link between the health of a mother and that of her child: undernourished mothers give birth to low-weight babies who, as children, are relatively more vulnerable to infection than children of well nourished mothers.

The purpose of this paper is to examine the relative contribution of a range of factors to the incidence of diarrhoea in young Indian children. The variables considered include, *inter alia*, the quality of water supply, the literacy of mothers, the nature of housing conditions, and the level of development of villages. Employing a unique set of data, the paper highlights two aspects in the study of diarrhoea incidence: the nutritional state of mothers, and the level of domestic hygiene, as manifest in their hand washing habits. Another purpose of the paper is to examine, the factors which determine whether mothers wash their hands with soap—prior to, or after, key events in their domestic routine—so as to prevent their children from being infected by diarrhoeal pathogens.

The econometric estimates which underpin the analysis are based on individual-record data for over 13,000 mothers of children under 3 years of age, living in rural households, and drawn from the 16 major states of India.[3] These data provide such information as: whether or not their children had suffered an episode of diarrhoea, their hand-washing habits, their, and their husbands', literacy status, their household circumstances, their housing conditions, and the quality of infrastructure in the villages in which they lived.

A recurring theme in the literature on the welfare of children in developing countries is the importance of having literate parents, particularly having a literate mother. There is a body of evidence that suggests that the number of children born to a woman is inversely related to her level of education (Dreze and Murthi, 2001; Borooah, 2000, 2003; Parikh and

[2] Some diarrhoeas may be caused by metabolic errors, chemical irritation or organic disturbance.

[3] These data are based on unit record data from a survey of 33,000 *rural* households—encompassing 195,000 individuals—which were spread over 1758 villages, in 195 districts, in 16 states of India. This survey—commissioned by the Indian Planning Commission and funded by a consortium of United Nations agencies—was carried out by the National Council of Applied Economic Research (NCAER) over January–June 1994 and most of the data from the survey pertains to the year prior to the survey, that is to 1993–1994. Details of the survey—hereafter referred to as the NCAER Survey—are to be found in Shariff (1999), though some of the its salient features are described here.

Gupta, 2001). Furthermore, there is evidence that children's health (including the likelihood of their surviving infancy and childhood), nutritional status and educational attainments are enhanced by having better educated parents, particularly the mother (Behrman and Wolfe, 1984; Thomas et al., 1991; Sandiford et al., 1995; Lavy et al., 1996; Ravallion and Wodon, 2000; Gibson, 2001). Moreover, a farm-household's total income depends on the highest education level reached by a household member rather than by the mean educational level of the household or by the educational level of the household head (Foster and Rosenzweig, 1996). Education also raises the wages of both men and women (Kingdon and Unni, 2001). Against this backdrop of the importance attached to maternal literacy, this paper asks if such literacy also delivers benefits in terms of protecting children from diarrhoea.[4]

The data also provided information on whether the mothers (of children under 3 years old) were anaemic. As is well known, the incidence of anaemia can reflect both dietary deficiency and the deleterious effects of infection on iron utilisation: it is, therefore, a good indicator of the health and nutritional disadvantages suffered by an individual (Osmani and Sen, 2003). Information on the incidence of anaemia in mothers was used to examine whether, or not, there was a link between maternal anaemia and the incidence of diarrhoea in young children.

2. The data

The data used in this study are from the human development survey conducted in 1993–1994 by the National Council of Applied Economic Research (NCAER), New Delhi. The women were asked whether *any* of her under 3-year-old children had had an episode of diarrhoea, and, if so, when the last episode occurred.[5] This study is based on the sub sample of women who had children below the age of 3 years. Insofar as the number of children in the household was not recorded, we can only analyse the *proportion* of women answering the 'diarrhoea question' in the affirmative. 62% of the 13,195 women answered 'yes' to the diarrhoea question.[6] Of the women who answered the diarrhoea question in the affirmative, 38% said that the latest bout had occurred in the last month and 51% said that it had occurred in the last year.[7] Consequently, nine-tenths of the bouts of diarrhoea that are analysed in this paper occurred in the 12 months prior to the interview. Although the severity of the bout is unknown, it is known that two-thirds of the children were referred to

[4] See Basu and Foster, 1998, Basu et al., 2002 for a discussion of the *nature* of literacy. They argue that some of the disadvantages to a person of being illiterate may be mitigated if he/she lives in a household in which other members are literate since, for many activities, having access to the ability of the literate members to read and write may serve as a form of 'surrogate'or 'proximate' literacy.

[5] The women were prompted for symptoms of diarrhoea: watery stools, repeated vomiting, marked thirst. Diarrhoea is formally defined as three or more watery stools in 24 h, but any episode diagnosed and/or treated as diarrhoea after an interview with the adult accompanying the child should be counted. The focus is on under-three children because information on diarrhoea was only available for such children. It should be remembered that 80% of deaths through diarrhoea occurred for this age group.

[6] The data did not offer information on the number of under-three children that a woman had and how many of them had suffered a diarrhoeal episode.

[7] So one can be reasonably confident of "good recall" by the mothers.

medical attention, mostly in response to repeated vomiting; one-third of the children were treated at home.

