Maternal Agency Influences the Prevalence of Diarrhea and Acute Respiratory Tract Infections Among Young Indonesian children

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Abstract To examine the relationship between measures of mother's caretaking, practice and individual agency on acute diarrhea and respiratory tract infections (ARTIs) of Indonesian children. Using population-based household data from the Indonesian Demographic Health Surveys for 2002–2003 (n = 9,151 children) and 2007 (n = 9,714 children), we selected 28 indicators related to mother' caretaking, and applied principal component analysis to derive indices for access to care, practice and experience, and agency. The association between index quartiles (level 1–4) and the prevalence of diarrhea and ARTIs in the youngest child <5 years of age was assessed with multivariate logistic regression adjusting for socioeconomic status, residence type, mother's age and education, family size, child's age and sex, immunization status and received vitamin A supplementation. Moderate levels (level 3) of practice and experience were associated with decreased diarrheal risk (adjusted OR 0.86, 95 % CI 0.75–0.98), but not for ARTIs. Children of mothers with higher levels (level 4) of agency were protected against both diarrhea (adjusted OR 0.68, 95 % CI 0.60–0.77) and ARTIs (adjusted OR 0.77, 95 % CI 0.66–0.91). Stratified analyses with child's age and mother's education, and tests of interaction, showed that agency had a stronger effect on diarrhea and ARTIs prevalence in children <2 years of age. Maternal caretaking, especially agency, is strongly associated with lower prevalence of diarrhea and ARTIs in younger children. Interventions specifically designed to promote maternal autonomy and decision-making may lead to improved child health.

Keywords Children · Diarrhea · Respiratory tract infections · Maternal agency · Indonesia

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Introduction

Worldwide, acute diarrhea and acute respiratory tract infections (ARTIs) are responsible for almost 30 % of deaths among children under 5 years of age [1]. In low-income countries, the annual incidence remains high with an estimated 2.5 billion cases of diarrhea and 151 million episodes of ARTIs [2, 3] making them the first and second causes of disability-adjusted life-years (DALYs) in children. These diseases are mainly concentrated in 15 countries, including Indonesia, that account for 75 % of worldwide diarrhea and pneumonia deaths [4]. Moreover, a recent national survey reported high prevalence of diarrhea

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(14 %) and ARTIs (29 %) among Indonesia children under age 5 [5]. Although multiple interventions at the level of the health system are available for prevention and treatment of these diseases, the role of the primary caretaker, usually the mother, remains poorly understood.

The mother's role in childhood disease management is influenced by numerous extrinsic and intrinsic factors. Extrinsic factors include familial and social determinants such as socio-economic status, family size, access to nutritional foods and education [6–9] as well as environmental factors such as access to drinking-water and clean air [10–12]. Intrinsic factors include individual characteristics such as motivation, attitudes and beliefs, self-efficacy and acquired maternal knowledge related to health and nutrition, and waste management and hygiene practices [13–15]. Improvements in these conditions that influence care practices have both individual and combined effects on child morbidity and mortality. For example, improvements in economic status reduce health risks especially for children whose mothers have better acquired knowledge [6], and breastfeeding, perhaps the most studied maternal factor, reduces risk of both diarrhea and ARTIs [16, 17].

A substantial literature has examined the role of intrinsic maternal factors such as autonomy (woman's freedom of decision making, access to financial resources, freedom of movement) and agency [18–20] on reproductive health, health seeking and child health, but their relation to diarrhea and ARTIs have not been specifically addressed, and the pathway for any association is unclear. In addition, there are numerous definitions of intrinsic concepts such as empowerment and maternal agency that are often context and culture specific, making comparisons at a population level challenging [21, 22]. Building upon the work of Caruso et al. [16] that demonstrates high levels of maternal agency has a significant protective effect on diarrheal episodes in children under five in Bolivia, we examine how these same factors (maternal access to care, maternal behaviour and experience and maternal agency) impact both ARTIs and diarrhea in children under five living in Indonesia. Additional investigation of the influence of maternal factors on child health in culturally and contextually diverse settings will provide needed information to more effectively inform interventions to reduce neonatal and child morbidity and mortality [16].

Methods

Study Design and Subjects

Data were obtained from the Indonesia Demographic and Health Survey (IDHS) 2002–2003 and 2007 [23, 24]. The IDHS are nationally representative two-stage stratified multi-cluster sampling household and family surveys. IDHS 2002–2003 involved 26 out of 30 provinces and was carried out between October 2002 and April 2003. The IDHS 2007 included all 33 provinces and was carried out between June and December 2007.

We selected data on all women with the youngest child under 5 years of age in IDHS 2002–2003 (n = 9,151) and IDHS 2007 (n = 9,714) from the original pool of 37,000 and 32,895 respondents, respectively. Mothers with children <5 years were selected based on information from the questionnaire including ever- and currently married women, having at least one living child, the age of youngest child being <5 years and having information on whether or not the child had diarrhea or ARTIs during 2 weeks before survey. The Women's Questionnaire with children of the 2002–2003 and 2007 IDHS only included ever- and currently married women 15–49 years old.

Outcomes Variables: Diarrhea and ARTIs Prevalence

We assessed two binary child morbidity outcomes as reported in the 2 weeks period before the survey visit: (1) an episode of diarrhea; and (2) an episode of ARTIs. The prevalence of diarrhea was calculated as the percentage of children under 5 years of age reported as suffering from diarrhea. We defined ARTIs prevalence as the percentage of children <5 years of age with a reported episode of cough accompanied by short, rapid breathing and difficulty breathing as a result of a problem in the chest. The episode of diarrhea and ARTIs in the child (aged <59 months) most recently born to the mother interviewed was of primary interest.

