Assessment of Child, Mother, and Environmental Factors Associated with Undernutrition in Children Less than Five Years Old in a Maya Community in Yucatan, Mexico

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Abstract: The objective of this study was to examine child, mother, and environmental factors associated with undernutrition in children less than five years old in a Maya community in Yucatan, Mexico. This investigation was designed as a case-control study. All cases (n=42) of undernutrition were included, and a sample of 52 controls was randomly selected from the study population. The frequency of investigated exposure factors was compared between cases and controls by using logistic regression. Undernutrition was associated with child's age (> 36 months old; OR = 3.53; 95% CI = 1.04, 18.40) and mother's marital status (married; OR = 0.29; 95% CI = 0.09, 0.90). The odds of undernutrition were 2.81 times higher in children infected with *Giardia* spp, but this association was not significant (P = 0.18) after controlling for child's age and mother's marital status. In conclusion, child's age and mother's marital status were associated with child undernutrition in study subjects. Futures studies on undernutrition in children should examine more carefully how mother's marital status alone or in combination with other factors (e.g. socio-economic, psychological factors) can influence child nutrition.

Keywords: Child, undernutrition, risk factors, oportunidades, Yucatan, Mexico.

1. INTRODUCTION

Undernutrition in children less than five years old remains an important public health problem in countries with low- or middle-income economies. In 2009, the World Health Organization estimated that 27% of children in developing countries under the age of five years are malnourished [1]. Poor diet, deficiencies in cell-mediated immunity, respiratory or gastro-intestinal infections are recognized as important risk factors for undernutrition in children [1]. A study in the Democratic Republic of Congo identified dwelling district (peripheral), economic level of the household (low), and mother's education (no schooling) as risk factors associated with undernutrition in children [2]. Another study in Kenya identified mother's education (primary or none), mother's marital status (ever in union, never married), and child's gender (boys) as factors associated with undernutrition [3]. Finally, broad factors associated with undernutrition in children include poverty, world conflicts, natural disasters, and limited or no access to health care [1].

In Mexico, undernutrition in children in rural communities is a public health issue of concern, yet detailed knowledge about the epidemiology and mechanisms that drive patterns of child undernutrition in rural communities is limited. The national prevalence of children less than five years old diagnosed with stunting decreased from 26% in 1988 to 15% in 2006, but stunting continues to be the main undernutrition problem [4]. During this time period, frequency of stunting was consistently higher in indigenous children, those with a low living condition index, or rural residence [1]. Mexico's *Oportunidades* is a large-scale poverty alleviation program (launched by the Mexican federal government in 1997) that targets low-income households with children by providing conditional cash transfers; the ultimate goal is to improve their lives through government interventions in health, nutrition and education [5]. An important nutritional metric is the reduction of new cases of undernutrition in children. Participation in *Oportunidades* has previously been found to have a positive effect on child growth [5-8].

In Yucatan, Mexico, although the prevalence of undernutrition in children less than five years old has been high, few studies have been conducted to understand the epidemiologic aspects of child undernutrition. In 1996, a national survey conducted in

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rural communities in Mexico revealed that the state of Yucatan had the highest prevalence of infants diagnosed with undernutrition [9]. A community study conducted among 84 Maya children between one and sixty months of age revealed that child growth rapidly decreased after four to six months of age; a monotonous diet was identified as a contributing factor associated with undernutrition [10]. In another study, anthropometric data from school children in a Maya community in 1938, 1987, and 1998 revealed patterns of stunted children growing into overweight adults— as a result of a nutritional transition toward western-type diets and reduced physical activity [11]. Finally, in a study conducted among Maya children four to six years old living in the capital city of Merida, the sex of child (boy), mother's height (below 150 cm), and birth weight (below 3,000g) were identified as risk factors for stunting [12]. None of these studies in Yucatan examined the association between mother's education, marital status, participation in *Oportunidades*, or intestinal parasite burden in children as explanatory variables for child undernutrition. The objective of this study was to examine child, mother, and environmental factors associated with undernutrition in children less than five years old in a rural community in Yucatan, Mexico.

