ORIGINAL ARTICLE

# Effects of poor water, sanitation, and hygiene on child health in Godawari Municipality, Lalitpur, Nepal, with special reference to diarrheal disease and nutritional status: a cohort study

Marina Vaidya Shrestha[1,2], Bishnu Prasad Choulagai[1], Abhinav Vaidya[2], Shankar Khanal[3], Shiva Raj Adhikari[4], Bandana Pradhan[1]

[1] Central Department of Public health, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal.
[2]Department of Community Medicine,Kathmanadu Medical College,Kathmandu University, Nepal.
[3]Central Department of Statistics. Tribhuvan University, Kathmandu, Nepal.
[4]Central Department of Economics, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

**Corresponding Author:** Marina Vaidya Shrestha **Email:** merinavs@gmail.com

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## ABSTRACT

Malnutrition is one of the global burdens of disease affecting children under-five in the developing world and has a bidirectional relation with diarrhea. This study aimed to determine the water, sanitation, and hygiene (WASH) effects on diarrhea and to assess its relationship with the nutritional status among exposed and non-exposed children under the age of five years. A prospective cohort of 434 children under-five was recruited and followed up for 12 months in Lalitpur. Socio-demographic, clinical, and anthropometric measurements of the participants were recorded using the World Health Organization (WHO) AnthroPlus. The observed incidence of diarrheal illness was 1.81 episodes per child/year (95% Confifence Interval (CI):1.75–1.87). Among poor WASH exposures, 63 (29.2%) children had diarrhea and among non-exposures, 59 (27.1%) had diarrhea. A total of 183 children (42.2%) had linear growth retardation (stunted), and 270 (62.2%) were malnourished. Hazards of diarrhea among exposed groups were 1.235 (95% CI: 0.785-1.943) times higher than in non-exposed groups. Based on the findings, it is recommended that the government and health organizations should plan Safe WASH activities or interventions for local communities. Moreover, they should encourage social support and promote behavioral change for adopting safe WASH practices.

**Key words:**
cohort study; diarrhea; hazard ratio; malnutrition; WASH

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# INTRODUCTION

Malnutrition is one of the global burdens of disease affecting children under-five.[1] Out of 141 countries surveyed, 88% (124 countries) had more than one form of malnutrition, while 29% (41 countries) experienced high levels of all three forms of malnutrition.[2] The consequences of malnutrition are severe and can have irreversible and long-lasting effects, leading to impairment of physical and mental growth.[3]

Approximately 45% of deaths among children under 5 years of age are linked to under-nutrition.[4] Geographically, more than 70% of protein-energy malnourished children live in Asia, 26% in Africa and 4% in Latin America and the Caribbean.[5]

Malnutrition among children is a public health problem in Nepal.[6] According to the Nepal Demography and Health Survey (NDHS, 2016), 36% of children under age 5 are stunted, 10% are wasted, 27% are underweight, and 1% are overweight.[7] This shows that Nepal faces a critical problem with child malnutrition.

The period from birth to five years is especially important for optimal physical, mental, and cognitive growth, health, and development.[8] Poor growth in early life increases the risks of illness and death in childhood.[9] Malnutrition in children occurs as a complex interplay among various factors like poverty, maternal health illiteracy, diseases like diarrhea, home environment, dietary practices, hand washing and other hygiene practices, etc.[10] The relationship between diarrhea and malnutrition has been one of the most extensively investigated topics in medical research.[11] There is less agreement on whether repeated episodes of diarrhea can adversely affect a child's growth.[12] Studies show that diarrhea is both a cause and an effect of malnutrition which impairs weight as well as height gains and reduces the critical catch-up growth.[13,14] The evidence linking poor WASH practices with child malnutrition is increasing.[15]

It is the need of the hour to discuss the issue of the relationship between exposures (poor WASH) and diarrheal disease comprehensively; so that it will be helpful to define the role of disease control programs in the prevention of childhood malnutrition (stunting, underweight). Therefore, this study aimed to determine the WASH effects on diarrhea and to assess its relation with nutritional status among exposed and non-exposed children under-five.

# METHODS

### *Study Site and Study Population*

A community-based prospective cohort study was conducted in Godawari Municipality from 2019 March to 2020 February among children under-five.