Independent Variables: Maternal Factors

We chose 32 maternal factors based in large part on previous research by Caruso et al. in 2010 [16] and included indices constructed based on specific maternal dimensions that may affect a child's risk of diarrhea and ARTIs as well availability of the variables in the IDHS datasets (Table 1). Definition of some maternal factors such as barrier to health care, knowledge of oral rehydration solution, parity, breastfeeding initiation, decision on visits to family or relatives, decision on large or daily purchases were slightly different from Caruso et al. to adjust with the Indonesian dataset and situations. Important factors added in the operational definitions that were different from definition of Caruso et al. were received tetanus injection [24], received vitamin A supplementation [24] and frequency of child eating per day [25]. Four variables with missing cases of >20 % were not included, and corresponded to the following: "heard about AIDS and sexually transmitted diseases", "decision for spending money" and "using

Table 1 Maternal factors of mothers and their operational definition

Variables[a]	Responses	Factors-loading matrix
Mother's access to health care		
Health facility visit	1 = Visited health facility last 12 months	0.343
Barrier to health care	1 = Did not have 4 or more big problem to health care	0.313
Prenatal care	1 = Had 3 or more antenatal care visit with 1 in the first 6 months	0.470
Unmet need for contraception	1 = Did not have unmet need for contraception	0.895
Delivery location and assistance	1 = Delivery at medical institution and assisted by health professionals	0.633
Received tetanus injection[b]	1 = Received tetanus injection before marriage	0.546
Vitamin A supplementation	1 = Received vitamin A supplementation 2 months after delivery	0.500
Knowledge of oral rehydration solution	1 = Heard oral rehydration solution from many sources	0.450
Maternal practice and experience		
Respondent age at first birth	1 = Mother's aged >18 years at first birth	0.358
Parity	1 = Parity <2.6 (2007 DHS fertility rate)	0.832
Preceding birth interval	1 = Preceding birth interval >24 months	0.725
Child death in the family	1 = No child death in the family	0.613
Breastfeeding initiation	1 = Breastfed immediately (<1 h)	0.843
Breastfeeding duration	1 = Still breastfeeding or breastfed at least 6 months	0.464
Supplemental feeding	1 = Gave no supplemental feeding in first 3 days of child life	0.844
Child's stool disposal	1 = Disposed stool properly	0.694
Frequency of child eating per day[a]	1 = Child eat at least 3 times a day	0.554
Maternal agency		
Decision on visits to family or relatives	1 = Respondent decides and/or couple jointly decide	0.723
Mother works	1 = Works	0.588
Decision on large purchases	1 = Respondent decides alone or couple jointly decides	0.775
Decision on daily purchases	1 = Respondent decides alone or couple jointly decides	0.559
Decision on own health care	1 = Respondent decides	0.689
Decision on food to be cooked that day	1 = Couple jointly decides	0.840
Pregnancy intention	1 = Wanted last child	0.627
Attitude toward domestic violence	1 = Believes domestic violence never justified	0.723
Respondent marital and living situation	1 = Married and living with husband	0.670
Age difference	Continuous: −15 to 52	0.704
Education difference	Continuous: −6 to 17	0.667

[a] Most of definitions for the maternal factors were taken from the previous research by Caruso et al. in 2010 [16], except definition of barrier to health care, knowledge of oral rehydration solution, parity, breastfeeding initiation, decision on visits to family or relatives, decision on large or daily purchases that were slightly different from Caruso et al

[b] Receiving tetanus injection is part of important component of antenatal care in Indonesia [24]

[c] Vitamin A capsule is given to the mothers in Indonesia in the 2 months after delivery of their last-born child as part of postpartum health care service [24]

[d] According to principle guidelines of the Infant and Young Child Feeding, a minimum meals frequency of 3 times (including main meals and snacks) for healthy breastfed children >6 months and for non-breastfed children, minimum is defined as 4 times for children 6–23 months [25]

contraception". The remaining 28 variables were condensed into three predefined indices: (1) access to care, (2) practice and experience, and (3) agency (Table 1 and Fig. 2).

Our conceptual framework on the influence of maternal factors to diarrhea and ARTIs in children was mainly taken from the framework of Caruso et al. [16] for maternal factors that constructed the model from Mosley and Chen [26] for the determinants of child mortality in developing countries. Our model was also influenced by the framework of UNICEF for the determinants of child malnutrition (1998) [27] and Berman et al. on household producing health behaviour [28]. We identified maternal factors as the intermediate factors that contributed to more proximate factors of child's exposure to pathogens and susceptibility to diarrhea and ARTIs (Fig. 1). We took into consideration some distal factors such as socioeconomic status, type of residence (urban versus rural), maternal education and age

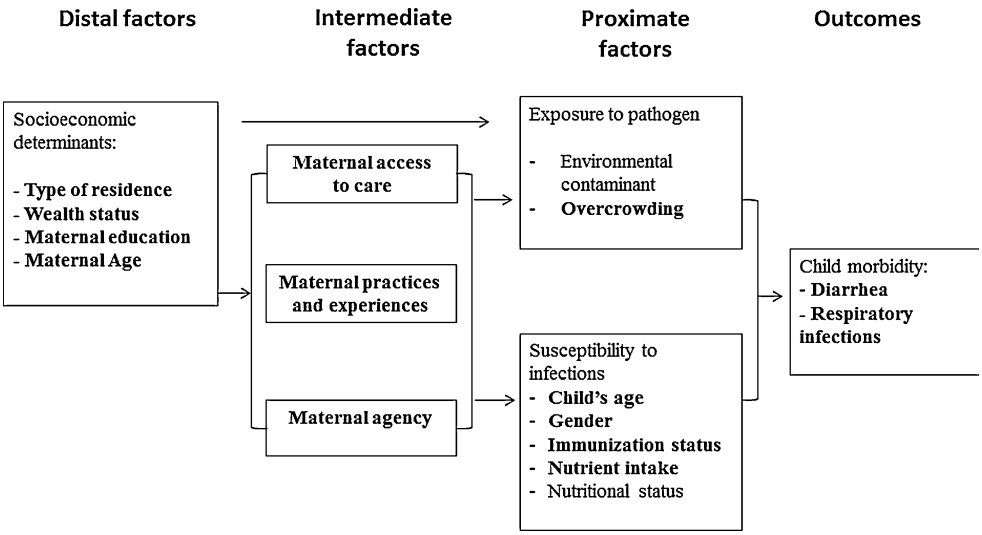

Fig. 1 Conceptual framework of the influence of maternal factors to the morbidity due to diarrhea and acute respiratory tract infection in children. The Framework was modified from Caruso et al. [16] for maternal factors that constructed the model from Mosley and Chen [26] for the determinants of child mortality in developing countries. This model was also influenced by the framework of UNICEF for the determinants of child malnutrition (1998) [27] and Berman et al. [28] on household producing health behaviour

as potential covariables that might influence the maternal factors.

