

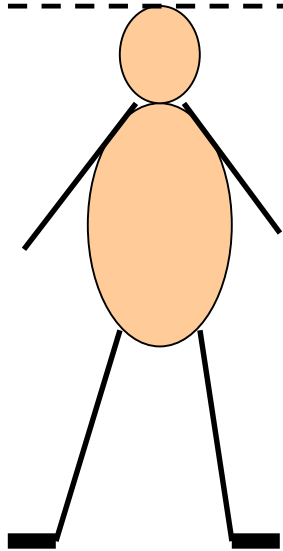
# WASH Benefits: Rationale & Bangladesh Summary Outcomes

Steve Luby, MD

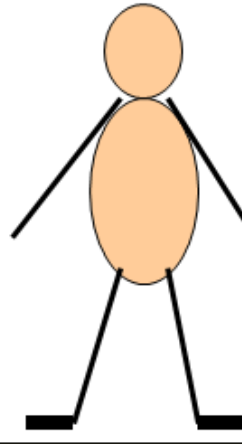
World Water Week  
Stockholm  
30 August 2018



*Normal height for age*



**Normal**

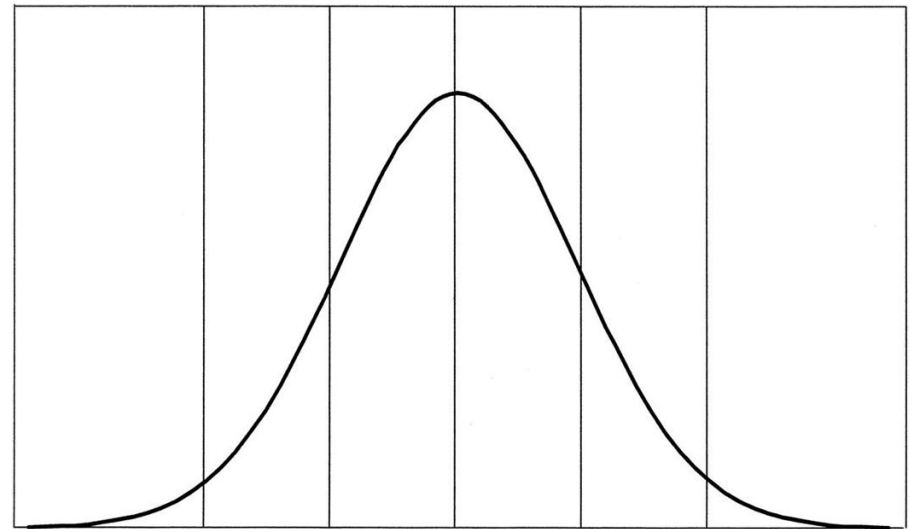


**Stunted**  
Low height for age

HAZ

Percentile

2      16      50      84      98



-2      -1      0      1      2

z Score

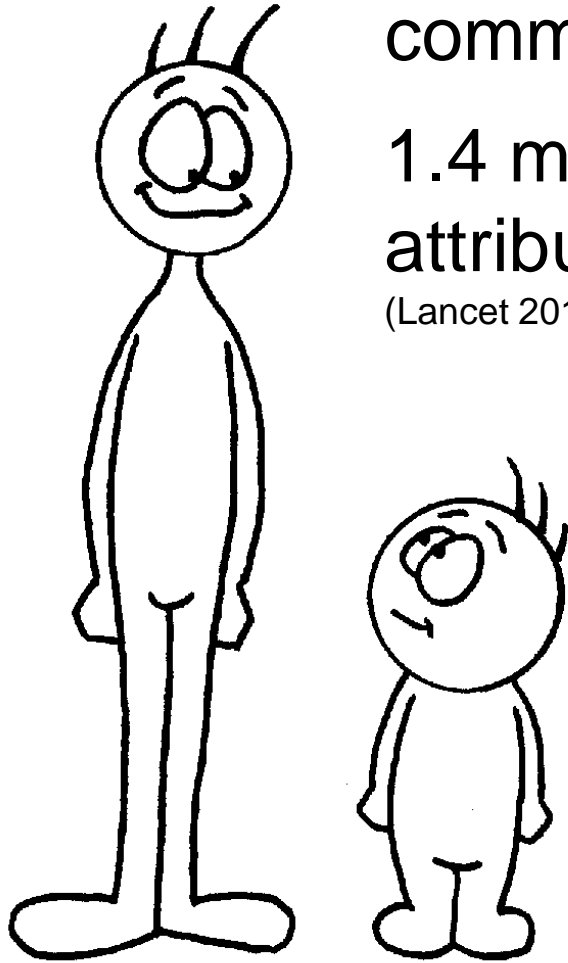
Children

# Why worry about stunting?

>2.5% prevalence of short stature in a community, suggests chronic under-nutrition

1.4 million child deaths annually attributable to undernutrition.

