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Rubbish index and diarrhoea in Salvador, Brazil

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Summary Urban solid waste (USW) is a public health problem worldwide that has not yet been completely evaluated in relation to childhood health. The main purpose of this study was to investigate associations between diarrhoea and exposure to USW among preschool children. A longitudinal study was carried out with 922 under-threes living in Salvador, Bahia, between 2000 and 2001. Both community and individual/home levels (strata) were evaluated by questionnaire and direct observation. The multilevel model, using Poisson regression with overdispersion, evaluated their contribution to the occurrence of diarrhoea. The children presented a mean longitudinal prevalence of 2.7% of days with diarrhoea during a mean period of 23 follow-up weeks. The main factors associated with diarrhoea were rubbish-in-street index [prevalence ratio (PR) = 1.30; 95% CI 1.02—1.66] and intrahome rubbish packaging (PR = 3.59; 95% CI 2.01—6.42). Other important variables were water-in-street index, child age, hygiene and cleanliness near the house, number of people per house, and drainage problems. The variables measured at the community level explained 4.77% of the variability of the children's number of days with diarrhoea.

1. Introduction

Diarrhoea is one of the most important global public health problems, and it was the third highest contributor to the global burden of disease in 1998 (Frenk and Murray, 1999). Diarrhoea is also one of the main causes of morbidity and mortality among children in developing countries. About 4.9 in 1000 children under five die from diarrhoea every year (1.6 to 2.5 million deaths per year); each child under five has an average 3.2 episodes of diarrhoea per year, with the greatest incidence among 6—11-month-old children (4.8 episodes per child per year), and acute diarrhoea disease (ADD) represents 21% of all deaths among under-fives (Kosek et al., 2003).

In 1999, the State of Bahia reported 45.5 deaths in 1000 live births, and 6.1% of these deaths were caused by ADD in children under five (Ministério da Saúde, Brazil, 2001). In Salvador, capital of Bahia, the infant mortality rate was

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24.4 in 1000 live births (8.6% of all deaths) in 1996; among children under one, infection and parasitic diseases represented the second most important cause of death (13.9%), 3.4 deaths in 1000 live births (SESAB, 1997). ADD was the second largest isolated cause of death among children under one (14%) (Ministério da Saúde, Brazil, 1998).

In Brazil, some epidemiological studies have presented evidence associating diarrhoea with urban solid waste (USW) exposure (Catapreta and Heller, 1999; Rego et al., 2005). Among the possible determinants of these effects on child health is a greater production of USW, leading to the population being exposed to rubbish when its collection is inefficient and final disposal is inadequate.

According to the National Research of Basic Sanitation (PNSB), 125 281 tons of USW were collected daily in Brazil in 2000. In the biggest cities (more than 200 000 inhabitants), between 800 and 1200 g of USW was collected per person per day, and in smaller cities, 450 to 700 g per person per day was collected, with about 30.5% of this rubbish inadequately disposed of (IBGE, 2002). It is estimated that 30 to 50% of the USW produced all over the world is not collected. Household solid waste (HSW) — solid or semi-solid waste produced at home, here also named rubbish or waste — represents about 50 to 75% of all USW produced in the Latin American and Caribbean regions (Acurio et al., 1998). In 2000, about 5516 tons of USW and 2540 tons of HSW (46% of the total USW) were collected daily in Salvador, about 1.04 kg per person per day of HSW and 2.27 kg per person per day of USW (LIMPURB, 2000), part of it probably lying on the street.

In spite of some evidence of association between the occurrence of infantile diarrhoea and deficiencies in environmental sanitation, especially the lack of an adequate sewerage system and also the quality and quantity of water for human consumption (Huttly et al., 1997), there are still some blanks in the knowledge of the relationship between environment and human health (Bradley et al., 1992).

Studies carried out in Brazil have pointed to a possible association between inadequate handling of HSW and diseases in children, especially diarrhoea (Catapreta and Heller, 1999; Rego et al., 2005). However, none of these quantified the different contributions to the occurrence of diarrhoea by variables measured at the community level, the individual or home level, or in hierarchical structures. This type of study is relatively new (Diez Roux, 2004).

The main purpose of this study is to evaluate the possible association between acute diarrhoea in children and exposure to household urban solid waste, measured at the community and individual or home level.

