Hand-Washing, Subclinical Infections, and Growth: A Longitudinal Evaluation of an Intervention in Nepali Slums

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AMERICAN JOURNAL OF HUMAN BIOLOGY 23:621–629 (2011)

Umezaki M, 28 Nov 2011

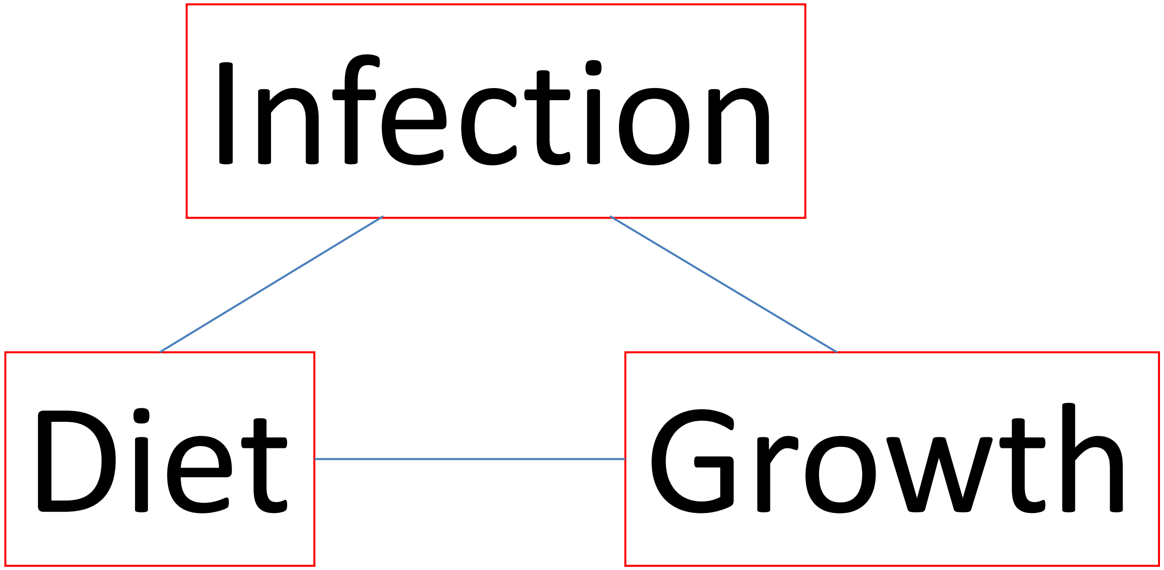
Objective: We conducted a longitudinal study to assess the impact of a hand-washing intervention on growth and biomarkers of child health in Nepali slums. This is the first study to evaluate the impact of hand-washing on markers of subclinical, asymptomatic infections associated with childhood growth faltering.

Methods: We recruited a total sample of infants in the target age-range (3–12 months) living in the eight largest Kathmandu slums, allocating them to intervention (n = 45) and control (n = 43) groups. In intervention areas, a smallscale community-based hand-washing program was implemented for six months; in control areas, mothers continued their normal practices. Time series linear regression was used to assess the impact of the intervention on levels of morbidity, mucosal damage, immune stimulation and growth.

Results: As expected, children with higher levels of mucosal damage exhibited worse growth over the period of the intervention (P = 0.01, <0.001 and 0.03 for height-for-age, weight-for-age, and weight-for-height z-scores, respectively). We observed a 41% reduction in diarrheal morbidity (P = 0.023) for the intervention group relative to control. However, the hand-washing intervention did not lower levels of mucosal damage or immune stimulation, nor slow growth faltering.

Conclusions: Reducing exposure to pathogens is an important global health priority. This study confirms the importance of hand-washing campaigns for reducing childhood morbidity. Yet our data suggest that promoting hand-washing is necessary but not sufficient to address chronic, subclinical infections. From a human biology standpoint, tackling the root causes of childhood infections is needed to address growth faltering in the context of highly contaminated slum environments.