2. MATERIALS AND METHODS

This study received approval from the *Universidad Autónoma de Yucatan's Centro de Investigaciones Regionales "Hideyo Noguchi"* Bioethics Committee (Protocol No. CEI-CIR-UADY 04-2012) and the University of Florida's Institutional Review Board (Project No. 233-2012). Children whose parents/guardians gave their informed written consent were enrolled in the study. The Director of the local health clinic received written notification of parasitology results. Children diagnosed with intestinal parasites were given the appropriate anti-parasitic treatment at the local health clinic.

2.1. Study Site and Study Population

The state of Yucatan, Mexico has a population of 2 million people distributed in 106 municipalities. This study was conducted in the municipality of Tunkas, which is located ~ 100 km east of Merida, the capital city of the state of Yucatan, Mexico. Tunkas has a population of 3,464 people according to Mexico's 2010 Census of Population and Housing [13]. Approximately, 47% of the population over five years of age speaks Maya, the indigenous language, compared to 27% for the rest of the state of Yucatan. The municipality of Tunkas was selected because it has a history of high prevalence of child undernutrition and 10 years of collaboration with the University of Florida and the *Universidad Autónoma de Yucatan* in dog rabies vaccination and dog overpopulation control efforts. In March and November 2012, two-hundred and thirty children less than five years old whose names were identified in medical records at the local health clinic in Tunkas were initially considered for inclusion; 80 (40%) of 230 children were enrolled in the *Oportunidades* program—a federal government, conditional cash transfer program that uses cash both as a mechanism to allow parents to provide for their needs and as an incentive for parents to invest in their children's health and wellbeing [7, 14]. Forty-two (18%) children had a current diagnosis of undernutrition. The burden of intestinal parasites in children was not known. However, as per public health policy at the local health clinic, children ≥ 2 years should receive prophylactic anti-parasitic treatment (albendazole) every six months until they are five years old.

2.2. Study Design

This investigation was designed as a case-control study. Sampling of study children was based on diagnosis of undernutrition (yes, no). The frequency of investigated exposure factors was compared between children with or without undernutrition. A questionnaire considering child, mother, and environmental factors was administered to each child's mother during a personal interview conducted in November 2012.

2.3. Selection of Cases

All known children less than five years old with a current diagnosis of undernutrition (n = 42) based on medical records at the local health clinic in Tunkas in March and November 2012 were included and classified as cases. Children with undernutrition were diagnosed by a public health worker (nutritionist) at the local health clinic by using anthropometric measurements and a physical examination. Cases of undernutrition were children with measurements that fell below two standard deviations under the normal weight-for age (WAZ) (underweight), height-for-age (HAZ) (stunting), or weight-for-height (WHZ) (wasting) [1].

2.4. Selection of Controls

Controls were defined as children less than five years old without a history of diagnosis of undernutrition based on medical records at the local health clinic in Tunkas in March and November 2012. Fifty-two control children were randomly selected from a list of 188 children without undernutrition. The software Research Randomizer [15] was used to generate random numbers to select children without undernutrition.

2.5. Data Collection

Data on children's name, age (months) and sex (boy, girl), as well as mother's name and participation in *Oportunidades* (yes, no) were obtained from records at the local health clinic in Tunkas. A personal interview was conducted in Spanish or Maya for data collection with the assistance of a Spanish- and Maya-speaking public health worker at the local health clinic in Tunkas. Additional child data, mother's demographic and environmental factors that can shape patterns of undernutrition among children in the study included: (i) Child's information: name, history of respiratory disease or diarrhea in the last 12 months (yes, no), child walks or plays barefoot outside the house (yes, no); (ii) Mother's demographic information: name, age (years), number of children, level of education (none, primary, secondary, high school), marital status (married, divorced, single, in union but not married, widow), and history of participation in *Oportunidades* (yes, no; duration in years); and (iii) Environmental factors: main source of drinking water (commercially available potable water, other); house infrastructure including materials used in construction of floor (concrete: yes, no), walls (concrete, other) and roof (concrete, other), toilet facilities (indoor-toilet, latrine, outside). Data obtained from records at the local health clinic in Tunkas were available for all study children. However, during house-to-house interviews for data collection in November 2012, family members of six children with undernutrition and of six without undernutrition were not present. Thus, data on exposure factors included in the questionnaire was limited to 42-6=36 children with undernutrition and 52-6=46 children without undernutrition. Data on current or past prophylactic or therapeutic treatment of study participants for parasitic infections were not available at the local health clinic.