Although the precise age of the under-three age children is not recorded, the survey does provide information on the interval (in months) between the date of the survey and the last live birth of the women: the mean and median intervals were, respectively, 16 and 12 months and only 10% of these women had children below 3-months old. While it is true that the chances of a child suffering a bout of diarrhoea through increased exposure increases with age, this effect should be balanced against the fact that children are most vulnerable when they are babies since their immune systems are not yet adapted to the environment.

2.1. Inter-state variation in the incidence of diarrhoea

The proportion of rural households with under-three children, who had had experienced an episode of diarrhoea varied markedly across the Indian states (Table 1). The relationship between the incidence of diarrhoea, and the relative prosperity of the state appears to be ambiguous. In Haryana (one of the richest states in terms of mean household income) more than 9 out of 10 households had had diarrhoea, while in neighbouring Punjab (as rich as

Table 1
The proportion of children in India under 3 years age who had had an episode of diarrhoea, by region and state

	Incidence of diarrhoea (%)
All India	61.7
Northern region	75.3
Haryana	92.3
Himachal Pradesh	69.6
Punjab	55.3
Central region	70.0
Bihar	66.2
Madhya Pradesh	91.0
Rajasthan	61.6
Uttar Pradesh	56.6
Southern region	52.6
Andhra Pradesh	65.2
Karnataka	38.0
Kerala	45.1
Tamil Nadu	63.7
Western region	46.1
Gujarat	43.2
Maharashtra	47.9
Eastern region	47.9
Assam	53.8
Orissa	69.3
West Bengal	31.4

Source: NCAER survey.

Haryana), the incidence was just over one in two, and in relatively poor West Bengal the incidence was about one in three.

2.2. Inter-caste variation in the incidence of diarrhoea

The sample was subdivided by 'community': Dalits (36%), Hindus (49%), Muslims (11%), and 'others' (4%).[8] The incidence of diarrhoea among under-three children varied markedly by caste: 64% for Dalits and 62% for Hindus, 57% for Muslims, and 49% for 'others'.

2.3. Maternal anaemia

The women in the sample were examined for signs of anaemia.[9] On the basis of the paleness of the inside of their lower eyelid, 14% of the 13,195 women were classed as anaemic (Table 2). There was some variation across the castes in their proportions of anaemic mothers ranging from: 12.5% for Hindus, 13.5% for Muslims, 14.9% for Dalits, 15.6% for 'others'.

However, the proportion of anaemic mothers in a state bore little relation to its relative prosperity: it was high in prosperous states such as Punjab and Himachal Pradesh and low in relatively poor states such as West Bengal and Orissa (Table 2). Instead, this proportion seems to vary inversely with the manner in which women were treated: broadly speaking, it was lowest in the more progressive states of Karnataka, Kerala and West Bengal—where the status of women was high—and highest in the states of Punjab and Rajasthan where women are assigned a more subordinate status.

2.4. Maternal literacy

Thirty-five percent of the 13,195 women were literate.[10] The rate varied from 96% in Kerala, to 60% in Himachal Pradesh and Assam, to around 20% in the Central Indian states of Bihar, Madhya Pradesh and Uttar Pradesh, reaching a low of 10% in Rajasthan (Table 3). Rates of maternal literacy were highest for women from the 'others' community (66%), next highest for Hindus (42%), and lowest for Muslims and Dalits at 34 and 22%, respectively.

2.5. Water quality and distance to water supply

The survey gave details of the main source of drinking water for each of the 1758 villages included. The water supply of a village was defined as being 'safe' if the main source was

[8] Dalits were those castes and tribes—also known as scheduled castes/tribes—recognised by the Indian Constitution in 1947 as deserving special recognition in respect to education, employment and political representation. Of the 468 women in the "other" category, 38% were Christian and 60% were Sikh.

[9] Involving an examination of eyes and lips for signs of paleness and nails for signs of concavity. This was the only information on maternal anaemia in the data. The best sign of anaemia, in this context, is pallor of the palpibral conjunctiva (inside the lower eyelid).

[10] Literacy is defined as the ability to both read and write, with understanding, a short simple statement relevant to everyday life.

Table 2
The proportion of mothers of children under 3 years age who were anaemic, by region and state

	Women who were anaemic (%)
All India	13.6
Northern region	18.4
Haryana	14.3
Himachal Pradesh	23.7
Punjab	21.1
Central region	13.3
Bihar	15.5
Madhya Pradesh	8.7
Rajasthan	27.6
Uttar Pradesh	8.8
Southern region	12.4
Andhra Pradesh	19.7
Karnataka	5.1
Kerala	5.2
Tamil Nadu	20.1
Western region	14.8
Gujarat	19.2
Maharashtra	12.2
Eastern region	10.2
Assam	16.2
Orissa	6.7
West Bengal	8.9

Source: NCAER survey.

one of: protected wells,[11] tanker truck, piped water, or hand pump. It was defined as being 'unsafe' if the main source was one of: ponds, dug wells, streams and canals. Hence the definition is entirely in terms of the source of drinking water and not in terms of any standard of purity. The survey also recorded if the distance to the main source of water in a village was "far" or "near", that is to say, more, or less than a fifteen minute walk away.