2. Materials and methods

2.1. Study design and population

The study site was Salvador, capital of Bahia, with a population of approximately 2.4 million (SEI, 2001) and a population density of 3443 inhabitants per km^2 (IBGE, 2000). The sample had originally been collected for a wider longitudinal study of the impact of sanitation on health. The sampling has been described in detail elsewhere (Teixeira et al., 2002). Briefly, 23 neighbourhoods were selected by using stratified random sampling to represent the range of environmental conditions found throughout the city. These were then divided into areas with differing levels of environmental services (water supply and excreta disposal) and average income (Teixeira et al., 2002). A random sample of neighbourhoods was chosen from each area. Each neighbourhood sample averaged 600 contiguous dwellings, occupying one or more census tracts. A census of each neighbourhood resulted in a list of all households with 0—3-year-old children, totalling 2445 children. A subset of these households was then chosen at random. In those with more than one eligible child, one of them was randomly recruited for the study, carried out from October 2000 to December 2001. The sample was selected by using 80% power, $\alpha = 5\%$, 20% of estimated loss, and error between 0.0016 and 0.0064, based on data from a previous epidemiologic study on diarrhoea carried out in the same areas in 1997 (Teixeira et al., 2002). Of the 1071 selected families that initially answered the socio-economic questionnaire, 934 were children enrolled in the longitudinal study, the others (137) being more than 3 years old at the beginning of the study. The families of 12 of those children moved from the neighbourhood during the follow-up period, so that 922 children remained in the longitudinal study and were followed for 6 months. They were visited twice a week, and the mothers were asked about the occurrence of diarrhoea in their child within the previous 48 to 72 h, using a questionnaire called 'Home following-up for 0—3-year-old children'. Informed consent for participation was obtained from all study households.

2.2. Diarrhoeal morbidity

Diarrhoea was defined as the occurrence of three or more liquid or semi-liquid stools in a period of 24 h, for at least 3 days, separated from any other episodes by at least three symptom-free days. The outcome measure was the longitudinal prevalence of diarrhoea — i.e. the ratio between the total number of diarrhoea days in the group and the total number of follow-up days in the same group — shown to be a better predictor of mortality than incidence ratio (Morris et al., 1996).

2.3. Socio-economic, domestic and peridomestic environmental data

Data were collected during the recruitment for the study by using a pre-coded socio-economic questionnaire and a structured observation instrument. The socio-economic questionnaire included information about family members, living conditions, family income and children's health conditions. The observation instrument included provision for the field workers to particularly note the child's and its mother's hygienic or unhygienic behaviours during their visits. This was done twice a week for 6 months (23 weeks). This instrument was composed of 33 different types of behaviour related to water and rubbish habits, domestic animal contacts, and domestic and peridomestic hygiene. Detailed observations of hygiene behaviour are given elsewhere (Strina et al., 2003). They provided the data for a compound score described later.

2.4. Field workers and implementation

All 15 field workers were graduate sanitary and environment engineering or civil engineering students from Federal University and had experience in data collection. After being given a week's training, they were selected on the basis of their performance in a role-playing exercise, which simulated the same conditions of home interview with the questionnaires. They were then trained for 10 days, when pilot-testing of all instruments was done. One in 10 households was re-interviewed by the supervisor, as a quality control measure.

2.5. Survey of sanitary and environmental conditions of small areas (sentinel areas)

The environmental evaluation of basic sanitation components in the 23 areas was carried out at the beginning of the cohort study, from August 2000 to January 2001. The unit of sanitary and environmental analysis was the 'street section' where the child lived (100 m-long street section in front of the child's house). Every child lived in one street section, but more than one child could live in the same street section, which was identified and updated by the field workers on maps (1:2000 scale).

For each street section, information relative to its infrastructure, sanitation, soil use and building and housing typology was collected with a questionnaire developed and tested previously (Borja, 1997). The quality control of observations was done by consensus among the field workers and experts, and additional quality control checks were performed before and after data entry using SPSS version 9.0 (Norusis, 1999).

The street sections were identified and grouped according to sanitation components (water supply, sewerage system, urban drainage, road pavement, and building typology) the sanitary and environmental condition indices of each street section were obtained by Rego (2002), using factorial correspondence analysis (FCA), followed by cluster analysis.