(Lancet 2012; 380: 2224–60)



**Guatemala trial follow-up** (*Am J Clin Nutr* 2013;98:1170–8.)

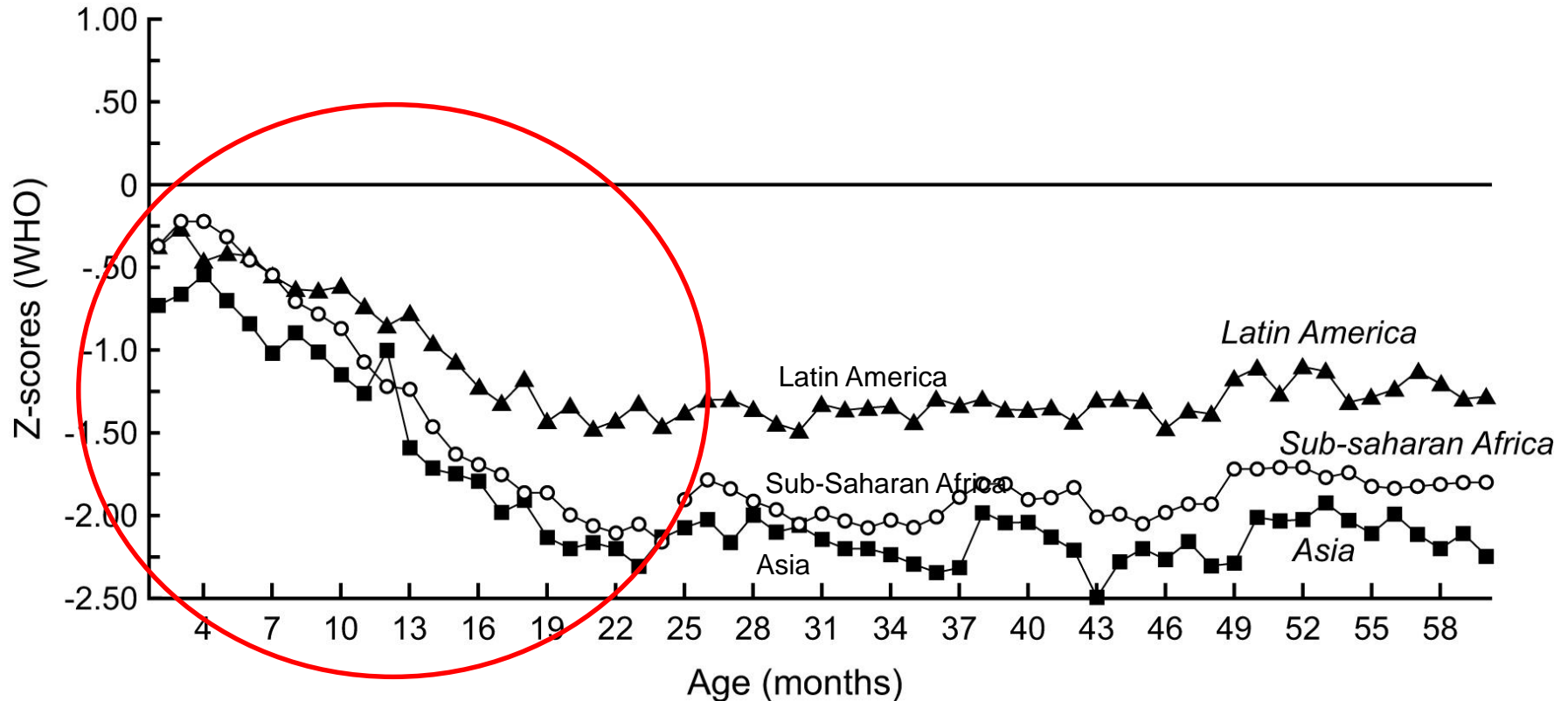
**1 SD increase in height at 2 years:**

- 0.78 more years in school
- 21% higher adult income

**Malnourished children face:**

- cognitive impairment
- less success in school
- decreased wages

# Critical period for growth faltering



# If children are malnourished

- Feed them more
  - But more calories are insufficient
  - need nutrient dense food
- Supplement with nutrient dense foods
  - only correct 15-30% of growth faltering  
(Dewey K. *Matern Child Nutr* 2008, 4 Suppl 1: 24--85 )