A feature of village society in India is that Dalits often belong to India's 'untouchable' castes,[12] and in consequence, are often assigned their own source of water, they are often barred from drawing water from sources used by 'caste' Hindus, or allowed to do so only under highly restricted conditions (Mendelsohn and Vicziany, 2000, p. 44). Hence, the survey separately recorded the main source of water for Dalits and whether this source was 'near' or 'far'.

For India in its entirety, 46% of mothers lived in villages with 'safe' drinking water and for 86% of them water was within 'easy' reach (Table 4). However, for those in the eastern states of Assam and Orissa and the Central states of Madhya Pradesh and Rajasthan, access

[11] A protected well is lined to block pathogens and closed with a metal cover and padlock. The bucket is stored inside and a windlass stops it touching the ground, cutting the risk of contamination.
[12] That is, persons with whom physical contact is unclean and polluting.

Table 3
The proportion of mothers of children under 3 years of age who were literate, by region and state

	Women who were literate (%)
All India	35.0
Northern region	41.5
Haryana	29.2
Himachal Pradesh	60.2
Punjab	47.3
Central region	18.2
Bihar	21.2
Madhya Pradesh	20.6
Rajasthan	10.4
Uttar Pradesh	18.6
Southern region	49.9
Andhra Pradesh	34.0
Karnataka	32.3
Kerala	96.1
Tamil Nadu	48.1
Western region	43.7
Gujarat	39.9
Maharashtra	46.0
Eastern region	46.3
Assam	61.9
Orissa	37.1
West Bengal	43.4

Source: NCAER survey.

to 'safe' drinking water was very poor: less than 7% of mothers in Assam and 10% in Orissa lived in villages with 'safe' drinking water and, for Madhya Pradesh and Rajasthan, the corresponding percentages were, 15 and 23% respectively. For 86% of mothers, the source of water was 'nearby' and it was only in Rajasthan (with its large area of desert) that access to water was a serious problem.

There was significant difference between Dalit and non-Dalit mothers in their access to safe water: only 42% of Dalit mothers, compared to 49% of non-Dalit mothers lived in villages with safe drinking water.[13] Similarly, only 78% of the Dalit mothers, in contrast to 91% of non-Dalit mothers, lived in villages where the source of water was 'nearby'.

2.6. Housing conditions

The survey also provided information on housing conditions. In this regard, the nature of the toilet facilities available to a household was of particular interest: these facilities are considered 'poor' if either there was no toilet in the house or, if it was a 'dry' toilet without water. The nature of ventilation in the house was also of interest: this is considered 'poor'

[13] Remembering that in a village, Dalits might have to access a different water source from non-Dalits.

Table 4
The proportion of mothers of children under 3 years age who were living in villages with 'safe' drinking water, by region and state

	'Safe' drinking water	Water source 'close'
All India	46.3	86.1
Northern region	66.1	80.3
Haryana	58.1	70.2
Himachal Pradesh	58.4	83.4
Punjab	84.0	93.8
Central region	26.6	83.0
Bihar	35.6	85.2
Madhya Pradesh	15.1	93.1
Rajasthan	22.7	42.1
Uttar Pradesh	34.7	94.4
Southern region	68.3	95.8
Andhra Pradesh	39.6	95.6
Karnataka	77.2	97.7
Kerala	72.5	97.5
Tamil Nadu	86.6	92.1
Western region	72.4	93.8
Gujarat	83.4	88.7
Maharashtra	65.8	96.9
Eastern region	27.7	79.6
Assam	6.6	76.5
Orissa	9.6	69.3
West Bengal	66.1	93.9

Safe: water from protected wells, tanker truck, piped water, hand pump. Close: less than 15 min by foot. *Source*: NCAER survey.

if there was: (a) no ventilation, *and* (b) no separate kitchen, *and* (c) food was cooked on a charcoal-fired stove (*chula*).

Eighty-eight percent of the women lived in homes with 'poor' toilet facilities and 48% lived in homes with 'poor' ventilation (Table 5). There was little variation across the states in the proportion with poor toilet facilities, except that in both Kerala and Assam this proportion, 32 and 46%, was relatively low. Kerala is a relatively progressive state with good social infrastructure and Assam is a relatively land abundant state. In terms of ventilation about one-third to one-half of the mothers lived in homes with 'poor' ventilation—except for Kerala, Himachal Pradesh and Assam, where the proportion living with poor ventilation was relatively low, and Bihar and Uttar Pradesh, where the proportion was relatively high.

2.7. Domestic hygiene

The survey also asked about hand washing habits before or after a number of events during the day.[14] For each of these events, it recorded whether hands were: (i) not

[14] Before cooking food, before serving food, before feeding food, before eating food, after defecation, after cleaning a child's stools, after disposing of a child's stools.