2.6. Collection of Fecal Samples

During house-to-house visits, a public health worker at the local health clinic in Tunkas facilitated communication with all mothers of children included in this study. Each mother was instructed to collect two fecal samples from her child on two consecutive days (one sample each day). On a first home visit (day 1), the child's mother was provided with two pairs of gloves and two sterile plastic specimen containers (100 ml), labeled with the child's name, and instructed in sanitary collection of the child's fecal sample after normal defecation. The child's first fecal sample was collected the following day (day 2) and the second sample was collected the day after (day 3). The mother was instructed to put on a pair of gloves and remove the screw cap to collect the fecal by "scooping" the fecal sample into the specimen container before replacing and securing the screw cap. The mother was instructed to avoid touching the feces with the gloves to prevent unnecessary contamination of other objects. The specimen container with the fecal sample was placed in a plastic bag "zip-lock" to reduce the risk of contamination. Next, the mother was instructed to remove one glove at the time by pulling them off from the proximal end with the opposite hand, entirely exposing the inner side of the glove. Both gloves were placed in a paper or plastic bag for disposal with other waste produced in the household. In addition, the mother was instructed to wash her hands with soap immediately after the sample was collected. All fecal samples were submitted to a field laboratory that was set up next to the local health clinic in Tunkas for identification of intestinal parasites. Seventy-nine of 82 (96%) children surveyed returned a fecal sample.

2.7. Identification of Intestinal Parasites

Fecal samples were received and processed by two of the investigators (JCG and AM) at the field laboratory. Identification of intestinal parasites in child fecal samples was performed following standard flotation by centrifugation procedures using a modified Sheather's solution [16]. In children, fecal samples No. 1 and No. 2 were combined for a modified Wisconsin flotation by centrifugation in order to identify geohelminths and tapeworms [16, 17]. Two direct smears of fresh feces preserved with Zinc-PVA were prepared from each sample and stained following standard trichrome procedures for identification of intestinal protozoa [18]. Stained slides were submitted to *Universidad Autónoma de Yucatán's Centro de Investigaciones Regionales Hideyo Noguchi* in the city of Merida to confirm the study results.

2.8. Statistical Analysis

A sample of 42 cases and 42 controls provided 95% confidence and 80% power to detect a 3.5-fold increase in the odds of diagnosis of undernutrition as a function of one specific exposure factor (e.g. 40% exposure among controls). A total of 52 controls (42 + 10) were included in the control group to compensate for potential attrition (i.e. families not present at their homes during time of data collection). The Wilcoxon rank sum test was used to compare continuous variables (child's age, mother's age, number of children in the house, number of months with participation in *Oportunidades*, and number of child's fecal samples collected and tested) among case and control children. The frequency of children with a positive diagnosis of intestinal parasites in different age groups (12 to 24, 25 to 36, and 37 to 64 months old) was compared by using a chi-square test. The software Statistix was used for data analysis [19].