Godawari Municipality lies in the South of Lalitpur district in Bagmati Province of Nepal: North-South 8.2 km, East-West 13.3 km with a total area of 96.11 sq. km. It is located at the height of 2831 m from sea level. According to the Housing survey of Godawari, 2017, the population of this Municipality was projected to be 116045 with a male to female ratio of 1: 0.99. The Municipality constitutes 14 wards.[16]

Based on the first baseline study,[17] exposure and non-exposure to poor WASH were identified. WASH exposures measured at baseline were used to estimate the risk outcomes. Exposures were the households with poor WASH scores and non-exposures were the households with good WASH scores. WASH scores were determined by the total number of WASH variables (n=17) which included improved water source, distance of water supply, water treatment, covered water container, daily cleaning of water vessels, water quality and quantity, type of toilet, toilet facility sharing, distance between water

source and toilet, use of sanitary toilet by children, hand washing facilities, critical hand washing, and hand washing with soap and water. Scores < 13 were considered as poor WASH (exposures) and > 13 were good WASH (non-exposures).

For the calculation of the sample size, following equation was used to estimate the required sample size,

$$n_1 = \frac{(Z\alpha_{/2}+Z_1-\beta)^2\, \bar{p}\, \bar{q}\, (r+1)}{r(p_1-p_2)^2}$$

Including 10% of the missing children,

Total sample = 400 + (400*0.1) = 440

where, exposed =220 and non-exposed =220.

**Source:** Kelsey et al. (1996)[18]

Out of 742 households from the 14 wards, 318 exposed and 411 non-exposed households were recruited. Randomization of households was done with random number generator in Statistical package for social sciences (SPSS) version 20. Out of which, 220 exposed and 220 unexposed households were selected. The selected households were contacted through telephone calls and personal visits to inform them about the follow-up study. Those who refused to participate or were unavailable during this period were not included. Subsequently, the next house number from randomization table was selected.

Therefore, proportionate numbers of households from each ward were taken. From the exposed and non-exposed households, the children under-five were followed for 1 year. With the help of trained volunteers from the Female community health volunteers (FCHVs), the episodes of diarrhea were noted during monthly visits and anthropometric measurements were recorded every 3 months. During the monthly home visits, families were enquired about the episode of loose stools, that the children had experienced since the last visit and any treatments they received. If a child under study was absent during a home visit, an absentee form was included, and information regarding the child's health and treatment of diarrhea during the period was gathered when the child was contacted in the subsequent visit.

***Exposure and outcome***

Poor WASH factor was the primary exposure. The primary outcome of interest was diarrheal disease and secondary outcome was malnutrition (stunting, underweight).

***Anthropometric measurements***

The secondary outcome measures were height (cm) and weight (kg), which were measured at the time of enrollment and thereafter every 3 months by the FCHV following standard procedures. Furthermore, FCHVs were trained with World Health Organization (WHO) protocol to reduce measurement error.[19] Nutritional status was assessed at four time-points during the follow-up. Supine lengths were obtained from children using Stadiometer and a digital scale. Anthropometric indices were calculated using AnthroPlus according to the WHO guidelines.[20] Child nutritional status as measured by the anthropometric indices were expressed as z-scores (i.e., differences from the median in standard deviations), weight-for-age (WAZ, underweight), and height-for-age (HAZ, stunting). Z-scores of $\geq -2$ were regarded as normal, those between $< -2$ and $\geq -3$ as moderate under-nutrition and those between $<-3$ as severe under-nutrition.[21]

***Adjustment for potential confounders***

Household food security was assessed with questions relating to the availability of food during the entire year. Those households with low food security were not included in the study.

***Data management and statistical analysis***

Data from the FCHVs were collected every third month. Completeness of the data was reviewed by the FCHVs and the primary investigator was informed by telephone monthly. Data was entered in the WHO AnthroPlus software and then transferred to an excel spread sheet. Subsequently, the data was cleaned and complete data was transferred to the SPSS for analysis.

Categorical variables were described by absolute and relative frequencies. We employed $\chi 2$ test to assess the differences in the distribution of categorical variables between the study areas.