Maternal agency refers to a "measure of the ability of mothers to formulate own choices, take control over own lives and resources that effect important life outcomes" [16]. To assess women's role in household decision-making, information was collected on women's participation in five different decisions: (a) her own health care; (b) large household purchases; (c) household purchases for daily needs; (d) visits to family or relatives; and (e) what food to cook each day. Women were considered to participate in decision-making if they make decisions alone or jointly with their husband.

Caruso et al. [16] investigated the cumulative effect of various maternal factors simultaneously using principal components analysis (PCA). In that study, PCA was applied to represent and explain the covariance relationships amongst the large scale correlated variables. We also performed PCA on the components of each individual index to reduce the variables into a simple single structure with greater interpretability and to yield the weight for the respective index [16, 29, 30]. The orthogonal solution was used to rotate factors and to produce the factors that were not highly correlated with each other [30]. For each index, all factors were retained based on having an eigenvalue >1, the Scree test, and the variance explained by the factors. If more than one component yielded during the extraction, they were pooled into one component by summing up their squares sums to the total variance [29]. Individual factor scores were used for the analysis only if all the questions in the index were answered. The positive response provided by mothers was valued as 1 (one) and considered to correspond to better access to care, maternal practices and experience, or maternal agency. The raw scores produced by the factors were recoded into quartiles so as to function on a relative scale [16].

Statistical Analysis

The data from the IDHS 2002–2003 and IDHS 2007 were pooled for analysis. We used SPSS Statistics 19 for Windows (SPSS Inc. Chicago 2010) for data analyses including PCA. Statistical analyses were performed in accordance to a predefined conceptual framework (Fig. 1). Variables from the distal model, such as type of residence (urban versus rural), wealth quintile, mother's age and education; and proximate model such as family size, child's age, sex, immunization status and vitamin A supplementation that had a $p < 0.25$ based on bivariate analysis by X^2 test were considered as potential confounders [31].

First, we performed bivariate and multivariate logistic regression models and assessed the association between individual maternal factors and diarrhea, and ARTIs prevalence. We calculated the unadjusted odds ratio (OR) and 95 % confidence intervals (CI) of each variable using bivariate analysis. Only if the 95 % CI did not include one, i.e. $p < 0.05$, we considered the result statistically significant. All potential covariates were included in logistic analysis to estimate the adjusted OR and 95 % CI. Thus, a multiple logistic regression model was used to account for the effect of several potential confounding factors, i.e., type of residence, wealth quintile, maternal education and age, family size, child's age and sex, child received complete immunization and vitamin A supplementation. We included the quartile level of the three indices of maternal factors (level 1 = lowest, level 2 = low, level 3 = moderate and level 4 = high) versus prevalence of diarrhea and ARTIs in a logistic regression model for the unadjusted OR and adjusted OR 95 % CI after adjusting for distal (type of residence, wealth quintile, maternal education and maternal age) and proximate factors (family size, child age and sex, immunization status and received vitamin A). Logistic

Table 2 Basic characteristics of the selected families, mothers and children from the Indonesian Demographic Health Survey 2002–2003 and 2007 in Indonesia

Characteristics	n (%) or mean (SD)
Families	
Area of residence	
Rural	10,604 (56.2)
Urban	8,261 (43.8)
Wealth quintile	
Poorest	4,582 (24.3)
Poorer	3,662 (19.4)
Middle	3,481 (18.5)
Richer	3,524 (18.7)
Richest	3,616 (19.2)
Mean family size	5.4 (2.1)
Family members ≥6	11,260 (50.7)
Mothers	
Mean age (years)	29.1 (6.1)
Mean length of schooling (years)[a]	8.5 (3.6)
Length of schooling ≤ 9 years[a]	17,610 (66.3)
Working	8,164 (43.3)
Fathers	
Mean age (years)	33.6 (7.1)
Mean length of schooling (years)[b]	8.7 (4.0)
Occupation[c]	
Not working	327 (1.7)
Agriculture self-employed	6,440 (34.1)
Services	2,560 (13.6)
Skilled manual	2,917 (15.5)
Sales	2,439 (12.9)
Others	4,173 (22.1)
Children	
Mean age (years)	1.7 (1.4)
Gender	
Boy	9,722 (51.5)
Girl	9,143 (48.5)
Adequately immunized[d]	
No	9,502 (50.4)
Yes	9,363 (49.6)
Vitamin A received last 6 mo[e]	
No	5,447 (28.9)
Yes	13,000 (68.9)

[a] Missing data n = 22

[b] Missing data n = 71

[c] Missing data n = 9

[d] Received complete immunization: BCG, DPT1-3, Polio1-3, and measles

[e] Missing data n = 418

regression was used to assess whether for any effect modification of child's age and mother's length of education category ($p < 0.05$, test homogeneity of the OR) against all three indices in the adjusted model. Finally, we performed stratification analyses on the child's age (<2 and ≥2 years) and length of mother's education (≤9 and >9 years) category as reported previously [32].

Population-attributable fractions (PAFs) for maternal factors that were associated with diarrhea and ARTIs were estimated as (proportion of cases exposed) × (OR − 1)/OR, where OR is for diarrhea compared with non-diarrhea.; and for ARTIs compared to non ARTIs [33].

This research was carried out in accord with current international ethical guidelines and principles. Ethical approval was not needed for the present analyses because data used in this study was obtained with permission from an open access data of MEASURE Demographic Health Survey [23, 24]. Moreover, the study was conducted on anonymous public use data without identifiable information on the surveyed subjects.

Results

Basic characteristics of respondents and their child are described in Table 2. More than half of the respondents resided in rural areas. The mean age of mothers is 29 years and the mean age of children is 1.7 years. Nearly half (43 %) of the mothers and children belonged to poor or poorest quintile families and half were from families consisting of at least six members. The mean age of the fathers was 34 years and they were mainly self-employed agricultural workers (36 %). Nearly half of mothers were working outside the home (43 %) and had ≤9 years of schooling (66 %).

All variables for distal and proximate factors listed in the model were significantly associated with diarrhea (Table 3) and with ARTIs, except for child age and gender. This includes the following variables resided in rural area, being poor, mother's schooling ≤9 years [32], mother's aged <29 years [34], overcrowding in the family ≥6 people [32], younger child and being a boy, not adequately immunized and received vitamin A supplementation.

Variables for the individual maternal factors and their factor loadings matrices from the PCA are presented in table 1. Using the eigenvalue cut-off as 1, most of loadings are >0.5 in only one component, indicating a simple structure and thus none of these variables warranted removal.