Unconditional logistic regression was used to model the odds of undernutrition in children. In the univariable analysis, variables with a *P* value ≤ 0.20 were considered eligible for multivariable analysis. Associations between exposure variables (*P* ≤ 0.20) were examined, and when a pair of variables was associated by use of a chi-square test (two tailed), the exposure variable judged as most biologically plausible was used as a candidate in the multivariable analysis. To determine the best fitting model, the variable with the smallest *P* value in the univariable analysis was entered into the model first. Thereafter, each of the remaining variables was added to the model containing the first variable to test whether its addition significantly improved the fit of the model. The variable with the highest likelihood ratio statistic (chi-square test with one degree of freedom) was selected for addition to the model and the process was then repeated; variables had to have a *P* value ≤ 0.10 to be retained in the model. Explanatory variables retained in the model were examined for confounding by adding each of the variables to the model and assessing the changes in the odds ratios (i.e., > 10%) of the remaining variables in the model. The logistic regression model was assessed for "goodness of fit" using the Hosmer-Leme show test. In the final models, four categories (i.e., divorced, single, in union but not married, and widow) for the variable of mother's marital status were collapsed into one category (not married).

3. RESULTS

The initial study sample included 42 cases and 52 controls. Five cases and eight controls were siblings from six families. Median age was higher in children with undernutrition (43 months), compared to children without undernutrition (37 months); but this difference did not reach statistical significance (*P* = 0.09). The median number of fecal samples collected and tested for intestinal parasites was not different between case (n = 2 samples) and control children (n = 2 samples) (*P* = 0.72). The frequency of children with a positive diagnosis for one or more intestinal parasites was not significantly different (*P* = 0.51) among the age groups of 12 to 24 months (4/15 or 27%), 25 to 36 months (5/19 or 26%), and 37 to 64 months old (16/41 or 39%).

Median mothers' age was similar among children with (28 years) or without undernutrition (27 years) (*P* = 0.19). Thirty-eight of 94 (40%) mothers were currently enrolled in the *Oportunidades* program. Among program participants, mother's number of years on the program was not different between children with undernutrition (median = 5 years) or without undernutrition (4 years) (*P* = 0.90). The median number of children in the house was not different (*P* = 0.72) between children with (n = 3 children) or without undernutrition (3 children).

Fifty-three of 81 (65%) mothers reported that their child plays barefoot in the house backyard. In addition, 30 of 82 (37%) mothers reported that family members defecate outdoors (house backyard) because the household is not equipped with an indoor toilet or a latrine. In all households, mothers reported potable water (commercially available) was the main source of drinking water used by their families.

In the univariable analysis of undernutrition in children, the variables for child's age and sex, mother's education level and marital status, type of toilet facilities used, and *Giardia* spp infection had *P* values ≤ 0.20 (Table **1**). Participation in *Oportunidades* was not associated with reduced odds of undernutrition (OR = 1.20; 95% CI = 0.52, 2.75).

In the multivariable analysis (Table **2**), the variables for age and marital status were retained in the final model. The odds of undernutrition were 4.38 times higher in children > 36 months old, compared to children 12-24 months old, after controlling for mother's marital status (OR = 4.38; 95% CI = 1.04, 18.40). In addition, The odds of undernutrition were 3.44 times lower in children whose mothers were married, compared to children whose mothers were not, after controlling for child's age (OR = 0.29; 95% CI = 0.09, 0.90). The Hosmer-Leme show goodness of fit test (1.37; df = 4; *P* = 0.84) indicated that there is no evidence of a poor fit for the data. Adding the variables

Table 1: Univariable Analysis for Comparison of Child, Mother, and Environmental Factors in Children with or without Undernutrition