Table 1 Potential community environmental risk factors for diarrhoea, Salvador, Brazil, 2000—2001

Level 2 variable	Children	
Category	*n*	(%)
Rubbish-in-street index		
Good (ref.): most of the streets have door-to-door collection, daily and non-daily collection, no rubbish heaps, no debris heaps	328	(35.6)
Regular: most of the streets have rubbish heaps or rubbish container collection, presence of debris heaps larger than 6 m^3, daily or non-daily collection	123	(13.3)
Unsatisfactory: most of the streets have no rubbish collection, no rubbish heaps, debris heaps smaller than 6 m^3	471	(51.5)
Water-in-street index		
Good (ref.): most of the streets have exclusively public water supply, no interruption of the water supply, good preservation of the system of pipes	599	(65.0)
Regular: most of the streets have exclusively public water supply, interruption of the water supply (3 to 4 times a week)	216	(23.4)
Unsatisfactory: most of the streets have public water supply together with other inadequate sources (well, irregular use of neighbourhood water called 'gato', spring, fountain, tap), interruption of the water supply (3 to 4 times a week), problems with preservation of the system of pipes (presence of leaking or burst pipes, pipes and water gauges in contact with sewerage system, pipe apparent on surface)	107	(4.2)
Sanitation-in-street index		
Good: two-thirds of the streets have sewerage system (condominium branch) and/or other kinds of network system combined with Bahia Azul; pre-existent network in operation or non-operating Bahia Azul network; check-up spot well preserved	207	(22.5)
Regular: one-third of Bahia Azul network in operation and the remaining network not Bahia Azul; network system and check-up spot in apparent good state	313	(33.9)
Unsatisfactory: most of the streets have no network system (excrement disposal in plastic bags and thrown in open air, open sewer, pit or gutter connected with drainage system)	402	(43.6)
Paving-in-street index		
Good: most of the streets have pavements made of concrete plates, ceramic tiles, gravel or Portuguese stones, and road paving with asphalt or paving stones	191	(20.7)
Regular: most of the streets have pavements made of ground and/or sand, and road paving with asphalt or paving stones	32	(3.5)
Unsatisfactory: most of the streets have no pavements, and road paving with gravel, ground, concrete plates, concrete blocks, prefab mortar	699	(75.8)

Ref.: referent group.

In this study the variables named as communitarian are ecological and represent characteristics of the sanitation conditions of the street sections where the children live. The contribution of these variables to the occurrence of diarrhoea in children was assessed through the multilevel analysis approach, which allows the evaluation of the role of the contextual and individual effects simultaneously.

2.6. Data handling and analysis

The longitudinal prevalence, defined above, was used as the epidemiological measure of diarrhoea (outcome variable). The main exposure variable, classified as surrounding environmental, is rubbish-in-street index (RSI), which was obtained by Rego (2002) using FCA (for the RSI, and other environmental indices, see Table 1). The variables were grouped in the following classes: surrounding environmental, socio-economic and demographic factors; mother's and child's hygiene behaviour; child's birth and health conditions.

In order to evaluate the association between RSI and longitudinal prevalence of diarrhoea, the multilevel model with Poisson distribution was chosen and the MlWin software was used (Goldstein et al., 2002). The multilevel modelling was performed at two levels: Level 2 variables were the surrounding environmental indices (obtained from the street section observation); and Level 1 variables were those collected from the individual observation of child, family and home (all the other variables). Multilevel modelling allowed determination of the contribution of each variable in the presence of others, considering the different levels involved and taking into account the possible correlation between the subjects of the samples who lived in the same street section (Goldstein et al., 2002). The multilevel modelling with Poisson errors and overdispersion was used because the main outcome variable of interest, days with diarrhoea, showed that the variance was much higher than the mean. The selection of variables for the multivariate analysis was based on the theoretical model, on the literature and on the results of the bivariate analysis. The variables that remained in the final model are shown in Table 2.