“Healthy children grow well; sick children do not”



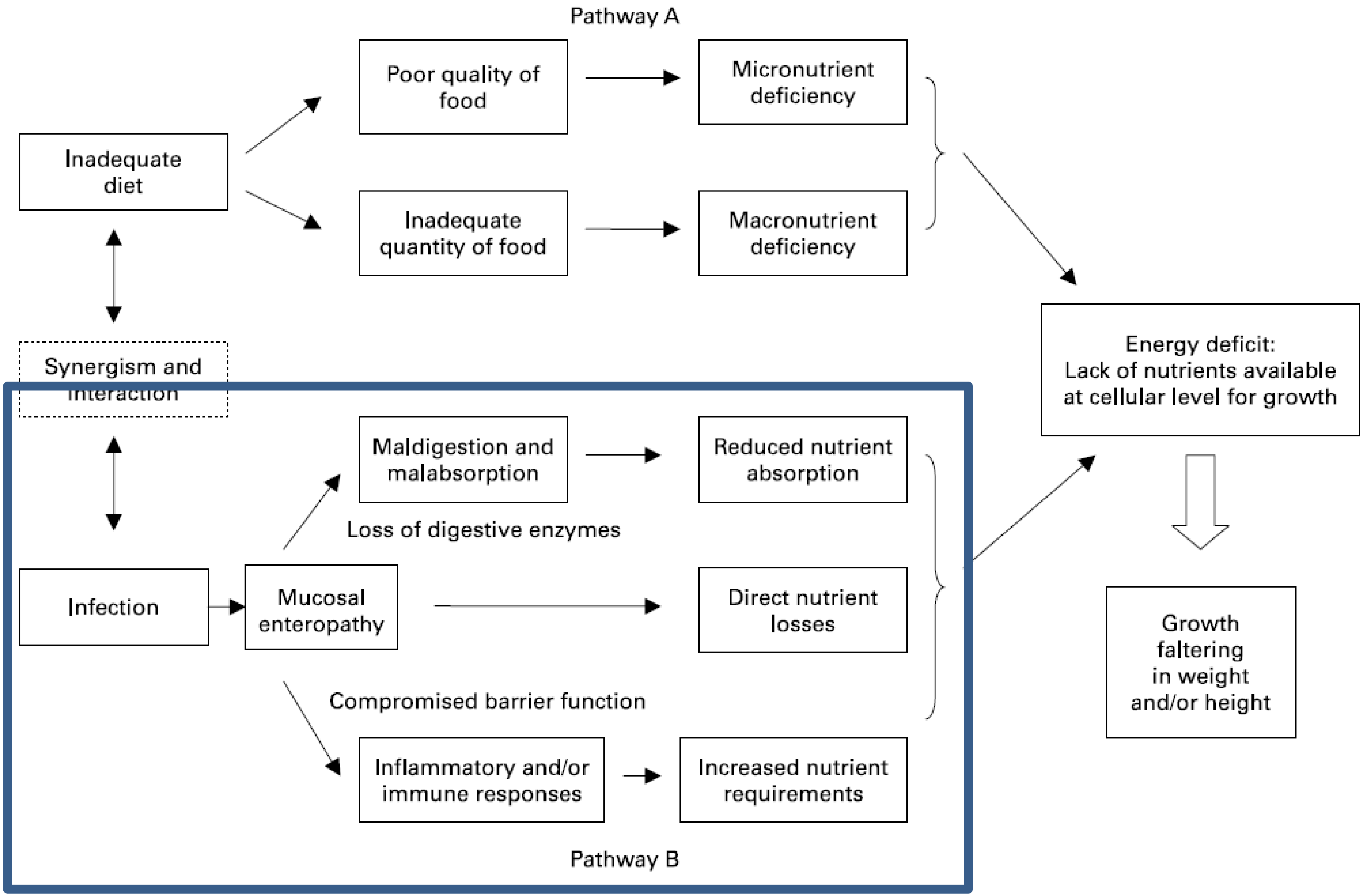
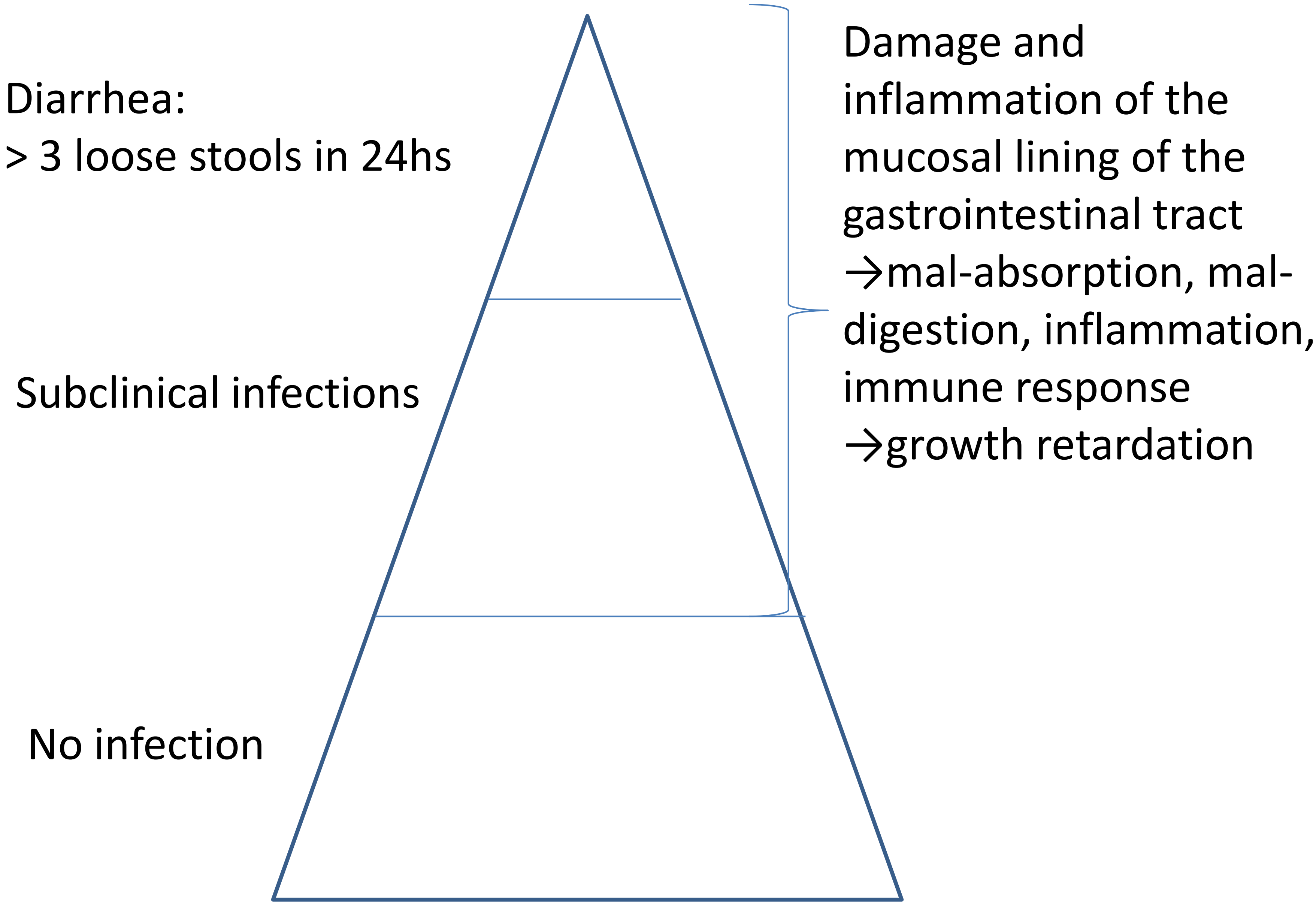