Variable	Undernutrition Yes n=36 (100%)	Undernutrition No n=46 (100%)	OR	95% CI	*P*
Child's factors					
Age (months)					
12-24	3 (8)	12 (26)	1.00	Reference	NA
25-36	9 (25)	11 (24)	3.27	0.70, 15.28	0.13
37-64	24 (67)	23 (50)	4.17	1.04, 16.72	0.04
Sex					
Girl	12 (33)	23 (50)	1.00	Reference	NA
Boy	24 (67)	23 (50)	2.00	0.81, 4.93	0.13
Respiratory disease					
No	8 (22)	9 (20)	1.00	Reference	NA
Yes	28 (78)	37 (80)	0.85	0.29, 2.49	0.76
Diarrhea					
No	29 (81)	34 (74)	1.00	Reference	NA
Yes	7 (19)	12 (26)	0.68	0.24, 1.97	0.48
Child plays barefoot					
No	12 (33)	16 (36)	1.00	Reference	NA
Yes	24 (67)	29 (64)	1.10	0.44, 2.78	0.83
Intestinal parasites in children					
Intestinal parasites					
No	23 (64)	31 (72)	1.00	Reference	NA
Yes	13 (36)	12 (28)	1.46	0.56, 3.78	0.43
Giardia spp.					
No	29 (81)	40 (93)	1.00	Reference	NA
Yes	7 (19)	3 (7)	3.22	0.77, 13.50	0.11
Trichuris trichiura					
No	32 (89)	37 (86)	1.00	Reference	NA
Yes	4 (11)	6 (14)	0.77	0.20, 2.98	0.70
A. lumbricoides					
No	32 (89)	40 (93)	1.00	Reference	NA
Yes	4 (11)	3 (7)	1.67	0.35, 7.99	0.52
Enterobius spp.					
No	36 (100)	42 (98)	1.00	Reference	NA
Yes	0 (0)	1 (2)	ND	ND	ND
Hymenoleptis nana					
No	36 (100)	42 (98)	1.00	Reference	NA
Yes	0 (0)	1 (2)	ND	ND	ND
B. hominus					
No	34 (94)	43 (100)	1.00	Reference	NA
Yes	2 (6)	0 (0)	ND	ND	ND
Mother's factors					
Education					
No	9 (25)	8 (17)	1.00	Reference	NA
Primary school	14 (39)	17 (37)	0.73	0.22, 2.40	0.60
Secundary school	10 (28)	11 (24)	0.81	0.22, 2.91	0.74
High school	3 (8)	10 (22)	0.27	0.05, 1.32	0.10

(Table 1). Continued.

Variable	Undernutrition Yes n=36 (100%)	Undernutrition No n=46 (100%)	OR	95% CI	*P*
*Oportunidades**					
No	24 (57)	32 (62)	1.00	Reference	NA
Yes	18 (43)	20 (38)	1.20	0.52, 2.75	0.66
Marital status					
Married	24 (66)	40 (87)	1.00	Reference	NA
Divorced	1 (3)	0 (0)	ND	ND	ND
Single	1 (3)	1 (2)	1.67	0.10, 27.90	0.72
In union but not married	9 (25)	5 (11)	3.00	0.90, 10.01	0.07
Widow	1 (3)	0 (0)	ND	ND	0.66
Mother is married					
No	12 (33)	6 (13)	1.00	Reference	NA
Yes	24 (67)	40 (87)	0.30	0.10, 0.90	0.03
Environmental factors					
Wall					
Cement	29 (81)	41 (89)	1.00	Reference	NA
Other	7 (19)	5 (11)	1.98	0.57, 6.86	0.28
Roof					
Cement	7 (23)	10 (22)	1.00	Reference	NA
Other	24 (77)	35 (78)	0.98	0.33, 2.93	0.97
Toilet facilities					
Toilet	17 (47)	31 (68)	1.00	Reference	NA
Latrine	2 (6)	2 (4)	1.81	0.24, 14.13	0.56
On the ground-backyard	17 (47)	13 (28)	2.38	0.94, 6.06	0.06

*Data were obtained from medical records of 42 case and 52 control children at the local health clinic.