Table 5
The proportion of mothers of children under 3 years age who were living in household with poor toilet and ventilation facilities by region and state

	'Poor' toilet facilities	'Poor' ventilation
All India	87.8	47.5
Northern region	88.3	39.6
Haryana	93.6	50.2
Himachal Pradesh	86.7	10.5
Punjab	81.2	44.2
Central region	94.3	66.9
Bihar	92.8	74.9
Madhya Pradesh	95.2	58.8
Rajasthan	97.2	56.9
Uttar Pradesh	92.8	75.6
Southern region	77.9	33.4
Andhra Pradesh	87.4	50.8
Karnataka	91.4	23.0
Kerala	32.1	9.5
Tamil Nadu	91.5	48.7
Western region	90.5	29.5
Gujarat	82.1	26.9
Maharashtra	95.5	31.0
Eastern region	79.3	37.4
Assam	45.8	19.3
Orissa	98.5	51.5
West Bengal	86.5	37.0

Source: NCAER survey.

washed,[15] (ii) washed only with water, (ii) washed with water and ash/mud, (iii) washed with water and soap. The hand washing habits of the mothers before feeding their children is of particular interest, because it was at this time that the child was particularly vulnerable to the transmission of pathogens.[16] Thirty-seven percent of the mothers did not wash their hands at all prior to feeding their children, 61% washed their hands with water only, and 3% washed their hands with water and soap.[17] There was some variation by community in the incidence of hand washing using soap and water: less than 2% of Dalit mothers did so, in contrast to nearly 6% for mothers from the 'other' community.

[15] This also includes missing answers.

[16] In India feeding is done by hand and not using cutlery. A distinction is often made between primary and secondary barriers against the spread of diarrhoeal pathogens (Bateman, 1994). Primary barriers are practices which prevent the infectious organisms from excreta *from entering the environment*. Secondary barriers are practices which stop faecal pathogens *which have entered the environment* from multiplying and finding new hosts.

[17] Only 11% of persons in Peru were observed to wash their hands after defecation and the use of soap was even rarer (Huttly et al., 1994).

Table 6
Proportion of mothers living in villages of different development levels, by region and state

	Low-development (%)	Medium-development (%)	High-development (%)
All India	31	39	30
Northern region	13	44	43
Haryana	9	36	55
Himachal Pradesh	34	46	20
Punjab	5	54	41
Central region	55	34	11
Bihar	44	40	16
Madhya Pradesh	56	34	10
Rajasthan	58	33	9
Uttar Pradesh	59	33	8
Southern region	10	40	50
Andhra Pradesh	25	38	37
Karnataka	5	48	47
Kerala	8	43	49
Tamil Nadu	2	26	72
Western region	11	40	49
Gujarat	14	49	37
Maharashtra	10	34	56
Eastern region	25	47	28
Assam	21	55	24
Orissa	40	39	21
West Bengal	11	50	39

Source: NCAER survey.

2.8. The level of village development

On the basis of their general level of facilities,[18] the 1758 villages in the survey were classified as (a) low-development villages, (b) medium-development villages, (c) high-development villages. Of the 13,195 mothers, 30% lived in high-development villages, 39% lived in medium-development villages, and 31% lived in low-development villages (Table 6). By and large, the proportion of mothers living in low-development villages was very low in the northern states (except for Himachal Pradesh), in the southern states (except for Andhra Pradesh), in the Western states and in the state of West Bengal. In the central states of Madhya Pradesh, Rajasthan and Uttar Pradesh, by contrast, a majority of mothers lived in low-development villages. Of the communities, 35% of Dalit women, 31% of Muslim women, 29% of Hindu women and 10% of 'other' women lived in low-development villages.

[18] For example: quality of roads, presence of transport, educational, health care, financial and commercial facilities.

3. Results

3.1. The diarrhoea equation

A logit model was estimated on data for 13,195 mothers who had children below the age of 3 years. The dependent variable of this equation (Y) was coded as taking the value 1 for woman i ($Y_i = 1$) if any of her under-three age children had ever suffered an episode of diarrhoea, and 0 ($Y_i = 0$) otherwise (Table 7, left hand panel).[19] Positive (negative) coefficient estimates imply that the probability of a household experienced diarrhoea among its children increases (decreases) with an increase in the value of the associated variable. The marginal probabilities indicate the *change* in the average probability consequent upon a *unit change* in the value of the relevant variable.[20] A mother being anaemic increases the likelihood of one of her (under 3 years of age) children experiencing diarrhoea by 7%, while her working as a labourer adds 3% to this probability. Conversely, the fact that she was literate and that she washed her hands with soap before feeding a child would reduce this probability by, respectively, 3 and 8%. The 'safety' of a village's water supply reduces the incidence of diarrhoea by 5%, while the inadequacy of household toilet facilities increased the likelihood of diarrhoea by an equal amount. Improving the quality of domestic hygiene reduce the chances of diarrhoea by 8%.[21] Living in a high- or a medium-development village reduced the probability of diarrhoea by 3% compared to living in a low-development village. Being a Hindu or a Dalit increased the likelihood of having experienced diarrhoea by 10%, and being Muslim increased it by 7%—compared to belonging to the 'others' community. The latter community, as observed earlier, comprised approximately 38% Christians and 60% Sikhs.