Fig. 1. A model of two pathways leading to childhood growth faltering.

Panter-Brick et al. (2009) BJN, 101.


Diarrhea:
> 3 loose stools in 24hs
Subclinical infections
No infection
Damage and inflammation of the mucosal lining of the gastrointestinal tract
→mal-absorption, mal-digestion, inflammation, immune response
→growth retardation

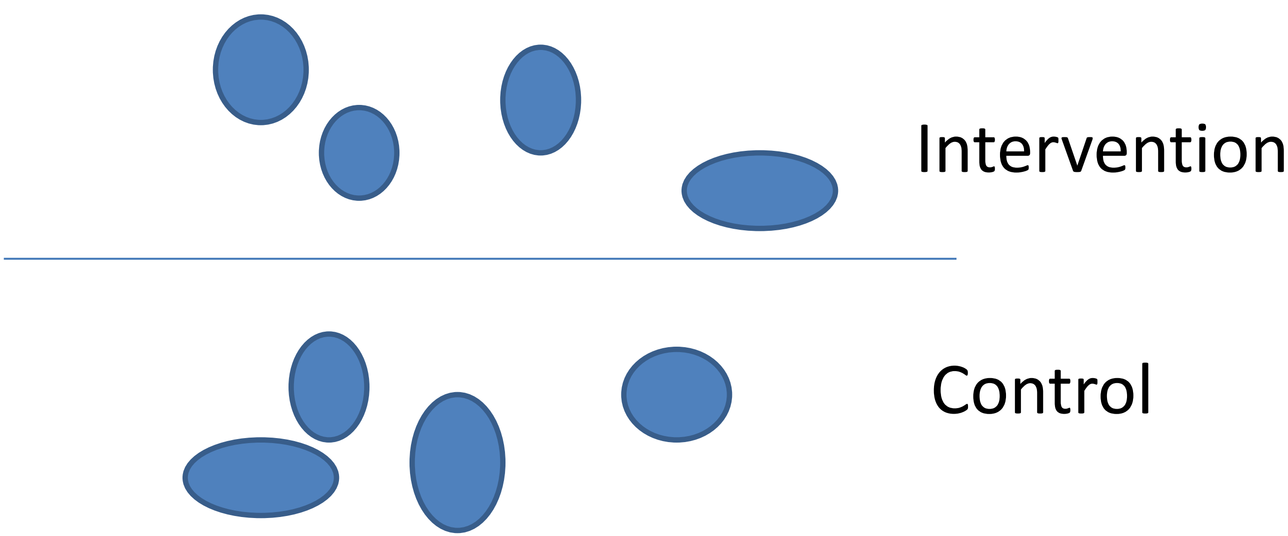
Impact study of behavioral intervention

Hand-washing with soap:
(Rabie and Curtis, 2006)

Clinical morbidity
Mucosal damage
Immune stimulation
Growth faltering

Study design

- 3-12 month old children in 8 slum settlements in Nepal
- Target sample size 100, 88 analyzed
- 8 settlements (4 cases and 4 controls)



Data collection

- Demographic and SES variables
- Hand-washing behaviors (before/after intervention)
  - Direct observation (n=75) for 3 h from 6 AM
  - Questionnaire

(1) after toilet
(2) After cleaning the baby's bottom
(3) Before cooking
(4) Before feeding the baby
(5) Before eating foods

Hand washing intervention

- In-depth interview + FGDs
- Community meeting in each area

    *education, discussion, short play

  Daily visits for 2 wks

  ～1 or 2 visits/week for 6 months

  Meeting/2wks + new soap

Health measures

- Six months from May 2007 (launch)

- Monthly: mucosal damage, immune stimulation, growth
- Weekly: Mobidity

Subclinical infection

Mucosal damage= Lactose: creatinine urinary test (Panter-brick et al., 2009) ↑

Lactose from breast milk → hydrolyzed by lactase

Immune stimulation= AGP (α-1-acid glycoprotein) and IgG on DBSs ↑

Whatman 903

Hb and albumin

Results

TABLE 1. Household demographic and socio-economic characteristics of control and intervention groups