Some individual maternal factors were significantly protective for diarrhea in children, namely mothers' delivery at a medical institution and assisted by a health professional, no child ever died in the family, no feeding by mothers to child in the first 3 days of life and proper child's stool disposal, mothers decision (alone or with her husband) on: (1) visiting to family or friends, (2) large purchases, (3) daily purchases, and (4) their own health care

Table 3 Distal and proximal **r**isk factors associated with the prevalence of diarrhea and respiratory tract infection in children aged <5 years

Risk factors	Diarrhea (n = 18,865)			Respiratory infections (n = 5,994)		
	Cases	%	Unadjusted OR (95 % CI)	Cases	%	Unadjusted OR (95 % CI)
Type of residence						
Rural (ref)	1,387	13.1	1.00	1,193	34.4	1.00
Urban	935	11.3	0.85 (0.78–0.93)**	786	30.8	0.85 (0.76–0.94)*
Wealth quintile						
Poorest (ref)	655	14.3	1.00	617	39.5	1.00
Poorer	517	14.1	0.99 (0.87–1.12)	411	33.4	0.77 (0.67–0.90)*
Middle	416	11.9	0.81 (0.71–0.93)**	348	31.8	0.72 (0.61–0.84)**
Richer	416	11.8	0.80 (0.70–0.92)**	340	29.5	0.64 (0.55–0.76)**
Richest	319	8.8	0.58 (0.50–0.67)**	263	27.6	0.58 (0.49–0.70)**
Mother's length of schooling[c]						
≤9 years (ref)	1,593	13.4	1.00	623	34.9	1.00
>9 years	729	10.4	0.75 (0.69–0.83)**	1,356	29.6	0.78 (0.70–0.88)**
Mother's age[d]						
<29 years (ref)	1,233	13.1	1.00	1,056	34.2	1.00
≥29 years	1,090	11.5	0.86 (0.79–0.94)*	923	31.8	0.90 (0.81–1.00)
Family size[b]						
≥6 people (ref)	1,215	12.8	1.00	995	32.1	1.00
<6 people	1,108	11.8	0.91 (0.83–0.99)*	984	34.0	1.09 (0.98–1.21)
Children's age[b,f]						
<2 years (ref)	1,326	14.8	1.00	970	33.5	1.00
2–4 years	997	10.1	0.65 (0.60–0.71)**	1,009	32.5	0.96 (0.86–1.07)
Children gender						
Boy (ref)	1,243	12.8	1.00	1,065	34.0	1.00
Girl	1,080	11.8	0.91 (0.84–0.99)*	914	32.0	0.91 (0.82–1.02)
Children received immunization						
Not complete (ref)	1,303	13.7	1.00	1,108	35.5	1.00
Complete	1,020	10.9	0.77 (0.71–0.84)**	871	30.3	0.79 (0.71–0.88)**
Children received Vitamin A Supplementation						
No	626	11.5	1.00	538	33,7	1.00
Yes	1,641	12.6	1.11 (1.01–1.23)*	1,401	32.9	0.97 (0.85–1.09)

* Statistical significant at $p < 0.05$, X^2 test

** Statistical significant at $p < 0.001$, X^2 test

[a] Missing data n = 127

[b] The variable was dichotomized based on median value of the population. Categorized based on the findings of previous study that family size of ≥6 people was significantly associated with diarrhea [32]

[c] Maternal schooling ≤9 years (less or equal to junior high school) represents low education profile of mothers [32]

[d] The poor child health outcomes are minimized at age 29 for the infant mortality outcome [34]

[f] The ages from birth to 2 years are critical period for child growth and development, feeding behavior and infectious diseases [39–44]

and never justified domestic violence (Table 4). Individual factors protective for ARTIs were mother's aged >18 years at first birth, still breastfed or breastfed ≥6 months, proper child's stool disposal, and mother's decision on large purchases and never justified any domestic violence. The individual variables that were associated with increased risk of diarrhea were: visited health facility last 12 months and parity <2.6. Whereas, variables associated with increased ARTIs prevalence by <16 % were: mother receiving vitamin A 2 months after delivery and child frequently ate in a day.

Among the indices of maternal factors, mothers with higher levels of access to care tended to have insignificantly higher risk of diarrhea. High level of maternal access significantly decreased risk of experiencing ARTIs compared to mothers with lower levels (Adj OR 0.84, 95 % CI 0.72–0.99) (Table 5). Maternal practice and experience (moderate level) was significantly associated with a lower

Table 4 Distribution of diarrhea and acute respiratory tract infection prevalence by maternal determinant factors among children <5 years