An interesting feature of the results (Table 7) is that, *after controlling for the other effects*, "affluence"—as measured by the value of the household asset index[22]—was associated with a *higher* likelihood of young children having had diarrhoea while "poverty"—as measured by the fact of a household's income being below a poverty line[23]—was associated with a *lower* likelihood.[24] Osmani and Sen (2003) have suggested, based upon the work of

[19] Under a logit model (Greene, 2000):

$$\Pr(Y_i = 1) = \frac{\exp(\boldsymbol{X}_i\hat{\boldsymbol{\beta}})}{1 + \exp(\boldsymbol{X}_i\hat{\boldsymbol{\beta}})} = F(\boldsymbol{X}_i\hat{\boldsymbol{\beta}})$$

where: $\boldsymbol{X}_i = \{X_{ij},\ j = 1, \cdots, J\}$represents the vector of observations, for child i, on J "diarrhoea influencing" variables and $\hat{\boldsymbol{\beta}} = \{\beta_j,\ j = 1, \cdots, J\}$ is the associated vector of coefficient estimates.

[20] If the variable is a discrete variable, a unit change in its value implies a shift from one category to another.

[21] Han and Hlaing (1989) point to a 30% reduction in diarrhoeal morbidity in Burma, through regular hand-washing with soap, in a similar vein, Khan (1982) estimated a reduction of 37% in the incidence of diarrhoea through hand-washing with soap after defecating *and* before ingesting food, and Peterson et al. (1998) suggested that the presence of soap in households in a refugee camp in Malawi resulted in 27% fewer episodes of diarrhoea.

[22] The value of the assets index was computed as the weighted sum of the following assets (with weights in parentheses): bicycle (1), bio-gas plant (3), motor cycle/scooter (3), car (10), radio/transistor (1), television (4), video-recorder (5), air cooler (3), fan (1).

[23] Internally computed by the NCAER survey.

[24] This remained true even when other measures of affluence and poverty were used.

Table 7
Logit estimates of the diarrhoea equation

Determining variables	Coefficients model 1	*Z* scores	Marginal probabilities	Coefficient model 2	*Z* scores	Coefficients model 3	*Z* scores
Hindu	0.450	4.5	0.106	0.454	4.6	0.389	4.0
Muslim	0.295	2.7	0.067	0.295	2.7	0.196	1.8
Dalit	0.458	4.5	0.105	0.454	4.4	0.378	3.7
Mother is anaemic	0.323	5.9	0.074	0.318	5.8	0.315	5.8
Mother is literate	−0.126	2.9	−0.030	−0.120	2.8	−0.075	1.8
Mother works as labourer	0.136	2.4	0.032	0.128	2.3	0.098	1.8
Drinking Water in village is ‘safe’	−0.229	5.7	−0.054	−0.227	5.7	−0.231	5.8
Toilet facilities are poor	0.232	3.9	0.056	0.229	3.9	0.158	2.7
Ventilation is poor	0.160	4.1	0.038	0.158	4.0	0.125	3.2
Household assets index	0.046	6.6	0.011	0.048	7.0	Excluded	
Household is poor	−0.120	2.6	−0.029	Excluded	−0.155	3.4	
High-development village	−0.118	2.3	−0.028	−0.118	2.3	−0.094	1.8
Medium-developed village	−0.122	2.6	−0.029	−0.122	2.6	−0.109	2.4
Mother washes hands with soap before feeding child	−0.335	3.0	−0.081	−0.329	2.9	−0.322	2.9
Intercept	−0.111	1.0	–	−0.138	1.2	0.123	1.1

Z scores pertain to the standard normal distribution 13,195 observations on mothers with children under the age of 3 years Dependent variable = 1, if children of the household, under age of 3 years, had had diarrhoea, and = 0 otherwise.

Barker (1998),[25] that low-weight babies who attain relative affluence in later life are more susceptible to certain diseases (cardio-vascular, diabetes) than low-weight babies who do not attain such levels of affluence. They explain this by saying that "when faced with inadequate access to nutritional resources (owing to maternal undernutrition) the foetus undergoes an adaptive mechanism in its physiology as well as metabolic processes ... this adaptation hampers its ability to cope with conditions of relatively plenty that might be encountered in later life" (p. 117). A similar mechanism might be at work with the incidence of diarrhoea in young children. There was little or no correlation in the data between whether or not a mother was anaemic and the state of household affluence. Consequently, one might infer that low birth babies were almost as likely, if not equally likely, to occur in affluent as in poorer households. However, an affluent household has more resources to "feed up" a low-weight baby in an attempt to transform into a healthy child. But in the process, such a child, whose physiological and metabolic mechanism has been adapted to a state of undernutrition, may become more, not less, prone to diarrhoeal infection. This is even more likely to be the case if the diet offered is particularly rich in fat and protein.[26]

There was the possibility that the value of the household index and the incidence of poverty were strongly correlated (for example, 91% of poor households reported a value of less than three for the household asset index) and the estimation results might be affected by such multicollinearity.[27] In order to guard against this, the diarrhoea equation was re-estimated, first, with the "affluence" variable included but with the poverty variable excluded and then, with the "affluence" variable excluded but with the poverty variable included. These results, shown in the right hand panel of Table 7, suggest that the results were not greatly altered under such a re-specification.