We assessed health-related outcome variables for under-nutrition (i.e., stunting, underweight). Since only a few under-nutrition cases were severe, the cases were pooled into a binary variable of stunted/normal, and malnourished/normal for the subsequent analysis. In the weight for age category, we found not only underweight but also overweight and obese. Consequently, we named underweight as malnourished. To consider the lag effect of exposure (poor WASH) on diarrhea, we used a Cox proportional hazards model (HR) to quantify the effect of exposure on diarrhea from January to December of the same study year. We selected 1 year period as the end of the exposure assessment period. In this study, we have operationalized "Event" as any episode of diarrhea at any time (within a year), and that time is considered as survival time. Those subjects who did not experience the event during the entire follow-up time were considered as censored cases. The hazard ratio (HR) and its 95% confidence interval (CI) were reported. Multivariate logistic regression was used to adjust the confounding effects between the factors found to be associated with either underweight or stunting. In creating the logistic regression model, we excluded the variables that were not associated with the outcomes in Chi-square or Bivariate analyses (*p* value up to 0.2 was included).

***Ethical Statement***

The Institutional Review Board and Ethics Committee of the Institute of Medicine at the Tribhuvan University, Kathmandu (study registration number: 369(6-11-E) 4014/075) granted ethical approval for this study. Written informed consent was obtained from the parents, or other heads of the households for all the enrolled children. Before conducting the questionnaire survey, permission was obtained from the local authority including the Godawari Municipality office and ward office.

# RESULTS

Among the 742 children under the age of 5, who were screened, only 440 were enrolled. There were 6 (1.4%) children who were lost to follow-up. After deducting the loss to follow-up children, only 434 (98.6%) were followed for 12 months. The observed incidence of diarrheal illness was 1.81 episodes per child/year (95% CI: 1.75–1.87). The incidence of diarrhea among exposed was 1.83 episodes per child/year (95% CI: 1.66-2.00) and among non-exposed was 1.798 episodes per child/year (95% CI: 1.684-1.912). Mean age of children under-five was 41.01 ±12.06 months. The total number of males were 249 (57.4%) and females were 185 (42.6%). The number of exposures were 216 (49.8%) and unexposed were 218 (50.2%).

Among exposures, 63 (29.2%) children had diarrhea and among non-exposures 59 (27.1%) had diarrhea. This shows that out of the total diarrheal cases under follow-up, 51.6% belonged to the exposure group whereas, 48.4% belonged to the non-exposure group. With respect to nutritional status, a total of 183 children (42.2%) were stunted, while 251 (57.8%)

had healthy nutritional status. Male children 105 (57.4%) were stunted more than female children 78 (42.6%).

Furthermore, a total of 270 (62.2%) children were underweight, while 164 (37.8%) were normal. Mid upper arm circumference (MUAC) among exposed and non-exposed, who were malnourished were 37 (17.1%) and 28 (12.8%), respectively. This shows that out of the total malnourished cases under follow-up, 56.9% belonged to the exposure group and 43.1% belonged to the non-exposure group (Table 1).

**Table 1:** General characteristics of participants (n=434)

| **Characteristics** | **Exposures (216) n (%)** | **Non-exposures (218) n (%)** |
|---|---|---|
| Mean age in months | 41.01 ±12.06 | |
| Sex | | |
| Male | 129(59.7) | 120(55) |
| Female | 87(40.3) | 98(45) |
| Education of parents | | |
| Literate | 196(90.7) | 185(84.9) |
| Illiterate | 20(9.3) | 33(15.1) |
| Religion | | |
| Hindu | 192(88.9) | 194(89.0) |
| Buddhist | 17(7.9) | 19(8.7) |
| Christian | 7( 3.2) | 5(2.3) |
| Ethnicity | | |
| Brahmin | 30(13.9) | 42(19.3) |
| Chettri | 83(38.4) | 75(34.4) |
| Dalit | 23(10.6) | 7(3.2) |
| Janajati | 77(35.7) | 87( 39.9) |
| Others | 3(1.4) | 7(3.2) |
| Occupation | | |
| Employed | 153(70.8) | 179(82.1) |
| Unemployed | 63(29.2) | 39(17.9) |
| Family Type | | |
| Joint | 101(46.8) | 93(42.7) |
| Nuclear | 115(53.2) | 125(57.3) |
| Cases of diarrhea | 63 (29.2) | 59(27.1) |
| Malnutrition | 134(62) | 136(62.4) |
| Stunting | 96(44.4) | 87(39.9) |
| MUAC | 37(17.1) | 28(12.8) |

*MUAC: Mid upper arm circumference*

Figure 1 shows that cases of diarrhea were observed throughout the year. Seasonal variation was observed in exposed and unexposed children. The diarrhea cases started to

increase during winter which lasted till the early months of spring season and then cases tended to decrease in both, exposed and non-exposed groups.