Households	All (n = 88)	Control (n = 43)	Intervention (n = 45)	P
Age of child (months)				
Mean	7.6	7.5	7.7	0.72
SD	2.4	2.5	2.3	
Sex of child %				
Male	48.0	46.5	48.9	0.50
Female	52.0	53.5	51.1	
Maternal education %				
None	53.4	51.1	55.6	0.91
Primary	18.2	18.6	17.8	
Secondary+	28.4	30.2	26.6	
Paternal education %				
None	27.3	25.6	28.9	0.08
Primary	20.5	11.6	28.9	
Secondary+	52.2	62.8	42.2	
Tenure %	54.5	53.5	55.6	
Own house	54.5	53.5	55.6	0.51
Rent house	45.5	46.5	44.4	
Rooms in house %				
One room	56.8	44.2	68.9	0.02
Two+ rooms	43.2	55.8	31.3	
Toilet %				
Own	18.2	16.3	20.0	0.43
Shared/Public	81.8	83.7	80.0	
Fuel type %				
Firewood	35.6	23.3	67.7	0.02
Kerosene	34.5	34.9	34.1	
Gas	29.9	41.9	18.2	
Income per month (Rs)				
Median	4500	4500	4000	0.65
IQ range	3,000–6,300	3,000–7,200	3,000–5,300	
Possessions				
Median	2	2	1	0.14
IQ range	1–3	1–3	1–3	
SES Score				
Median	5	6	5	0.08
IQ range	3–9	4–10	3–7.5	

P from χ^2 test, two-tailed t-tests, or Mann-Whitney U tests.

Intervention G

↓

Crowded

Firewood

TABLE 2. Changes in mothers' reported hand-washing practices over the six month intervention period

Hand-washing junctures	Baseline			Endline			Change in HW from baseline to endline (*P* value)[b]	
	Control ($n = 43$)	Intervention ($n = 45$)	Group differences (*P* value)[a]	Control ($n = 43$)	Intervention ($n = 45$)	Group differences (*P* value)[a]	Control	Intervention
1. After visiting toilet	95.2	95.5	0.674	90.7	100	0.053	0.625	0.500
2. After cleaning baby's bottom	76.2	86.4	0.175	83.7	100	0.005	0.549	0.031
3. Before cooking	10.3	13.6	0.449	2.3	71.1	<.001	0.125	<0.001
4. Before feeding	17.6	33.3	0.104	18.6	62.2	<.001	0.500	0.004
5. Before eating	4.8	22.7	0.016	0	60	<.001	0.100	0.003

[a] χ^2 tests.
[b] McNemar's test.