3.2. The domestic hygiene equation

The 'domestic hygiene equation' was estimated as a logit equation whose dependent variable was the variable Z: this variable was coded as taking the value 1 for woman i ($Z_i = 1$) if she washed her hands with water and soap before feeding her children, and as 0 ($Z_i = 0$) if she did not, $i = 1, \ldots, 13{,}195$. A positive (negative) coefficient implies that the probability of a mother washing her hands with soap before feeding increases (decreases) with an increase in the value of the influencing variable. The marginal probabilities compute the *change* in the average probability consequent upon a *unit change* in the value of the variable.

That were was a "cultural dimension" to the likelihood of a woman washing her hands with soap before feeding her children: relative to mothers from the 'others' community, Dalit, Hindu and Muslim, were less likely to do so (Table 8). The likelihood of hand washing was higher for more affluent households and for literate mothers. Easy access to water also had an important influence on hand washing habits. When the water source is 'faraway'—households economise on water and mothers tend not to wash their hands

[25] Which they term the 'Barker hypothesis'.
[26] For example the emphasis on buffalo milk in Haryana.
[27] Although all of the variance inflation factors were relatively small and their mean was 2.4.

Table 8
Logit estimates of the domestic hygiene equation

Determining variables	Coefficient estimate (*Z* value)	Marginal probabilities
Hindu	−0.568 (2.6)	−0.012 (2.6)
Muslim	−0.498 (1.9)	−0.009 (2.3)
Dalit	−0.811 (3.4)	−0.016 (3.6)
Mother is literate	0.315 (2.6)	0.007 (2.5)
Drinking Water in village is 'nearby'	1.135 (4.1)	0.017 (6.3)
Anganwadi in village	0.292 (2.5)	0.006 (2.5)
Trained midwife within 5 km of village	0.277 (2.4)	0.006 (2.3)
Household assets index	0.032 (2.0)	0.001 (2.0)
Household is poor	−0.408 (2.4)	−0.008 (2.7)

Figures in parentheses are *Z*-values dependent variable = 1, if mother washed hands with soap before feeding child = 0, if she did not 13,195 observations on mothers with children under the age of 3 years.

with soap.[28] In addition, easy access to "awareness-raising" facilities such as *anganwadis* and trained midwives. *Anganwadis* were devised in the early 1970s as a baseline village health centre, their role being to: provide government-funded food supplements to pregnant women and children under the age of five, operate as immunisation outreach agents, provide information about nutrition and balanced feeding and provide vitamin supplements, run adolescent girls' and women's groups, and monitor the growth, and promote the educational development, of children in a village.

4. Simulation results

In order to estimate the strength of various developmental policies on improvements in domestic hygiene and on the likelihood of having had diarrhoea, a simulation was constructed in which: (a) 75% of previously illiterate mothers were (randomly) 'made' literate: this raised the maternal literacy rate from its sample value of 35% to its 'simulation value' of 83%; (b) 75% of mothers for whom the village water supply was 'faraway' were (randomly) 'brought close' to the water source: this raised the proportion of mothers for whom water was 'nearby' from its sample value of 86% to its 'simulation value' of 97%; (c) 75% of mothers who lived in villages without an *anganwadi* were (randomly) 'given' a village *anganwadi*: this raised the proportion of mothers with an *anganwadi* in the village from its sample value of 50% to its 'simulation value' of 88%; (d) 75% of mothers who lived in villages without easy access to a trained midwife were now (randomly) 'given' such access: this raised the proportion of mothers with easy access to a midwife in the village from its sample value of 34% to its 'simulation value' of 84%.

Using the new values of the determining variables—in consequence of the changes above—the domestic hygiene equation (Table 8) predicted for each mother the (revised)

[28] Esrey et al. (1985, 1991), in a review of 67 studies in 28 countries in 1986, and a further 17 studies in 1991, concluded that improvements in water availability were probably more important than improvements in water quality in the containment of diarrhoea.

Table 9
The effect of changes in domestic hygiene on the likelihood of diarrhoea in children under 3 years age

Variables whose values were changed	Value in sample	Value in simulation
Percentage of mothers who were literate	35	83
Percentage of mothers living in villages with water 'nearby'	86	97
Percentage of mothers living in villages with *anganwadi*	50	88
Percentage of mothers living in villages with midwife within 5 km	34	84
Percentage of mothers who washed hands with soap before feeding children[a]	2.5	3.9
Percentage of under-three children having had diarrhoea[b]	62	60

[a] Predictions from domestic hygiene equation estimates in Table 8.
[b] Predictions from diarrhoea equation estimates in Table 7.

probability that she washed her hands with soap and water before feeding her children. These showed that, on average, 3.9% of mothers (instead of 2.5% actual number) would wash their hands under the new circumstances. It was assumed that the 333 mothers who washed their hands before the changes would continue to do so, however, now, mothers who previously *did not* wash their hands were 'transformed', on a random basis, into mothers who *did* wash such that, after the transformation, the proportion of mothers who washed their hands with soap and water, before feeding their children, was 3.9%. In consequence, the number of hand washing mothers rose from 333 to 522.