Photo: Mubina Agboatwalla



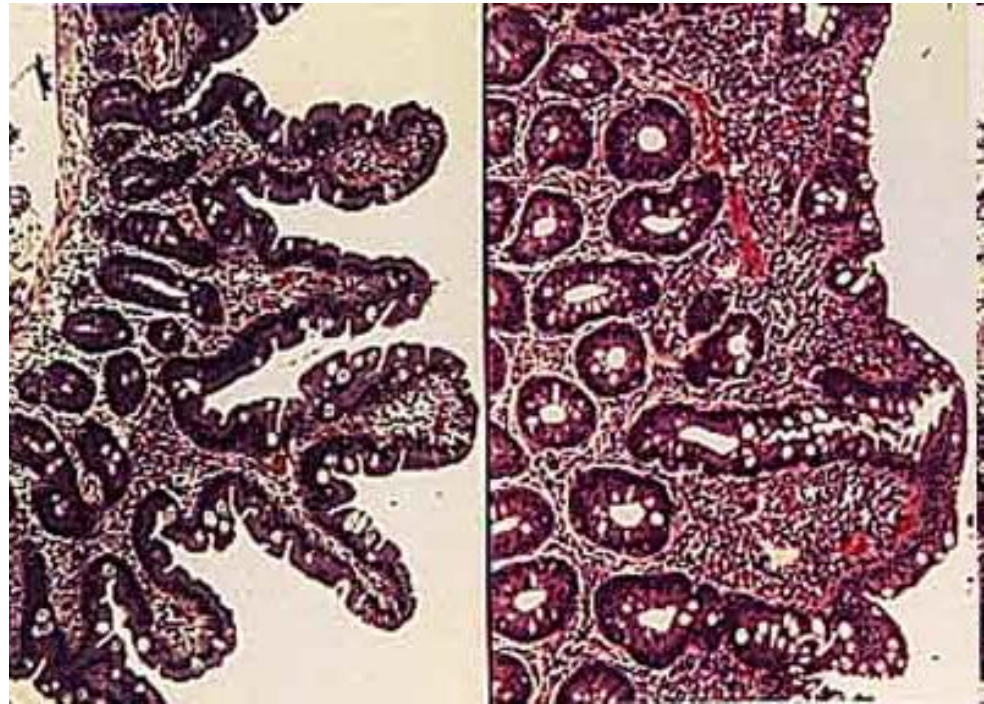
- 118 Kcal
- 9.6 gm fat
- 2.6 gm protein
- $\geq 100\%$  RDA of 12 vitamins
- 9 minerals



# Potential contributor to stunting

Environmental Enteropathy  
Environmental Enteric Dysfunction

- Change in intestinal villa architecture
- Inflammatory cell infiltration



**Normal**

**Environmental Enteropathy**

<http://www.bio.davidson.edu/courses/Immunology/Students/spring2006/Mohr/Villi%20Atrophy.jpg>