3. Results

Among the 922 children followed-up in this longitudinal study, 550 (60%) had diarrhoea for at least a day, with a mean of 4 days (SD = 8.22) and a median of 1 day of diarrhoea. The days of diarrhoea were distributed within an average observational period of 160 days (23 weeks), with a minimum follow-up period of 1 week and a maximum of 28 weeks. The longitudinal prevalence of diarrhoea in the study population was 2.7%; i.e. in every 100 follow-up days children averaged 2.7 days of diarrhoea. The proportion of children in the sample was almost the same for both sex and age, ranging from 1 to 36 months, with a mean of 18.4 months (SD = 9.74) and a median of 18 months. About 33% of the children were 1 year old or younger. Most children (856, 92.8%) lived with their mothers, who were the informants of choice. As for the children's health status at the beginning of the follow-up, 169 (18.3%) had been hospitalized for different reasons over the previous 12 months (Table 1); 141 (15.3%) of these appeared unhealthy. The nutritional status was measured in 814 children using the *Z*-score (weight-for-age), the results ranging from −4.6 to +5.18, with a mean value of −0.14 and normal distribution pattern.

An average of 3.1 people were identified per dormitory unit (SD = 1.36). Of the mothers or other members of the family, the father excluded, 38.7% (*n* = 357) were principally responsible for the maintenance of the house. Among children's carers, 204 (22%) had a schooling level lower than primary school. In 167 (18.1%) of the houses there was no bathroom inside the house; in 153 (16.6%) there was a stream or swamp near the house; and in 258 (28%) the houses or the streets showed flooding problems during rainfall. It was determined that only 40% of the rubbish generated in the houses was transferred directly from the front of the house or building to the public collecting truck; 4% was burned, buried, or thrown in the river, stream, swamp or sewerage, and the remainder (56%) was put on rubbish dumps or dumping grounds.

As to the sanitary and environmental conditions of the community, a major proportion of children were observed to reside in street sections with unsatisfactory RSI (51.5%), water (11.6%), sewerage (43.6%) and pavement (75.8%) indices (Table 1).

The bivariate analysis revealed positive and statistically significant associations for almost all the variables. Only those statistically significant variables were retained in the multilevel model, together with some variables identified as very important in the literature (Table 2).

In the final model, regarding the second level or community—environmental variables, a positive and statistically significant association was observed between the longitudinal prevalence of diarrhoea and the unsatisfactory 'rubbish-in-street' indices [prevalence ratio (PR) = 1.30; 95% CI 1.02—1.66], and 'water' indices (PR = 1.44; 95% CI 1.07—1.95) (Table 2).

Table 1 shows that, with Level 1 variables, there is a positive and statistically significant association between longitudinal prevalence of diarrhoea and the absence of intradomiciliary rubbish packaging (PR = 3.59; 95% CI 2.01—6.42). Other important variables showing positive and statistically significant associations with the longitudinal prevalence of diarrhoea were: the average number of people per house (PR = 1.10; 95% CI 1.04—1.16); house or street flooding during rainfall (PR = 1.27; 95% CI 1.04—1.56); presence of a rubbish dump near the house (maximum distance of 100 m) (PR = 1.32; 95% CI 1.05—1.65); score of negative habits regarding the perihouse dumping ground (presence of food leftovers, stool, and accumulated package-free rubbish, dumped on the front area or in the backyard of the house, or a child playing on the rubbish dump) (PR = 1.32; 95% CI 1.07—1.64); score of hygienic care (eating with bare hands, mothers not washing hands after handling nappies and/or stool, presence of dirty dishware in the sink, presence of sewerage or stagnant water in the backyard or other areas of the house, children playing in the sewerage drain stream) (PR = 1.30; 95% CI 1.07—1.64). Other important variables related to the children's health status were: hospitalization in the last year (PR = 1.24; 95% CI 0.99—1.54)

Table 2 Final model of multilevel analysis[a] of the association between rubbish-in-street index and longitudinal prevalence of diarrhoea in children under three, Salvador, Brazil, 2000—2001