Intervention → hand washing with soap (reported) ↑

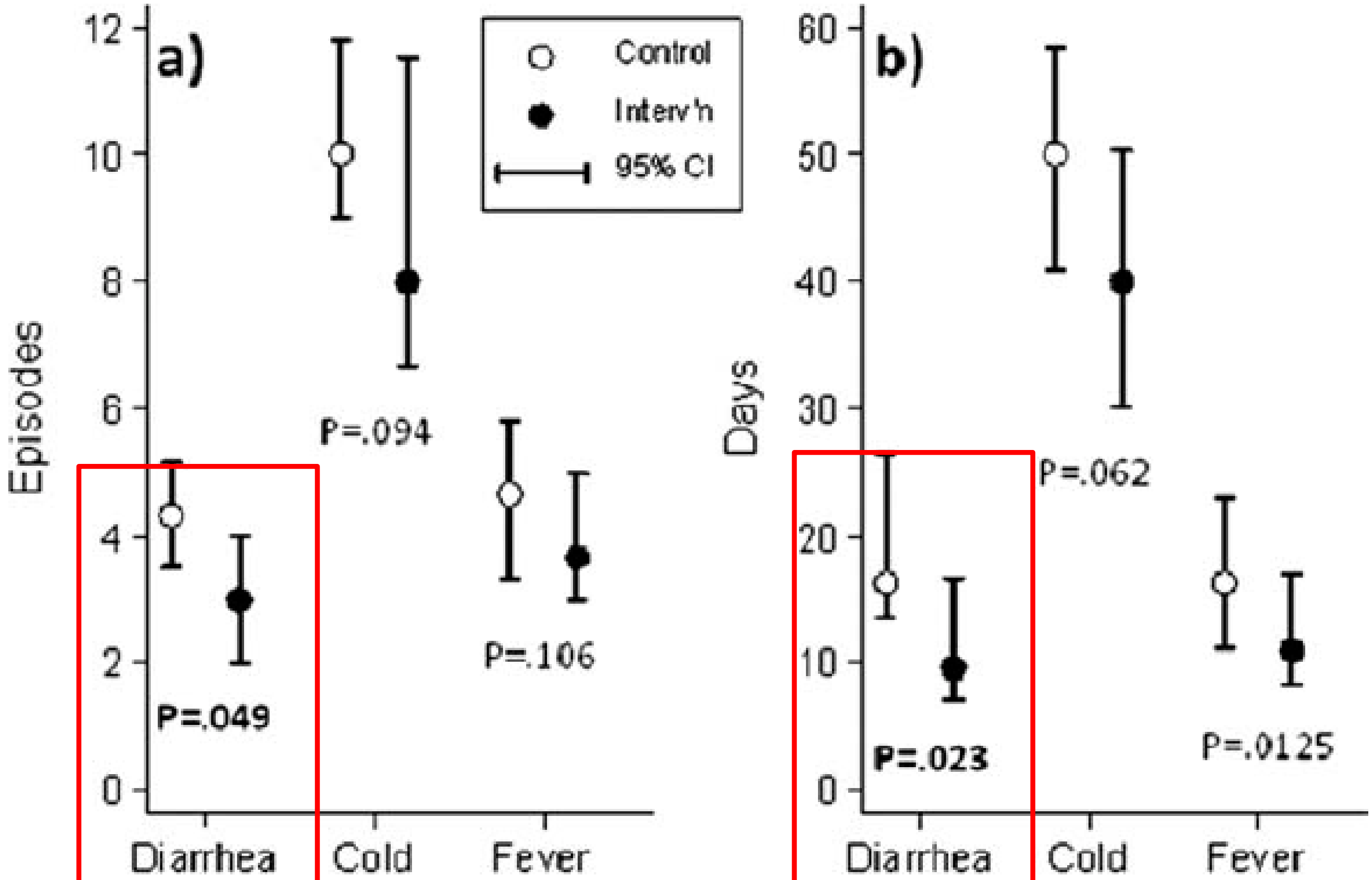


Fig. 1. (a,b) Impact of hand-washing on child morbidity (episodes and days of sickness) over six month intervention period. Circles indicate median values.

Intervention → Diarrhea ↓

TABLE 3. Associations between biochemical and growth variables (n = 88)

	Predictor	Coef.	Std. Err.	*P*	95% CI	Rho
IgG	Age	0.448	0.033	<0.001	(0.384, 0.512)	0.459
	AGP	1.598	0.215	<0.001	(1.177, 2.018)	
	Alb	0.130	0.011	<0.001	(0.109, 0.151)	
	Hb	0.015	0.009	0.101	(−0.003, 0.034)	
	Constant	−4.839	0.979	<0.001	(−6.757, −2.921)	
AGP	Age	−0.012	0.006	0.041	(−0.023, 0.000)	0.092
	IgG	0.043	0.006	<0.001	(0.030, 0.050)	
	L:C	1.036	0.540	0.055	(−0.023, 2.095)	
	Alb	0.000	0.002	0.964	(−0.004, 0.004)	
	Constant	0.287	0.201	0.153	(−0.107, 0.681)	
Albumin	Age	−0.022	0.109	0.839	(−0.235, 0.191)	0.121
	Hb	0.213	0.031	<0.001	(0.153, 0.272)	
	Constant	11.696	3.395	0.001	(5.042, 18.350)	
HAZ	Age	−0.093	0.006	<0.001	(−0.104, −0.082)	0.945
	L:C	−1.162	0.452	0.010	(−2.049, −0.276)	
	IgG	−0.011	0.005	0.029	(−0.021, −0.001)	
	Constant	−0.047	0.191	0.805	(−0.422, 0.328)	
WAZ	Age	−0.159	0.006	<0.001	(−0.170, −0.147)	0.939
	L:C	−1.932	0.525	<0.001	(−2.960, −0.904)	
	AGP	−0.219	0.036	<0.001	(−0.289, −0.149)	
	Alb	0.006	0.002	0.001	(0.003, 0.009)	
	Constant	0.739	0.224	0.001	(0.300, 1.178)	
WHZ	Age	−0.081	0.008	<0.001	(−0.096. −0.066)	0.844
	L:C	−1.499	0.705	0.034	(−2.881, −0.117)	
	AGP	−0.251	0.048	<0.001	(−0.346, −0.157)	
	Alb	0.007	0.002	0.002	(0.002, 0.012)	
	Constant	1.163	0.277	<0.001	(0.619, 1.707)	

Time series linear regression analysis. Rho = between-subject variability explained by the model. Only significant models ($P < 0.05$) are presented.