# Epidemiology

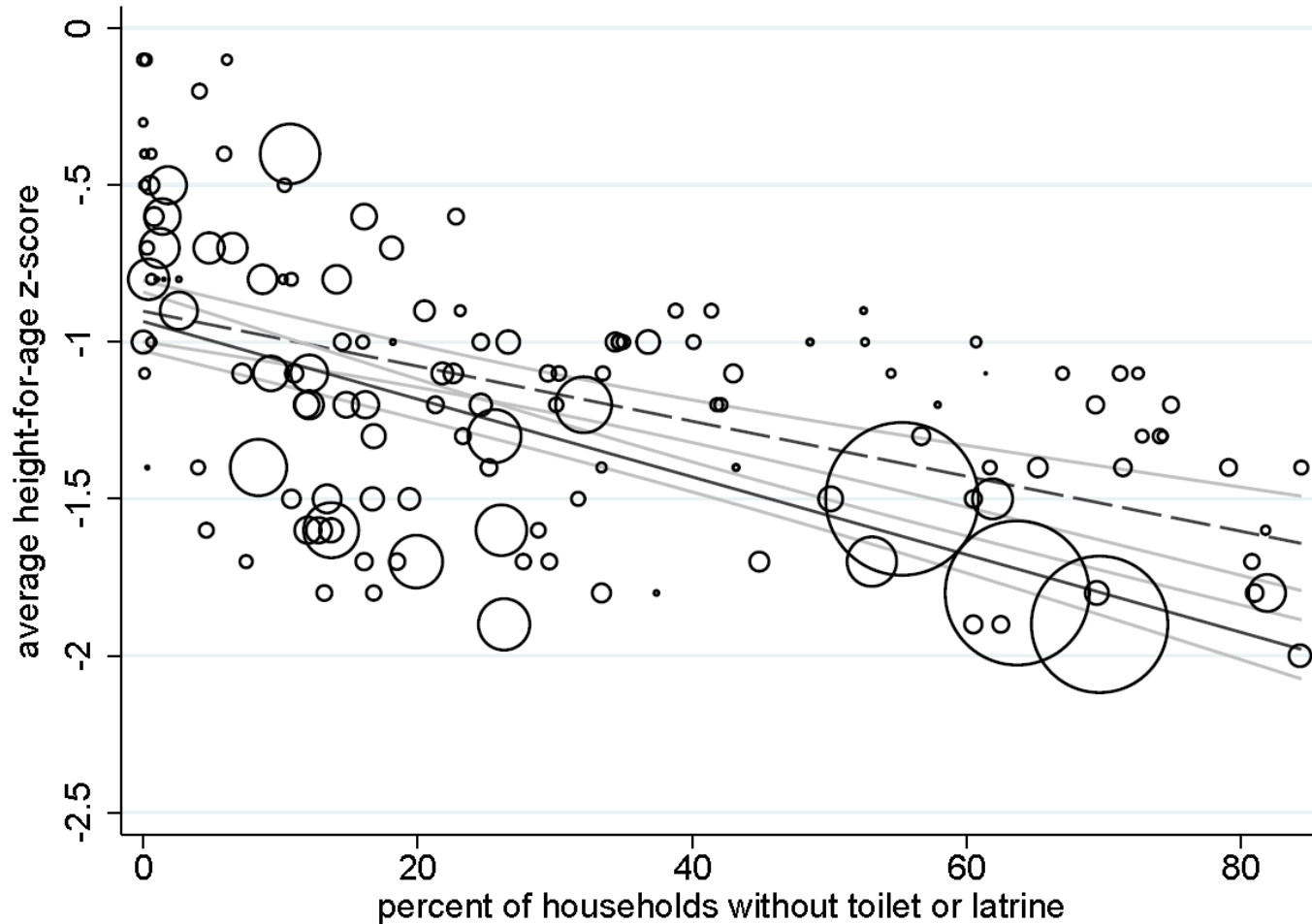
## Environmental Enteropathy

- Widespread in
  - low income tropical countries
  - where food, water and environment are commonly contaminated with feces
- Acquired in early childhood
  - Stillborn children in endemic countries have normal intestinal cellular structure
  - Resolves with migration to developed countries (after 2 – 5 years)
- Peace corps workers, U.S. soldiers in Vietnam acquired environmental enteropathy within 3 – 6 months.
  - Resolved within 12 months of returning to developed country

**Suggests an environmental cause**

# Child height versus open defecation

## 150 DHS assessments



- $R^2 = 54\%$
- Minimal change in coefficient when adjusted for
  - GDP
  - Maternal
    - Height
    - Literacy
  - Water accessibility
  - Food availability
  - Breast feeding rates
  - Polity and autocracy scores