Variable	Children *n*	Children (%)	Longitudinal prevalence	Prevalence ratio adjusted	(95% CI)
Level 2 variables[b]					
Community environmental risk factors					
Rubbish-in-street index					
0 = good (ref.)	328	(35.6)	2.5	1.00	
1 = regular	123	(13.3)	2.9	1.30	(0.92—1.85)
2 = unsatisfactory	471	(51.5)	2.4	1.30	(1.02—1.66)
Water-in-street index					
0 = good (ref.)	599	(65.0)	2.2	1.00	
1 = regular	216	(23.4)	2.3	1.03	(0.80—1.35)
2 = unsatisfactory	107	(11.6)	4.2	1.44	(1.07—1.95)
Level 1 variables					
Intrahouse environment					
Intrahouse rubbish packaging					
0 = recipient with cover	202	(21.9)	1.8	1.00	
1 = recipient without cover	709	(76.9)	2.5	1.02	(0.79—1.32)
2 = no packaging	11	(1.2)	14.0	3.59	(2.01—6.42)
Perihouse environment					
House or street flooding during rainfall					
0 = no	664	(72.0)	2.1	1.00	
1 = yes	258	(28.0)	3.9	1.27	(1.04—1.56)
Presence of rubbish dump near the house (observed)					
0 = no	746	(80.9)	2.1	1.00	
1 = yes	176	(19.1)	4.0	1.32	(1.05—1.65)
Socio-economic					
Average no. of people per domicile					
Continuous variable	922			1.10	(1.04—1.16)
Demographic					
Child age (months)					
Continuous variable	922			0.95	(0.94—0.96)
Cultural (behaviours, habits and customs)					
Score negative habits regarding perihouse dumping ground					
0 = negative perihouse dumping ground score = 0	735	(79.7)	2.1	1.00	
1 = negative perihouse dumping ground score >0	187	(20.3)	3.9	1.32	(1.07—1.64)
Score of negative hygienic care					
0 = negative hygienic care score = 0	497	(53.9)	1.7	1.00	
1 = negative hygienic care score >0	425	(46.1)	3.3	1.30	(1.06—1.60)
Exclusive maternal breastfeeding (younger than 6 months)					
0 = yes	7	(0.8)	1.3	1.00	
1 = no	915	(99.2)	2.5	2.16	(0.62—7.56)
Child's health status and birth conditions					
Child with unhealthy appearance					
0 = no	781	(84.7)	2.2	1.00	
1 = yes	141	(15.3)	4.0	1.56	(1.25—1.94)
Hospitalization in the last year					
0 = no	753	(81.7)	2.3	1.00	
1 = yes	169	(18.3)	3.3	1.24	(0.99—1.54)
Z-score nutritional status (weight-for-age)					
Continuous variable	814			0.99	(0.91—1.08)

Ref.: referent group.
[a] Multilevel model with Poisson distribution with overdispersion.
[b] The variance decomposition shows: Level 2 = 4.77% and Level 1 = 95.23%.

and child with unhealthy appearance (according to the informant) in the previous 15 days (PR = 1.56; 95% CI 1.25—1.94). Higher diarrhoea longitudinal prevalence was identified among younger children (Table 2). The variables that remained in the final model, considered as potentially confounding but not statistically significant, were Z-score nutritional status (weight-for-age) (PR = 0.99; 95% CI 0.91—1.08) and exclusive maternal breastfeeding of children younger than 6 months of age (PR = 2.16; 95% CI 0.62—7.56).

It was observed that Level 1 variables, measured from the observation of child, family and home, were responsible for 95.2% of variability in the model, while Level 2 variables, measured in the street sections, accounted for 4.8% of the variability in the number of days of diarrhoea in the model. Although small, the variability was statistically significant at the 5% level (Table 2).

4. Discussion

The results of this study indicated that the urban population, and particularly the children, had been suffering the consequences of inadequate rubbish collection. The relevance of waste to diarrhoeal morbidity in children was confirmed, both in the house external environment (community and perihouse) and in the intrahouse space.

It was observed that children residing in the street sections where the RSI was unsatisfactory (no rubbish collection and a rubbish dump smaller than 6 m^3) showed 30% more days of diarrhoea than children residing in places where the RSI was considered good [rubbish collection performed door-to-door with a compacter, a dump truck or an alternative method of collection (not wheelbarrow or men), daily or alternate collection without rubbish or debris dumps]. Regarding Level 2 variables, it was observed that the children residing in street sections classified with 'unsatisfactory' water index (water supply of the public network added to the use of other inadequate sources, such as a well, illegal use of the public network, fountain or conduit, water supply three to four times a week, supply network with conservation problems) showed 44% more days of diarrhoea than children residing in street sections classified with a 'good' water index (water supply exclusively from the public network, constant water supply flow, good conservation of the public network).