Table 2: Logistic Regression Models for Factors Associated with Undernutrition in Children

Variable	Adjusted Odds Ratio	95% Confidence Interval	*P*
Child's age			
12-24 months (n=15)	-	-	-
25-36 (n=20)	3.53	0.72, 17.37	0.12
37-64 (n=47)	4.38	1.04, 18.40	0.04
Child's mother is married			
No (n=18)	-	-	-
Yes (n=64)	0.29	0.09, 0.90	0.03

for child's sex (*P* = 0.19), mother's high school education (*P* = 0.17), toilet facilities (*P* ≥ 0.25), a positive diagnosis of *Giardia* spp (*P* = 0.18), or participation in *Oportunidades* (*P* = 0.85) did not significantly change the odds ratios (≥ 10%) for the variables of child's age and mother's marital status, indicating that their relationships with undernutrition in children were not confounded by neither of those five variables. Finally, because 5 cases and 8 controls were siblings, an additional model without these 13 study subjects was examined. Removal of these observations did not change the finding of an association between mothers' marital status and child undernutrition (i.e. the adjusted odds ratio = 0.24; 95% CI = 0.07, 0.81; *P* = 0.02) after controlling for age.

4. DISCUSSION

Our study results revealed that undernutrition in children was associated with child's age and mother's marital status. A positive diagnosis of intestinal parasites in children was not associated with undernutrition. Odds of undernutrition were lower among children whose mothers had high school, but the study sample size was too small to properly assess this association.

In this study, the odds of child undernutrition were associated with age. The association between age and undernutrition is in agreement with results of a previous study, where the estimated prevalence of stunting was higher in Mexican children 24-59 months old in 1988 and 1999, compared to Mexican children less than 24 months old in the same time period (but not in 2006, when the prevalence of stunting in both age groups was similar: 14 and 16%, respectively) [4]. In a community study conducted among 84 Maya children between one and 60 months of age, a rapid decrease in standardized growth scores (WAZ, HAZ, and WHZ) was observed after four to six months of age; a monotonous diet (re-hydrated milk, tortillas, beans, eggs, and chicken once a week) was identified as a contributing factor associated with undernutrition in children [10]. Our analysis could not take into account the effects of variation in time when children were first diagnosed with poor nutrition or the length of time that children remained undernourished. Thus, it is difficult to determine if undernutrition in children more than two years old in our sample is the result of early weaning, delayed consumption of fortified food, and severe or frequent infections during the critical period for child linear growth, including gestation and the first two years of life [1, 5].

We identified an association between mothers' marital status and child undernutrition. This association was independent of the association observed between child's age and undernutrition. In this study, most mothers (14/18) who identified themselves as not married were in union but never been married. Previous studies [9-11] conducted in Yucatan have not examined the relationship between mother's marital status and child undernutrition. It is possible that marital status is related to socioeconomic factors (e.g. employment, household income), psychological factors (e.g. mother's depression),or other factors that shape living conditions and the nutritional status of children. A previous study in two urban settlements in Nairobi showed an association between mother's marital status (never married, ever in union) and undernutrition in children; however, an explanation for this association was not offered [3]. In a recent study conducted on Mexican children six to 18 months old, undernutrition was associated with parental stress (including mother's depression, child acceptability, and relationship with their spouses) which was characterized by neglect and lack of enthusiasm while children were eating [20]. Finally, studies conducted in Bangladesh, Brazil, India, Nigeria, Pakistan, and Vietnam have identified an association between mother's depression and undernutrition in children [21-28].

A positive diagnosis of intestinal parasites in children was not associated with undernutrition. While univariable analysis indicated that the odds of undernutrition were 3.22 times higher in children infected with *Giardia* spp, this variable was not retained in the final logistic regression model (OR = 2.81; P = 0.18) after controlling for child's age and mother's marital status. Thus, the observed association between *Giardia* spp infection and undernutrition is inconclusive. Yet, there is ample evidence in the public health literature that *Giardia* infection contributes significantly to acute and chronic global disease burden. In a study [29] conducted in rural Ecuador, children infected with *Giardia intestinalis* had lower levels of hemoglobin and double the risk of stunted growth. In that study [29], the frequency of children infected with *G. intestinalis* was higher (26%), compared to this study in Yucatan (13%). *Giardia* infection may cause nutrient malabsorption, and the resulting deficits may be exacerbated in children already affected with undernutrition [29, 30].