When these new levels of domestic hygiene, in conjunction with the new levels of maternal literacy were substituted into the diarrhoea equation (Table 7) the average probability of young children in the household having had diarrhoea fell from the sample value of 62% to the 'simulation value' of 60% (Table 9).

We also investigated the impact of several of the exogenous variables on the likelihood of experiencing diarrhoea in the family (Table 10). If we raise the proportion of mothers living in villages with safe drinking water from its sample value of 46% to its 'simulation value' of 74%, the incidence of diarrhoea falls from its sample value of 62% to its 'simulation value'

Table 10
The effect of changes in infrastructure on the likelihood of diarrhoea in children under 3 years age

Variables whose values were changed	Value in sample	Value in simulation
Percentage of mothers living in villages with 'safe' water	46	74
Percentage of under-three children having had diarrhoea[a]	62	60
(+) Percentage of mothers living in houses with poor toilet facilities	88	44
Percentage of under-three children having had diarrhoea[a]	62	58
(+) Percentage of mothers who were anaemic	14	7
Percentage of under-three children having had diarrhoea[a]	62	57

[a] Predictions from diarrhoea equation estimates in Table 7.

of 60%.[29] If, in addition, the household toilet facilities were improved at the same time from its sample value of 88% to its 'simulation value' of 44%, the incidence of diarrhoea declined further to 58%. Finally, we assume that the proportion of anaemic mothers fell from it sample average of 14% to its simulation average of 7%. When this intervention was added to the earlier interventions the incidence of diarrhoea fell further to 57%.

5. The decomposition of inequality in probabilities

The estimated equations can be use to predict for *each* mother in the sample the probability of experiencing diarrhoea, conditional upon the relevant values of the determining variables. Using these predicted probabilities, one can compute, using the methodology of inequality decomposition, how much of the overall inequality in these probabilities can be explained by a particular factor.[30]

Suppose that the sample of $N = 13{,}195$ mothers is divided into M mutually exclusive and collectively exhaustive groups with $N_m (m = 1, \ldots, M)$ mothers in each group. Let $\boldsymbol{p} = \{p_i\}$ and $\boldsymbol{p_m} = \{p_i\}$ represent the vector of (estimated) probabilities of a mother having a child who had had a diarrhoeal episode for, respectively, all the mothers in sample $(i = 1, \cdots, N)$ and all the mothers in group m. Then an inequality index $I(\boldsymbol{p}; N)$ defined over this vector is said to be *additively decomposable* if:

$$I(\boldsymbol{p}, N) = \sum_{m=1}^{M} I(\boldsymbol{p_m}, N_m) w_m + \boldsymbol{B} = \boldsymbol{A} + \boldsymbol{B} \tag{1}$$

where: $I(\boldsymbol{p}, N)$ represents the *overall* level of inequality, $I(\boldsymbol{p_m}, N_m)$ represents the level of inequality within-group m, $\boldsymbol{A}$, expressed as the weighted sum of the inequality in each group, w_m being the weights, and $\boldsymbol{B}$ represent, respectively, the *within-group* and the *between-group* contribution to overall inequality.

If, indeed, inequality can be 'additively decomposed' as in (1), then the proportionate contribution of the between-group component ($\boldsymbol{B}$) to overall inequality is a measure of the amount of inequality that can be 'explained' by the factor (or factors) used to subdivide the sample (for example, the quality of water supply or maternal literacy status) (Cowell and Jenkins, 1995). Only inequality indices which belong to the family of *Generalised Entropy Indices* are additively decomposable (Shorrocks, 1980). These indices are defined by a parameter θ, and if $\theta = 0$ the weights are the population shares of the different groups (that is, $w_j = N_j/N$) and, since the weights sum to unity, the within-group contribution $\boldsymbol{A}$ of (2) is a weighted average of the inequality levels within the groups. When $\theta = 0$, the inequality index takes the form:

$$I(\boldsymbol{p}, N) = \frac{\left(\sum_{i=1}^{N} \log(p_i/\bar{p})\right)}{N} \tag{2}$$

[29] The simulation values were chosen as plausible policy goals. The important point is that, though chosen arbitrarily, they provided a benchmark for evaluating the effectiveness of alternative policies.

[30] For example, how much of the inequality in the 13,195 probabilities of having a (under-three) child who had had diarrhoea can be accounted for by differences in literacy status (literate/illiterate) between the mothers?