The variables measured in the street sections (community) accounted for 4.8% of the variability of the number of days of diarrhoea in the model, indicating that the sanitary and environmental conditions, at least in relation to the rubbish-in-street and water indices, were relevant to the explanation of the occurrence of diarrhoea in children from a statistical perspective.

In Belo Horizonte, Brazil, 40% more diarrhoea, parasitic infections and dermatologic diseases was found among children under five without a USW collecting service compared with those with an adequate service (Catapreta and Heller, 1999). In a prevalence study in Salvador, with children under two, rubbish disposal appears to have the strongest association with diarrhoea (PR = 2.74; 95% CI 1.28—5.87), comparing here those homes that dumped with those that had rubbish collected (Rego et al., 2005).

This study points to a strong association between the lack of adequate rubbish packaging and diarrhoea in children. Among the Level 1 variables related to the USW in the intradomiciliary environment, the longitudinal prevalence of diarrhoea is 3.6 times higher among children living in homes where the rubbish was not packaged in comparison to those living in homes where rubbish was kept in covered receptacles. It is possible that those families that did not pack the rubbish or that generated very little, leaving almost nothing to be packaged or discarded, either giving, reusing or recycling almost everything that is generated, do not have receptacles in which to keep it, or perhaps feel they do not need to package it if the waste is burned, buried or thrown randomly in the backyard or in areas near their homes. Rubbish bags represent an additional cost to the domestic budget, and a possible solution would be the distribution of bags by the collecting companies.

Populations living in the poorest areas generate less waste, with less recyclable components (LIMPURB, 1999; Rego et al., 2002), than populations in other areas. Selling recyclable products may contribute to the household budget or be a means of subsistence for some dwellers on the economic periphery. The practice of donation and reutilization of potentially disposable products is frequently performed with food waste and clothes, etc. (Rego et al., 2002). No matter how economically important recycling may be to the bulk of the population, the collection of recyclable products is still small: 0.29% of the USW generated in 2000 (LIMPURB, 2000).

Children having a dumping ground near their homes (Level 1 variable) had 32% more days of diarrhoea than those living in places where no dumping ground was to be found. In fact, a rubbish dumping ground nearby allows a proliferation of vectors such as flies (Cohen et al., 1991); fly control in Pakistan was responsible for a 23% decrease in childhood diarrhoea (Chavasse et al., 1999). This proximity to rubbish grounds therefore exposes children to direct and indirect contact with diarrhoeal agents.

In Salvador the solid composition of HSW is 46.85% organic material, 3.17% toilet paper and 2.21% disposable nappies (LIMPURB, 1999), evidence of contamination of USW by stool being the most important source of diarrhoeal disease agents. Children may come into direct contact with contaminated USW, thus getting diarrhoea as they play in the perihouse or near the rubbish grounds, on the ground both inside and outside their homes, which is common behaviour in our culture (Rego et al., 2002). Children may also come into contact with USW indirectly, by means of contaminated clothes or objects brought back home by adults or older children (Rego et al., 2005).

Some types of behaviour, habits and customs observed in this follow-up study were considered negative because of the potential risk of child diarrhoea. There were 32% more days of diarrhoea among children either playing near a rubbish dump or in whose house food leftovers, rubbish or stool were spread or dumped on the house floor or its surroundings, in comparison with the prevalence among children not exposed to these conditions. Some of these practices raise the possibility of children's putting contaminated objects into their mouths and thus getting infected. This reinforces the need for interventions aimed at developing hygienic practices, such as adequate disposal of stool and other preventive measures to control diarrhoea (Huttly et al., 1998).

This study indicates that USW, which is contaminated and spread throughout the environment, is associated with child diarrhoea. The factors that determine this relation are complex, as they involve cultural aspects (behaviours, habits and customs) that need the involvement of both the educational and public domains to reduce the problems caused by USW. That requires, from the public sector, investment in urban infrastructure and services, including the adequate collection of USW, to balance the unequal access to goods and services that characterize Brazil.

It seems evident that people exposed to an unfavourable socio-economic climate show worse health conditions. However, some questions remain, not only concerning the existing links between socio-economic and environmental factors but also regarding which populations are more vulnerable within different areas (individual, family and community) (Global Forum for Health Research, 2000).

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