Variables	Diarrhea (n = 18,865)				Respiratory infections (n = 5,994)			
	Cases	%	Unadjusted OR (95 % CI)	Adjusted[a,b] OR (95 % Cl)	Cases	%	Unadjusted OR (95 % CI)	Adjusted[a,c] OR (95 % Cl)
Mother's access to health care								
Visited health facility last 12 months	1,318	13.5	1.27 (1.16–1.38)**	1.27 (1.16–1.39)**	1,130	32.5	0.94 (0.85–1.05)	0.96 (0.86–1.08)
Did not have ≥4 big problem to health care	2,315	12,3	0.90 (0.40–2.00)	0.91 (0.41–2.02)	6	28.6	1.23 (0.48–3.18)	1.23 (0.47–3.20)
Had ≥3 antenatal care visit with 1 in the first 6 months	2,223	12.3	0.88 (0.71–1.09)	1.02 (0.81–1.28)	1,878	32.8	0.77 (0.59–0.99)*	0.92 (0.69–1.17)
Did not have unmet need for contraception	565	11.9	0.95 (0.86–1.06)	0.92 (0.82–1.02)	487	34.7	01.10 (0.97–1.25)	1.05 (0.92–1.19)
Delivered at medical institution and assisted by health professionals	1,690	11.6	0.77 (0.70–0.85)**	0.88 (0.79–0.98)*	1,429	31.6	0.78 (0.69–0.94)**	0.93 (0.81–1.06)
Received tetanus injection before marriage	1,295	11.9	0.91 (0.83–0.99)*	0.99 (0.90–1.08)	1,096	31.4	0.84 (0.75–0.93)*	0.90 (0.80–1.01)
Received vitamin A 2 months after delivery	1,097	12.2	0.99 (0.91–1.08)	1.01 (0.92–1.11)	976	33.6	1.05 (0.95–1.17)	1.12 (1.00–1.25)*
Knowledge of oral rehydration solution	2,202	12.3	0.92 (0.76–1.12)	1.11 (0.90–1.36)	1,868	32.8	0.82 (0.65–1.05)	0.95 (0.74–1.22)
Maternal practice and experience								
Mother's aged >18 years at first birth	1,706	11.9	0.86 (0.78–0.95)*	0.98 (0.88–1.10)	1,424	31.7	0.80 (0.71–0.90)**	0.87 (0.76–0.99)*
Parity <2.6 (2007 DHS fertility rate)	861	13.1	1.12 (1.02–1.22)	1.13 (1.00–1.28)*	725	34.4	1.10 (0.98–1.23)	1.11 (0.96–1.29)
Preceding birth interval >24 months	1,344	12.3	0.99 (0.91–1.08)	0.99 (0.89–1.10)	1,134	33.1	1.01 (0.91–1.13)	1.04 (0.91–1.19)
No child death in the family	2,062	12.1	0.79 (0.69–0.91)*	0.86 (0.74–0.99)*	1,758	32.7	0.89 (0.74–1.05)	0.94 (0.78–1.13)
Breastfed immediately (<1 h)	792	11.8	0.94 (0.85–1.03)	0.9 (0.86–1.03)	683	32.8	1.00 (0.89–1.12)	1.01 (0.90–1.13)
Still breastfed or breastfed ≥6 months	2,179	12.4	1.11 (0.93–1.33)	0.97 (0.81–1.17)	1,827	32.9	0.92 (0.75–1.12)	0.79 (0.64–0.97)*
Gave no feeding in first 3 days of child life	844	11.6	0.90 (0.82–0.98)*	0.85 (0.78–0.93)*	702	3026	0.97 (0.87–1.09)	0.94 (0.84–1.06)
Child eat ≥3 times a day	1,524	11.7	0.84 (0.77–0.93)**	0.97 (0.88–1.07)	1,375	33.6	1.08 (0.96–1.03)	1.16 (1.02–1.31)*
Child's stool disposed properly	1,617	11.4	0.73 (0.66–0.80)**	0.88 (0.79–0.98)*	1,385	31.0	0.70 (0.62–0.79)**	0.82 (0.72–0.93)*

Table 4 continued

Variables	Diarrhea (n = 18,865)				Respiratory infections (n = 5,994)			
	Cases	%	Unadjusted OR (95 % CI)	Adjusted[a,b] OR (95 % Cl)	Cases	%	Unadjusted OR (95 % CI)	Adjusted[a,c] OR (95 % Cl)
Maternal agency								
Mother decide alone or with husband on visits to family/friends	1,973	12.0	0.81 (0.71–0.91)*	0.84 (0.74–0.95)*	1,694	32.9	0.96 (0.82–1.12)	1.00 (0.86–1.18)
Respondent works	1,004	12.3	1.00 (0.91–1.09)	1.10 (1.00–1.21)	903	33.8	1.07 (0.96–1.19)	1.06 (0.95–1.19)
Couple decided on large purchases	1,800	11.9	0.82 (0.74–0.91)**	0.89 (0.80–0.99)*	1,483	32.0	0.82 (0.73–0.93)*	0.85 (0.74–0.96)*
Couple decided on daily purchases	2,160	12.1	0.71 (0.60–0.84)**	0.77 (0.64–0.92)*	1,843	32.7	0.81 (0.65–1.00)	0.83 (0.67–1.04)
Couple decided on food to be cooked that day	2,056	12.3	0.96 (0.83–1.10)	0.93 (0.81–1.07)	1,747	32.9	0.97 (0.82–1.15)	0.96 (0.81–1.14)
Mother decided on own health care	1,904	11.7	0.72 (0.64–0.80)**	0.75 (0.67–0.85)**	1,619	32.6	0.91 (0.79–1.04)	0.94 (0.81–1.09)
Couple desire for more children	1,831	12.2	0.93 (0.84–1.04)	0.93 (0.83–1.03)	1,581	33.3	1.06 (0.92–1.21)	1.06 (0.92–1.21)
Husband is living with mother	2,219	12.3	1.00 (0.81–1.23)	1.01 (0.81–1.25)	1,880	33.0	0.99 (0.77–1.27)	0.99 (0.77–1.27)
Never justified domestic violence	1,375	10.9	0.69 (0.63–0.76)**	0.74 (0.67–0.81)**	1,106	30.5	0.67 (0.67–0.84)**	0.80 (0.72–0.90)**
		Mean	SD	95 % CI		Mean	SD	95 % CI
Age difference		4.7	4.9	(4.5–4.9)		4.5	4.8	(4.3–4.7)
Education difference		3.2	6.5	(2.9–3.5)**		3.4	5.3	(3.2–3.6)**

* Statistical significant at $p < 0.05$, X^2 test

** Statistical significant at $p < 0.001$, X^2 test

[a] Adjusted for type of residence, wealth quintile, length of mother's schooling (continuous), mother's age (continuous), family size (continuous), child's age (continuous) and sex, immunization status and received vitamin A supplementation

[b] Included in the analysis, n = 18,447

[c] Included in the analysis, n = 5,859

risk of diarrhea (Adj OR 0.86, 95 % CI 0.75–0.98) (Table 5). On the contrary, high levels of maternal practices and experience was not associated with ARTIs in children. A high level of maternal agency was significantly protective against both diarrhea and ARTIs (Adj OR 0.68, 95 % CI 0.60–0.77); and (Adj OR 0.77, 95 % CI 0.66–0.91), respectively. Although data were derived from two survey periods (2002–2003 and 2007), findings were consistent between both periods as shown by a similar trend of ORs and CI at the same quartile of maternal agency (data not shown).

A significant interaction was identified between age category and the highest level of maternal practices and experiences on diarrhea prevalence ($\beta = -0.27$; $p = 0.04$) and between mother's length of education and the highest level of maternal access to health care ($\beta = -0.31$; $p = 0.02$). A significant interaction exists between child's age and low maternal practices and experiences; between maternal education and the second highest level of maternal access to health care, and between the lowest level of maternal practices and experiences, and agency on ARTIs prevalence. These interactions indicate differences in age and maternal education effects between levels of maternal practices and experiences on both diseases, and maternal education effects between levels of all three maternal indices on ARTIs. No significant interaction between child age, maternal education, and age/family size and maternal agency was observed for either diarrhea or ARTIs.