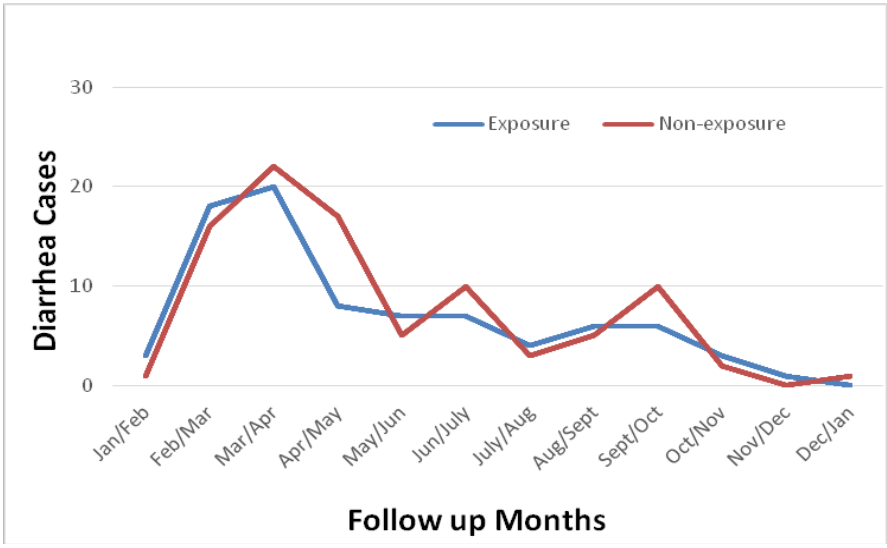


**Figure 1** Cases of diarrhea in time series graph among exposed group and non-exposed groupin Godawari municipality during the four different seasons

Cox regression analysis was performed to identify the HR of diarrhea risk among the exposed group in comparison to the non-exposed group. The hazards of risk of diarrhea were consistently higher (HR=1.235, $p$=0.362) among exposed groups when compared to non-exposed groups except in the 5$^{th}$ month of follow-up. Nonetheless, the HR of diarrhea was not statistically significant.

The HR was 1.23 (95% CI, 0.78 – 1.94) which indicates that the hazards of diarrhea among the exposed groups was 1.23 times higher than non-exposed groups, though it was not statistically significant (95% CI; 0.78 –1.94, $p$=0.362) as shown in Figure 2.