Mucosal damage

→ HAZ, WAZ, WHZ ↓

Immune stimulation

→ HAZ, WAZ, WHZ ↓

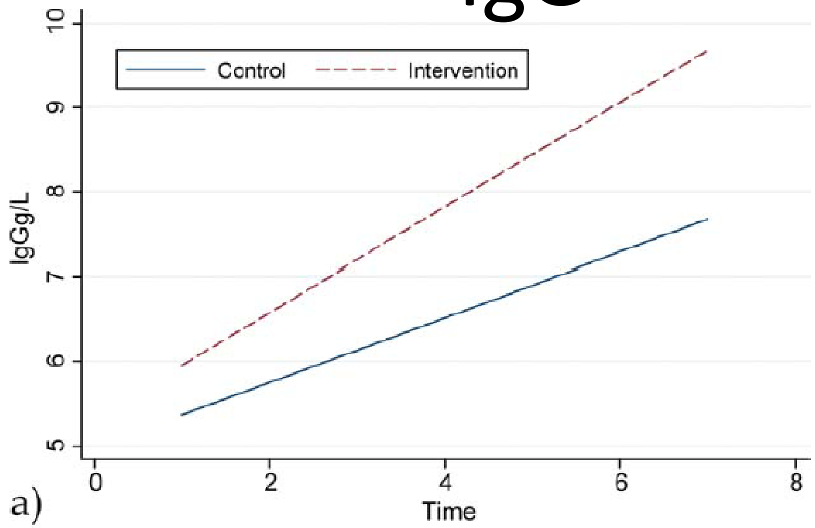
TABLE 4. Impact of hand-washing on biochemical and growth variables (n = 88)

	Predictor	Coef.	Std. Err.	*P*	95% CI	Rho
IgG	IgG (baseline)	0.463	0.060	<0.001	(0.345, 0.582)	0.178
	Age (baseline)	0.108	0.056	0.054	(−0.002, 0.218)	
	Group	−0.235	0.397	0.555	(−1.013. 0.544)	
	Time	0.384	0.055	<0.001	(0.277, 0.491)	
	Time*group	0.237	0.077	0.002	(0.087, 0.387)	
	Constant	1.349	0.514	0.009	(0.341, 2.357)	
WAZ	Age (baseline)	−0.263	0.045	<0.001	(−0.352, −0.175)	0.932
	Group	−0.068	0.219	0.755	(−0.497, 0.361)	
	Time	−0.122	0.008	<0.001	(−0.137, −0.107)	
	Time*group	−0.027	0.011	0.012	(−0.049, −0.006)	
	Constant	1.065	0.374	0.004	(0.333, 1.798)	
WHZ	Age (baseline)	−0.225	0.034	<0.001	(−0.292, −0.158)	0.814
	Group	0.241	0.172	0.162	(−0.097, 0.579)	
	Time	−0.045	0.010	<0.001	(−0.065, −0.024)	
	Time*group	−0.034	0.014	0.019	(−0.062, −0.006)	
	Constant	1.699	0.285	<0.001	(1.140, 2.258)	

Time series linear regression analysis, controlling for baseline differences between groups where appropriate. Rho = between-subject variability explained by the model. Only significant models ($P < 0.05$) are presented.