A stratified analysis by age showed a tendency that higher ratings on maternal factors indices were independently associated with lower diarrhea prevalence in

Table 5 Association between Maternal factors and child morbidity due to diarrhea and respiratory infections

Variables	All N (%)	Diarrhea (n = 18,865)				All N (%)	Respiratory infections (n = 5,994)			
		Cases	%	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)		Cases	%	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)
Mother's access to health care index										
Lowest (reference)	4,881 (25.9)	645	13.2	1.00	1.00	1,515 (25.3)	557	36.8	1.00	1.00
Low	4,355 (23.1)	487	11.2	0.83 (0.73–0.94)*	0.90 (0.79–1.02)	1,257 (21.0)	419	33.3	0.86 (0.74–1.01)	0.93 (0.79–1.09)
Moderate	4,688 (24.9)	568	12.1	0.91 (0.80–1.02)	1.04 (0.91–1.18)	1,509 (25.2)	497	32.9	0.85 (0.73–0.98)*	0.97 (0.82–1.14)
High	4,941 (26.2)	622	12.6	0.95 (0.84–1.06)	1.11 (0.98–1.27)	1,713 (28.6)	506	29.5	0.72 (0.62–0.84)**	0.84 (0.72–0.99)*
Maternal practices and experience index										
Lowest (reference)	5,219 (27.7)	694	13.3	1.00	1.00	1,679 (28.0)	549	32.7	1.00	1.00
Low	4,657 (24.7)	575	12.3	0.92 (0.82–1.03)	0.92 (0.81–1.04)	1,575 (25.3)	509	33.6	1.04 (0.90–1.21)	1.07 (0.92–1.10)
Moderate	4,792 (25.4)	550	11.5	0.85 (0.75–0.95)*	0.86 (0.75–0.98)*	1,504 (25.1)	483	32.1	0.97 (0.84–1.13)	1.02 (0.87–1.04)
High	4,197 (22.2)	503	12	0.89 (0.79–1.00)	0.91 (0.79–1.05)	1,296 (21.6)	438	33.8	1.05 (0.90–1.23)	1.14 (0.95–1.02)
Maternal agency index										
Lowest (reference)	4,532 (24.0)	696	15.4	1.00	1.00	1,720 (28.7)	613	35.6	1.00	1.00
Low	4,676 (24.8)	630	13.5	0.86 (0.76–0.96)*	0.87 (0.77–0.98)*	1,566 (26.1)	556	35.5	0.99 (0.86–1.15)	1.02 (0.88–1.18)
Moderate	4,785 (25.4)	519	10.8	0.67 (0.59–0.76)**	0.73 (0.64–0.83)**	1,397 (23.3)	443	31.7	0.84 (0.72–0.97)*	0.91 (0.78–1.06)
High	4,872 (25.8)	477	9.8	0.60 (0.53–0.68)**	0.68 (0.60–0.77)**	1,311 (21.9)	367	28.0	0.70 (0.60–0.82)**	0.77 (0.66–0.91)*

Indices were categorized into quartiles

* Statistical significant at $p < 0.05$, X^2 test. ** Statistical significant at $p < 0.001$, X^2 test[1]Adjusted for type of residence, wealth quintile, length of mother's schooling (continuous), mother's age (continuous), family size (continuous), child's age (continuous) and sex, immunization status and received vitamin A supplementation