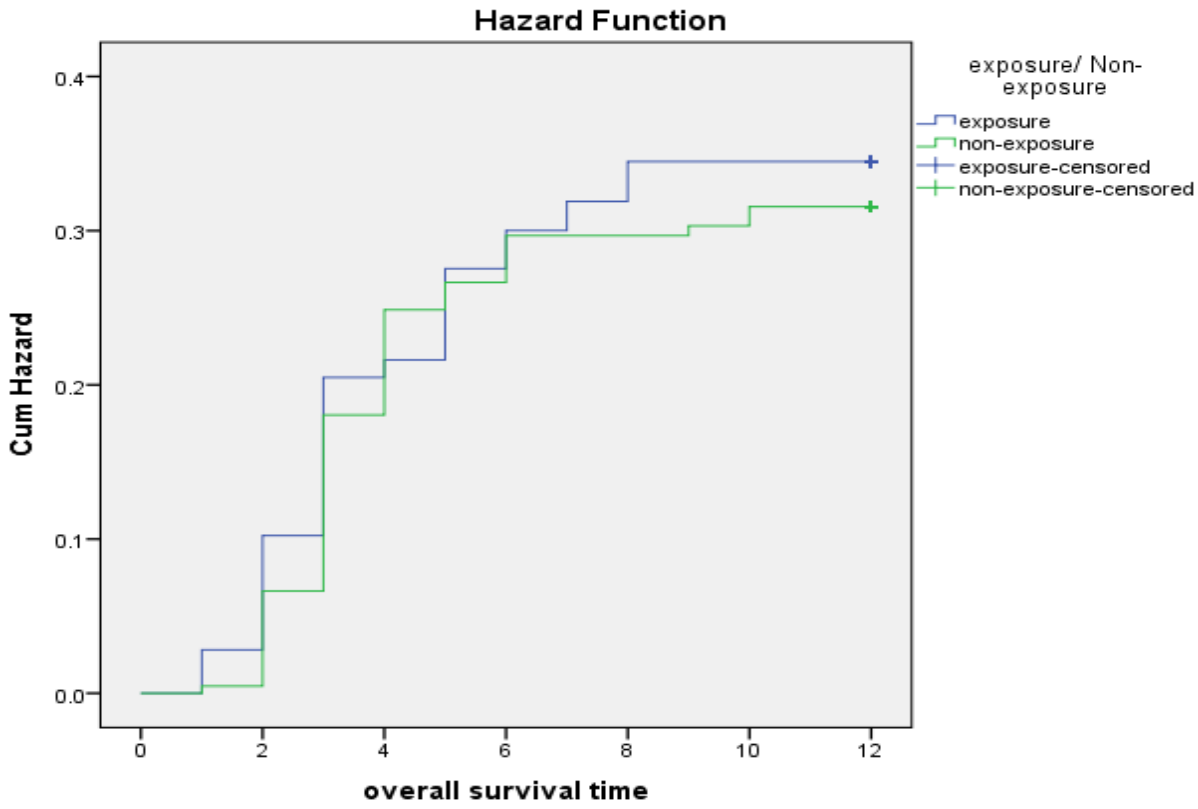


**Figure 2**. Kaplan-Meier curve. Hazard function of diarrhea among exposed and non-exposed groups by Cox regression

Several demographic characteristics were found to be significantly associated with being underweight and stunted, such as: child's sex, education, ethnicity, family type, and other variables like diarrhea status, use of water treatment method, sharing toilet, and critical hand washing.

In the logistic model for stunting, the parents' education (odds ratio, OR =2.54), diarrheal status (OR=1.84) and water treatment (OR=1.55) were significant risk factors for the child.

Furthermore, sex of the child, and type of family in the logistic model were significantly related to a child being underweight ($p$=0.003, $p$=0.04). Sex of the child (OR = 1.84) was a highly significant risk factor for being underweight whereas family type (OR =0.64) was a strong protective factor (Table 2).

**Table 2:** Logistic regression method to assess the factors associated with stunting and underweight in children under five years of age

| Variable for stunting | COR (95% CI) | *p* value | AOR (95% CI) | *p* value |
|---|---|---|---|---|
| Education | | | | |
| Literate | 0.39(0.21-0.71) | 0.002* | 2.54(1.40-4.59) | 0.01* |
| Illiterate | 1 | | 1 | |
| Ethnicity | | | | |
| Brahmin | 2.59(0.60-11.04) | | 2.11(0.49-9.15) | 0.31 |
| Chettri | 0.83(0.19-3.56) | | 0.78(0.18-3.40) | 0.75 |
| Dalit | 1.71(0.42-6.88) | 0.04* | 1.62(0.40-6.57) | 0.49 |
| Janajati | 2.04(0.44-9.43) | | 1.36(0.28-6.58) | 0.69 |
| Others | 1 | | 1 | |
| Diarrhea status | | | | |
| Yes | 1.87(1.22-2.86) | 0.003* | 1.84(1.16-2.92) | 0.009* |
| No | 1 | | 1 | |
| Water treatment | | | | |
| Yes | 0.62(0.41-0.95) | 0.02* | 1.55(0.99-2.43) | 0.05* |
| No | 1 | | 1 | |
| Sharing toilet | | | | |
| Yes | 1.68(1.08-2.62) | 0.02* | 0.72(0.44-1.16) | 0.18 |
| No | 1 | | 1 | |
| Critical hand washing after defecation | | | | |
| Yes | 0.43(0.10-1.82) | 0.24 | 1.94(0.42-8.89) | 0.39 |
| No | 1 | | 1 | |
| Variable for underweight | | | | |
| Child's sex | | | | |
| Male | 0.59(0.40-0.87) | 0.009* | 1.84(1.23-2.77) | 0.003* |
| Female | 1 | | 1 | |
| Family type | | | | |
| Joint | 1.30(0.88-1.92) | 0.18 | 0.65(0.43-0.99) | 0.04* |
| Nuclear | 1 | | 1 | |
| Diarrhea status | | | | |
| Yes | 1.49(0.96-2.33) | 0.07 | 0.67(0.42-1.08) | 0.10 |
| No | 1 | | 1 | |
| Sharing toilet | | | | |
| Yes | 1.50(0.93-2.40) | 0.09 | 0.62(0.38-1.03) | 0.06 |
| No | 1 | | 1 | |
| Critical hand washing after defecating child | | | | |
| Yes | 4.21(0.80-21.97) | 0.06 | 0.20(0.03-1.08) | 0.06 |
| No | 1 | | 1 | |