No impact of intervention on mucosal damage

IgG



WHZ

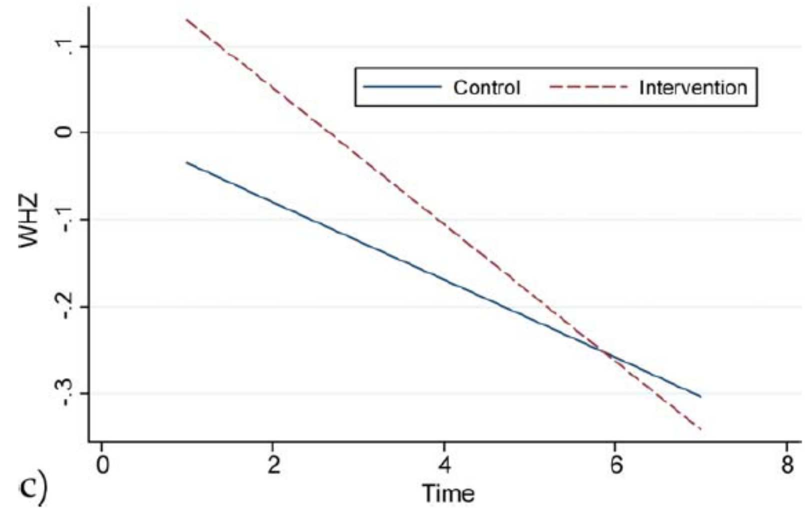
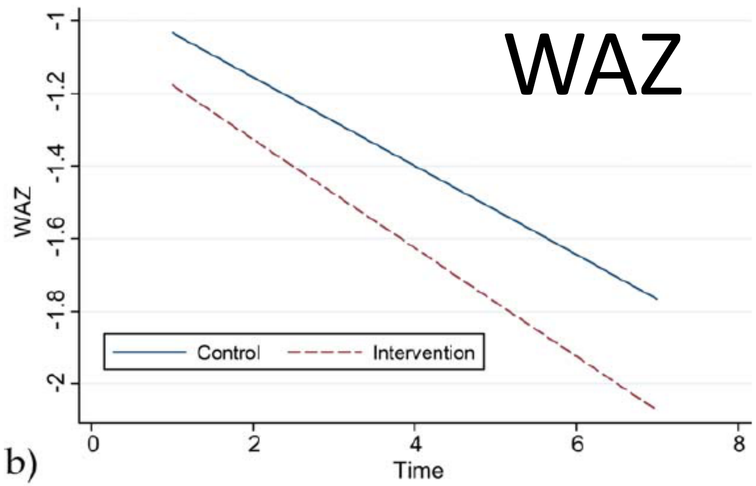


Fig. 2. Changes in IgG, WAZ and WHZ over the six month intervention. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

WAZ



Bad impact
of Intervention？

Findings

Hand washing intervention

→ behavioral changes (reported)

→ diarrhea ↓

→ subclinical infection (mucosal damage, immune stimulation) NS

→ Growth NS

[Interpretation]

Hand washing can reduce severe forms of infection, but not sub clinical (often chronic) forms of infection.

Points that should be considered

- Small sample size.
- Observation period
- Slum children who have numerous chances of infection (contaminated foods/water, poor quality and over-crowded houses etc). A *Giardia* study by Goto et al. (2008, 2009) in BGD. → Behaviors and Environment.

Unexpected negative impact of intervention

SES difference between Intervention group and control group? Intervention group was “over crowded” and “poor” at baseline?

Heterogeneity in slums

CONCLUSION

Hand-washing is a highly effective means of reducing diarrhea in young children; indeed, so effective that it has been promoted as a "do-it-yourself" vaccine against childhood infections (Curtis et al., 2005). However, the results from our preliminary study suggest that its impact on the more subtle, yet often chronic, forms of infection may be limited. For children living in highly contaminated, overcrowded environments, with poor access to clean water and sanitation, hand-washing may be necessary, *but not sufficient* to reduce levels of subclinical mucosal damage and immune stimulation that are strongly associated with growth faltering.

From the standpoint of human biology and health, what are needed are comprehensive, structural interventions that address the root causes of these infections—poverty and poor living conditions. Focusing attention solely on hygiene interventions that target individual behaviors, in the context of recurrent infections in slum environments and in the absence of improvements to wider living conditions, may have limited global and local health impacts.