Table 11
Percentage within- and between-group contributions to inequality in the probabilities of being a 'hand-washing' mother[a] and of incidence of diarrhoea: mean logarithmic index

Decomposition by	Hand-washing mother	Diarrhoeal episode
Mother's literary status[b]		
Overall inequality	0.16514	0.00627
Within-group contribution to overall inequality (%)	76	95
Between-group contribution to overall inequality (%)	24	5
Quality of water supply[c]		
Overall inequality		0.00627
Within-group contribution to overall inequality (%)		71
Between-group contribution to overall inequality (%)		29
Quality of water and toilet facilities[d]		
Overall inequality		0.00627
Within-group contribution to overall inequality (%)		58
Between-group contribution to overall inequality (%)		42
Quality of water and toilet facilities and maternal anaemia[e]		
Overall inequality		0.00627
Within-group contribution to overall inequality (%)		46
Between-group contribution to overall inequality (%)		54

[a] Mothers who washed their hands with soap and water before feeding their children.
[b] Mother: literate/illiterate.
[c] Water: 'safe'/not 'safe'.
[d] Four subgroups: water, 'safe'/not 'safe'; toilet facilities, 'poor'/not poor.
[e] Eight subgroups: water, 'safe'/not 'safe'; toilet facilities, 'poor'/not poor, mother, anaemic/not anaemic.

where $\bar{p} = \sum_{i=1}^{N} p_i/N$ is the mean probability over the entire sample. The inequality index defined in Eq. (2) is known as the Theil's (1967) mean logarithmic deviation (MLD) and, because of its attractive features in terms of the interpretation of the weights, it is used to decompose inequality in the likelihood of a incidence of diarrhoea.

Table 11 shows, firstly, the results from decomposing the likelihood of mothers (of children under 3 years age) washing their hands with soap and water, before feeding their children, by subdividing the sample of mothers according to whether they were literate or not. Maternal literacy provided a very good explanation for the observed inequality in the distribution of the likelihood of mothers washing their hands with soap before feeding their children: 76% of the overall inequality in this distribution was due to within-group inequality and 24% was due to inequality between literate and illiterate mothers.

Table 11 also shows the likelihood of mothers experiencing diarrhoea among their young children by subdividing the sample according to various attributes. It becomes apparent that, first, the level of inequality associated with the distribution of the 13,195 probabilities of mothers experiencing a diarrhoeal episode was very low. The values of the MLD index and of the Gini coefficient were 0.006 and 0.06, respectively. By contrast, the distribution of incomes across the households had an MLD value of 0.43 and a Gini value of 0.49. In short, diarrhoea in children did not respect household affluence.

Moreover, maternal literacy is not a good explanation for the observed inequality in the distribution of the likelihood of young children having had a diarrhoeal episode: only 5%

of this inequality could be attributed to the literacy status of the mother. When, however, the sample of mothers was divided according to whether or not they lived in a village with a safe supply of drinking water, 29% of the observed inequality in the distribution of this likelihood was explained by inequality between the two groups.

When the sample of mothers was subdivided by whether they lived in a village with 'safe' water *and* by whether their houses had poor toilet facilities, 42% of the observed inequality in the distribution of the 'diarrhoea probabilities' could be explained by inequality between the four subgroups. In other words, in addition to the 29% (of observed inequality) 'explained' by the quality of water, a further 13% was 'explained' by the quality of sanitation.

Lastly, when the sample of mothers was subdivided by whether they lived in a village with 'safe' water *and* by whether their houses had poor toilet facilities *and* by whether they were anaemic (eight subgroups), 54% of the observed inequality in the probabilities could be explained by inequality between the eight subgroups. In other words, *over half* the observed inequality in the likelihood of mothers of young children having experienced episodes of diarrhoea could be 'explained' by just *three* factors: the quality of water supply, the quality of toilet facilities, and by whether the mother was anaemic.[31]

6. Conclusion

This study examined the relative strength of the different factors contributing to diarrhoea among young children in India. The results point to the importance of good hygiene practices within the home in reducing the incidence of diarrhoea among young children. Furthermore, children born to undernourished, i.e., anaemic, mothers may be more susceptible to infection than children whose mothers are well nourished.

The paper also found evidence to suggest that the benefits of improved domestic hygiene are at least as large as those emanating from improvements in the quality of drinking water. The problem, however, is that the level of domestic hygiene is a choice variable for households and improvements in it can only be affected by altering the variables which underpin this choice—*inter alia* maternal literacy, easy access to water, and institutional support. This makes improvements in the level of domestic hygiene not easily open to policy intervention.

With this caveat, this paper supports an accumulating body of research which points to the importance of soap as a 'do-it-yourself' prophylactic against diarrhoeal diseases. In turn, these findings point to a set of anti-diarrhoea policies which are complementary to the more traditional emphasis on improving the quality of drinking water. These policies—which are already being implemented in many countries with the support of international agencies like the World Bank—involve, in essence, a global partnership between soap manufacturers and public health officials to promote hand-washing. This is a step in the right direction.

Nonetheless, this paper concludes that a three-pronged attack—comprising improvements in water quality and in sanitation and a reduction in the incidence of anaemia among women—may be the most effective way of fighting diarrhoea among young children. As this study has shown, over half of the inequality that exist in the incidence of diarrhoea

[31] The marginal contribution of anaemia was 8%.

between young children in India, could be explained by inequality between them in three factors: water and sanitation quality and maternal anaemia.

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