In this study, after controlling for child's age and mother's marital status, the odds of undernutrition were 2.7 times lower (OR = 0.36) in children whose mother had a high school degree, compared to mothers who did not; but this association did not reach statistical significance (P = 0.17). Low level of mother's education was a socioeconomic determinant associated with an increased risk of undernutrition (stunting) in children less than six years old in Brazzaville, the capital city of the Democratic Republic of Congo; although a low level of education is generally associated with poverty, the effect of education of the mother on undernutrition was independent of the economic level of the household [2]. This finding is relevant because it underscores the importance of mothers' education in making better health care decisions for their children, regardless of the economic level of the household. Mother's education was also an important predictor for child stunting in two slums of Nairobi [3].

We examined the association between participation in *Oportunidades* and child undenutrition because there is evidence that it can improve the lives of low-income households with children, and reduction of new cases of undernutrition is an important nutritional metric. In this study, however, *Oportunidades* was not associated with reduced odds of undernutrition among study participants. *Oportunidades* is a well-known program in the community of Tunkas, and all mothers in the community share (health, nutrition) information that can improve their lives on a day-to-day basis. Previous (experimental) studies carefully assessed the efficacy of participation in *Oportunidades* on child growth in rural communities in six central Mexican states (Guerrero, Hidalgo, Puebla, Querétaro, San Luis Potosí, and Veracruz) at the inception of the program in 1998.In two studies [5, 8], children were selected from 506 rural communities which had been randomly assigned to immediate incorporation into the program in 1998-1999 (n = 320 communities) or 18 months later (n = 186 communities). Participation in *Oportunidades* improved child growth during the first year of the program [5, 8], and effects were stronger in children who lived in the poorest households [5]. In these two studies, sharing (leak) of health and nutrition information (prescribed by *Oportunidades*) was less likely or negligible because the program was relatively new, and treatment and control children were selected from different communities. In another study conducted in 2003, a doubling of cash transfers to households associated with study children 24 to 68 months old was associated with better outcomes of child physical, cognitive, and language development [6]. In that same study, the number of years in the program was not associated with any of the outcomes. In our study, although we measured number of years on the program, we did not measure cumulative cash transfers to households associated with study children, and this is a study limitation. Finally, in another study [7], an additional 18 months in the *Oportunidades* program for children whose mothers had no education resulted in improved child growth of about 1.5 cm assessed as height for age, independently of cash received. To our knowledge, no other published studies have examined the association between participation in *Oportunidades* and undernutrition in children in rural Yucatan.

This study has several limitations. First, although this investigation was designed as a case-control study, we used existing cases instead of new cases of undernutrition. Thus, it is difficult to establish temporal relationships between investigated exposure factors and undernutrition in children; although, most mothers classified as not married had never been so. Second, the study sample was small to adequately assess exposure factors such as *Giardia* infection in children, or mother's education and their relationship with undernutrition in children. Third, the questionnaire was not structured to measure the economic level of each household, which would be important to assess the independent and combined effects of mother's education, economic level of the household, as well as mother's participation in *Oportunidades* on undernutrition in children. Although we collected data on the number of children in the household, child rank order data were not collected. Another limitation was that medical records at the local health clinic did not include a history of anti-parasitic treatment in children, and this situation limited our ability to assess the protective effects of prophylactic therapy on intestinal parasite infection and its relationship with undernutrition. Finally, study results cannot be extrapolated to rural or urban communities in other states in Mexico, as differences in health care access, genetic, cultural, and socioeconomic factors would be expected to affect nutrition status in children less than five years old.

5. CONCLUSION

In this study, child's age and mother's marital status were associated with child undernutrition. Futures studies on undernutrition in children should examine more carefully how mother's marital status alone or in combination with other factors (socio-economic, psychological factors) can influence child nutrition.

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