*AOR: Adjusted odds ratio ; COR:Crude odds ratio ; *: statistically significant at <0.05*

## DISCUSSION

In this cohort study, the incidence of diarrheal disease was identified in a population that had previously lacked data. The overall incidence of disease in children under-five was found to be higher when compared with a Vietnamese cohort study which showed 0.81 episodes.[22] However, a review article in India demonstrated a similar trend.[23] Our study targeted only children under the age of five years whereas, the Vietnamese study targeted all age groups. Therefore, this can be the reason for obtaining a higher incidence rate in our study, as cohort studies targeting all age groups tend to show a lower incidence rate. We can also comprehend that the results may vary depending on the study area and design.

The incidence rate in this cohort also showed wide variation with research from geographically, and culturally similar regions.[22,23] The unexpectedly low diarrhea prevalence among children from our baseline study[17] suggests a decreased transmission of diarrhea, perhaps because many families participating in the study had access to improved water sources, sanitation, and behavioral change due to FCHV's active role in those areas. At the time of the study, rotavirus vaccine had not been introduced into the national immunization program in Nepal.[24]

The seasonal variation showed that the disease burden was greatest during the winter months. Similarity of seasonal variation of diarrheal episodes was seen in a cohort study done in Kabul[25] whereas contrast variation was reported in a study performed in India.[23] Regarding the seasonality of diarrhea, a retrospective study reported by Chao et al.[26] elucidated a wide spectrum of variation in the seasonality of different pathogens, their association with site-specific weather patterns, and consistency. Recognizing the pathogens' prevalence in relation to weather conditions can block the transmission channel and help in the prevention of diarrhea.[26]

This study tried to find a relationship between altered growth and diarrhea among poor WASH exposures and non-exposures. Linear growth retardation (stunting) among exposures was higher than in non-exposures although the association between them was not significant. This result corresponds with the findings from a study done in rural India by Rah et al.[27] This shows that there is evidence for the effects of WASH practices contributing to linear growth and diarrhea.

A significant difference in malnutrition among male children was seen in this study which could be explained by male preferences in society. However, systematic review and meta-analysis showed that under-nutrition in children under-five is more likely to affect boys than girls.[28]

Children whose parents were illiterate (no schooling) were found to have a relatively higher risk of being stunted. This finding is consistent with those found in previous studies,[29,30] which can be explained as educated parents would be more conscious about their children's health; therefore, education has a direct and indirect impact on family income and childcare.

This study has some limitations. First, the follow-up study could have been performed for a longer period so as to confirm the association of poor WASH exposure to diarrhea and consequent malnutrition. Second, cases of diarrhea were reported based on self-reporting limiting a pathological lab test.

## CONCLUSION

The relation between poor WASH and diarrhea was found to be positively

correlated even though the result did not show any statistical significance. Distinct seasonal variation for the diarrheal disease was observed in the study population. The main risk factors for stunting and underweight, because of diarrheal diseases, in children under-five included parents' low-level education and the absence of a water treatment facility.

## RECOMMENDATION

Therefore, it is recommended to eliminate diarrheal disease in the community. Health authority of government and concerned organizations should work together to intervene with safe WASH activities for implementing the people's behavioral change and supporting them through education and incentive packages. This study implies that the government has to focus on safe WASH practices to reduce diarrhea and consequently malnutrition in children under-five.

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