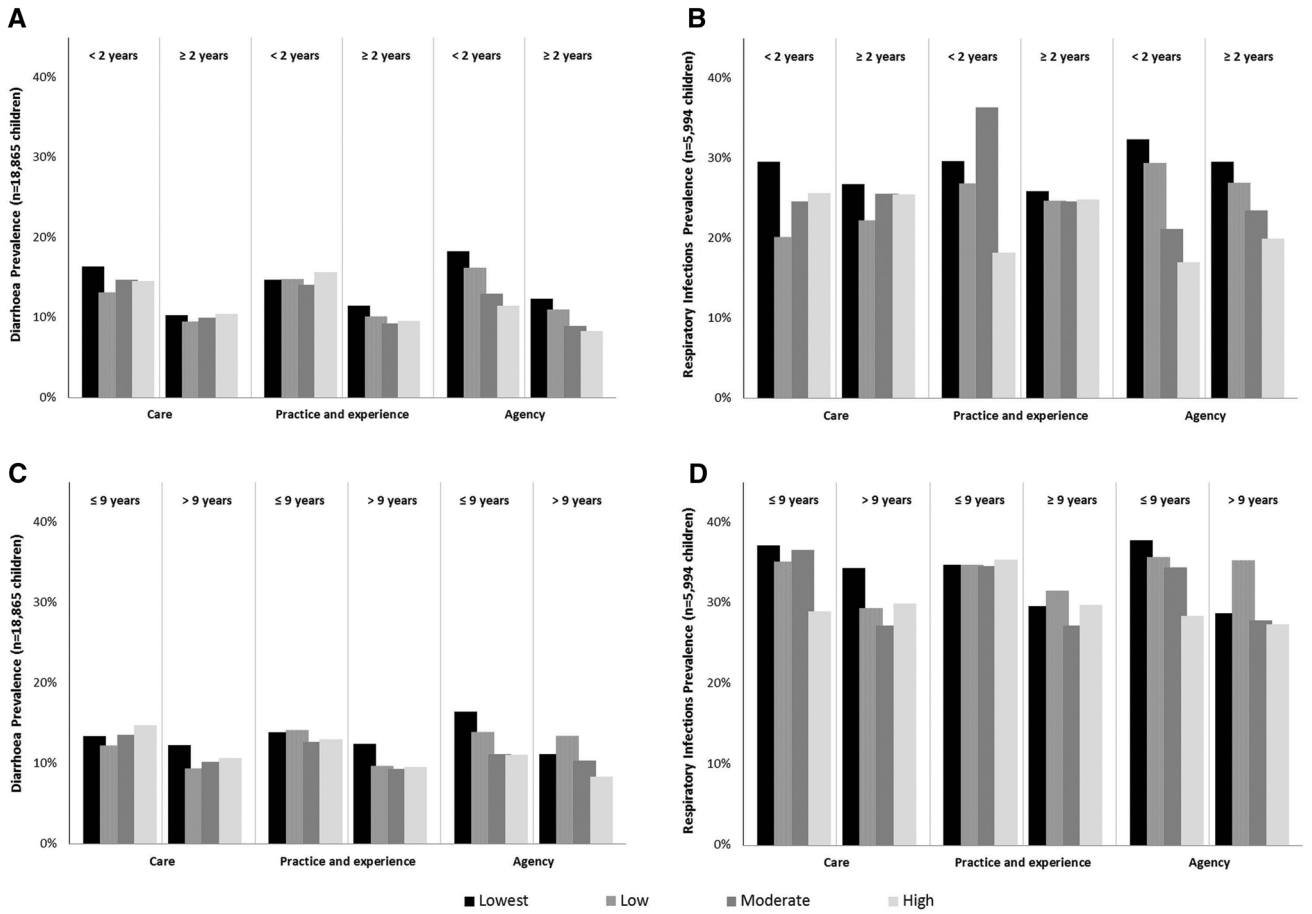

Fig. 2 Trend of various maternal factors affected diarrhea and acute respiratory tract infection in children in Indonesia according to child's age group differences: **a** diarrhea, and **b** respiratory infections; and length of mother education differences: **c** diarrhea and **d** respiratory infections

children <2 years, especially for maternal agency indices (Fig. 2a, b). Stratification on the length of mother's education showed a strong effect of maternal agency independent of the education level of mother (Fig. 2c). Even in the highest level of education, the strong effect of maternal agency on diarrhea and ARTIs persisted (Fig. 2c, d).

The PAF of overall distal factors (type of residence, maternal education and age, and socioeconomic status) represented a total of 19 % of diarrhea and 32 % of ARTIs burden among children (Fig. 3). The PAF for socioeconomic variables comprised the largest proportions contributing to diarrhea (16 %) and ARTIs (25 %). The PAF of maternal factors (intermediate factors) represented a total of 15 % of diarrhea and 40 % of ARTIs burden. Among maternal factors, maternal agency was the most influential factor on the occurrence of diarrhea (8 %) and ARTIs (21 %). The total contribution of risk from the proximate factors (family size, child age and sex, immunization and vitamin A) was 13 % for both diarrhea and ARTIs prevalence. Finally, child age <2 years and vitamin A supplementation contributed to about 5 % of the diarrhea burden, and incomplete immunization affected the risk of having ARTIs by 5 %.

Discussion

This study indicates that maternal agency provides substantial protection against both diarrhea and ARTIs, especially in children aged <2 years. Moreover, this protection is independent of other factors known to be associated with these illnesses, including maternal age and education, and family size. We also observed that higher maternal practice and experience reduced the risk of diarrhea in children of more educated mothers. In addition, high maternal access to health care, particularly in low educated mothers, reduced the risk of ARTIs in all children.

Our findings indicate lower morbidity in children of mothers who (alone or jointly with her husband) have a critical role related to household mobility and decision making, notably the final say on visits to family or relatives and large and daily households purchases. This influence is

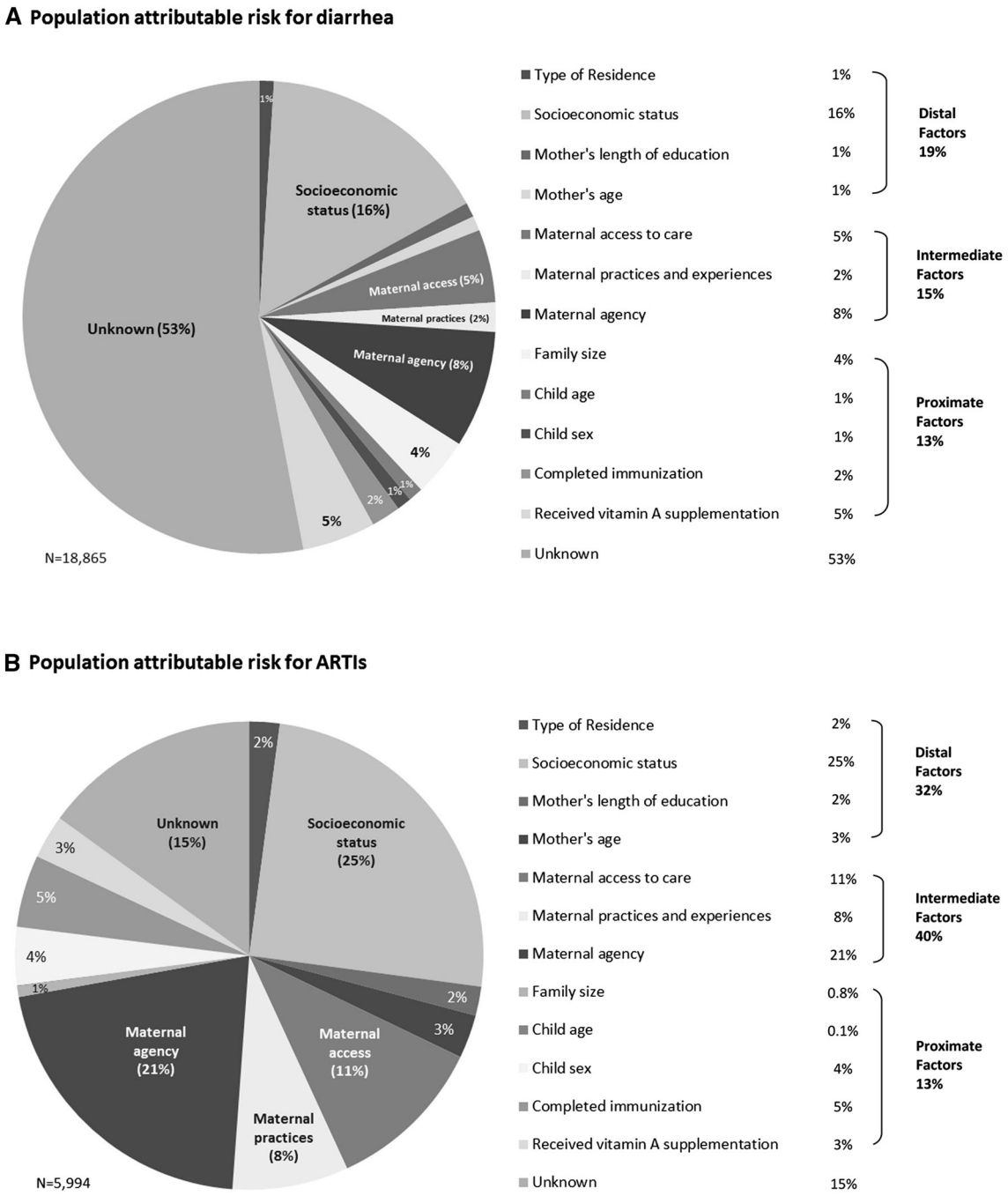

Fig. 3 Population attributable fraction derived from the multivariate logistic regression on the risk factors for **a** diarrhea and **b** acute respiratory infection

also seen when mothers decide themselves about their own health care and had the specific attitude of not accepting any degree of domestic violence. Others have reported that women's decision-making power or control over resources has an important influence on dietary diversity [35]. Diet diversity is found to have a strong links with nutritional outcomes [36, 37] and nutritional status is interrelated with childhood infections. In comparison, a study in rural India indicated that mothers with higher participation in decision-making in households had less underweight and wasted infants [38]. Women with autonomy regarding their own health might have more ability to safeguard their children's health as well, while mothers experiencing domestic abuse are less able to protect themselves and their children [35]. In Bangladesh, the influence of attitudes toward domestic violence on diarrhea was mediated

through the strong association between this attitude and better child nutritional outcomes [35]. The effects of maternal agency are more obvious in mothers with children under 2 years of age and persisted even when mothers had higher education. The protective effect of high level of maternal agency on diarrhea prevalence exhibited in the present study is consistent with previous similar study among mothers and children in Bolivia [16].

We observed that in children under 2 years of age, higher levels of maternal agency reduced the risk of diarrhea and ARTIs independent of mother's education and age and family size. Children aged <2 years are generally more vulnerable to infections including diarrhea and respiratory infection as supported by previous studies in developing countries [39, 40]. In the Indonesian context, the ages from birth to 2 years are critical, especially due to low rate of early initiation and exclusive breastfeeding, and inappropriate complementary feeding practices. WHO recommends that infants are exclusively breastfed for the first 6 months of life because early initiation and exclusive breastfeeding are associated with decreased morbidity of infectious illness [41, 42]. However, only 34.5 % of newborns in Indonesia received breast milk within the first hour after birth and the proportions of exclusive breastfeeding 0–6 months (38 %) were low [43]. This age group (6–24 months) is in the period of weaning and may be exposed to foods prepared under unhygienic conditions or contaminated with pathogens [44]. The higher level of maternal agency may allow mothers to act more effectively in ways that reduce risk of exposure of children to contaminated foods.

We observed that maternal access to care and maternal practices and experience are not as influential as maternal agency to child morbidity. Maternal agency might contribute to a child's life and have long-lasting effects and a daily impact [16], whereas maternal access to care and maternal practice and experiences may be more restricted to short term or temporary effects [16].

We found that visiting health facility in the past 12 months is strongly linked with an increased risk of diarrhea in children, in line with findings from Bolivia [16], likely due to the increase risk of contact with diarrhea patients at the health center [33] or reverse causality. The importance of maternal education in the utilization of health care services that influenced ARTIs prevalence has been well described [45]. It has also been reported that the risk of diarrhea in children is reduced when mothers deliver at medical institutions and are assisted by health professionals, likely due to the association of delivery practices with ante-natal care used before delivery leading to a better knowledge, attitude and practices for child health.

Among the individual factors of maternal practices and experiences the following are protective for diarrhea: [1] no history of child death in the family, [2] no feeding by mothers to the child in the first 3 days of life, and [3] proper disposal of the child's stool. These findings are consistent with results of a previous study from Bolivia [16]. The positive effect of child's stool disposal is supported by some evidences that interventions to improve excreta disposal are known to be effective in preventing diarrheal disease [46].

For the risk of ARTIs, the factors of mother's age >18 years at first birth, still breastfed or breastfed ≥6 months, and proper child's stool disposal provide protective effects. Breastfeeding is well known as a maternal factor protecting children against both diarrhea and ARTIs [16, 17]. Our findings also suggest that receiving postpartum maternal vitamin A supplementation increased the risk of ARTIs in Indonesian children. This finding is in agreement with a meta-analysis of studies conducted in developing countries (2003) indicating that vitamin A supplementation slightly increased the incidence of respiratory tract infections [47]. A recent study did not find any additional benefits of this intervention in reducing illness in children aged <6 months in Brazil [48].

Our present study shows that socioeconomic factors are responsible for the highest proportion of both diarrhea and ARTIs burden, a finding similar to that reported in Brazil [33]. Maternal agency contributed to the highest population risk fraction compared to other maternal factors. However, the importance of maternal access to health care and maternal practices and experiences should not be neglected because both factors contributed 7 % of the total burden of diarrhea and 19 % of ARTIs. We observed a high proportion of unknown factors in the PAF, especially on diarrhea prevalence, potentially reflecting the fact that some contributing factors might not have been assessed in the logistic models such as mother's and child's health and nutritional status, nutrient intake, and environment exposures for both risk of diarrhea and ARTIs, low birth weight and smoking behavior of parents for risk of ARTIs [49].

The major strength of our study is its focus on multidimensional maternal factors that influence the morbidity of children in a developing country. Few studies have comprehensively investigated the influence of maternal factors representing health (maternal access to care, maternal behaviors and experience), and non-health aspects (maternal agency) on child health. The main limitation of this study, similar to that found by Caruso et al., is that the variables selected for the indices were limited to data available in the DHS with not enough variables about mother's health status to create a maternal health index, which was found to be important in many studies. In addition, the design of DHS in reporting diarrhea and ARTIs is prone to recall bias. Thus, a prospective study

would be ideal to find causal relationships between maternal factors and child diseases outcomes.

Interventions that focus directly on increasing the level of maternal agency are needed, especially for mothers with children <2 years. More research to understand how to facilitate mother's agency that may affect child morbidity and mortality is needed. In addition, interventions to improving maternal access to child health care services and practices should be targeted towards low-educated mothers. Future studies should evaluate whether the effect shown by maternal agency, maternal access to care, practices and experiences are consistent across low income countries with the greatest disease burdens.

In conclusion, a high level of maternal agency may protect children against diarrhea and ARTIs, especially among children under 2 years of age. The results of the present study will be useful in designing a prevention strategies, health plans and policies related to child morbidity by empowering mothers in Indonesia and other developing countries.

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