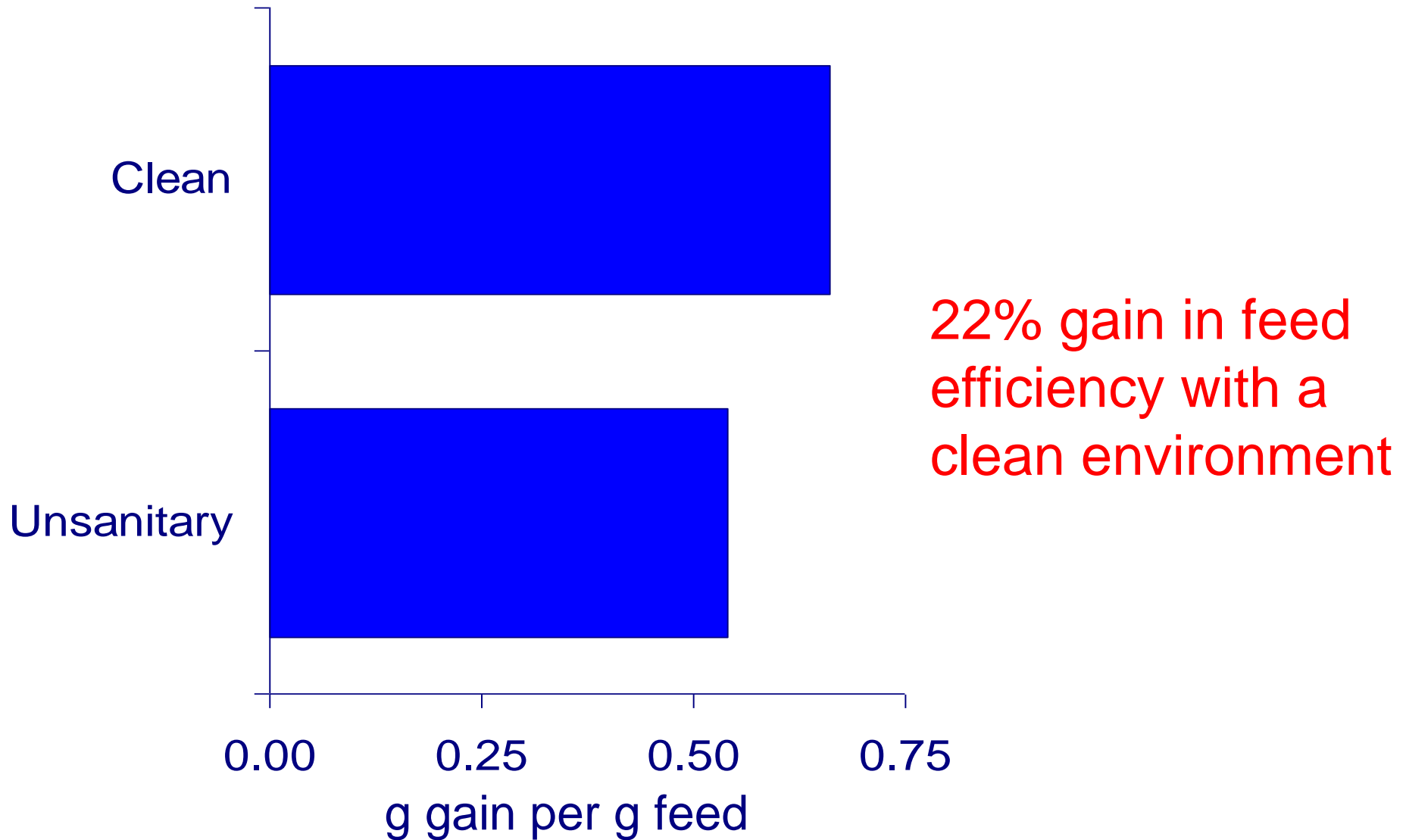
# Do farm animals grow better in a clean environment?

- Randomized trial of chickens
- Outcome: Feed efficiency
  - g weight gain per g feed
- Unsanitary vs. clean cages
  - Unsanitary
    - Multiple cycles of chicks raised in the same cages
    - Feces, dust and dander allowed to accumulate
  - Clean
    - Cages steam cleaned between cycles
    - Bedding changed 3 times per week



[www.farmsanctuary.org](http://www.farmsanctuary.org)

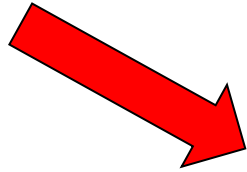
# Feed efficiency of chicks



# WASH Benefits Causal Hypotheses

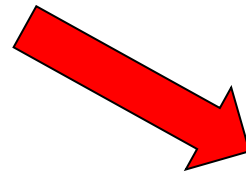
## Improvements in:

- Drinking water quality
- Sanitation
- Hygiene
- Nutrition



## Less:

- diarrhea
- parasites
- environmental enteropathy



## Improved:

- child growth
- child development

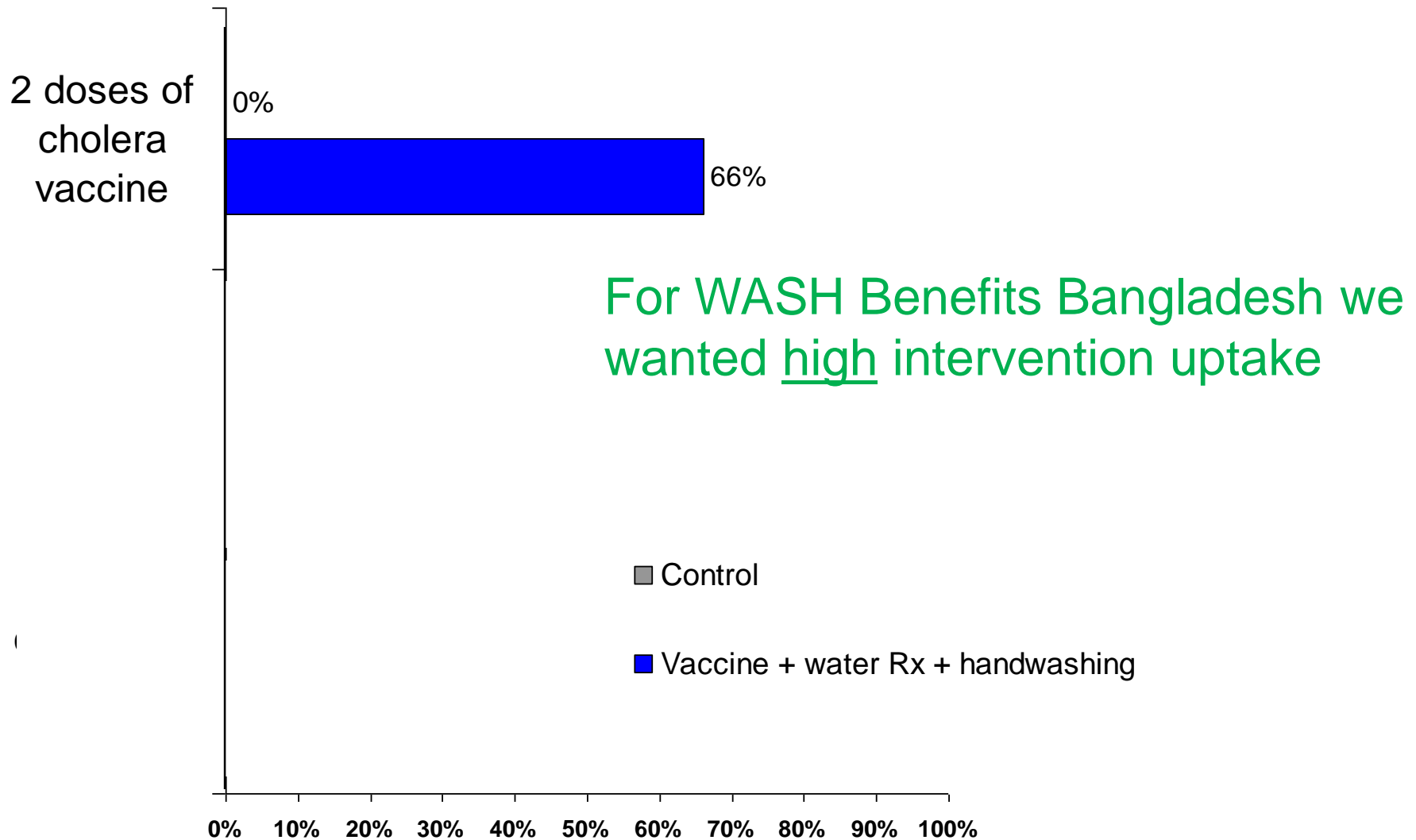
# Design Overview

## WASH Benefits

- Two similar (but standalone) cluster-randomized trials
  - Bangladesh : aimed for an efficacy study
  - Kenya : aimed to model a strong NGO-like model
- Enroll children before birth, and follow them for two years
- Many village clusters and children
- Infrequent outcome measurements

# Intervention uptake

Dhaka cholera vaccine demonstration project (N=268,896)



# The Integrated Behavioural Model for Water, Sanitation, and Hygiene

Robert Dreibelbis<sup>1\*</sup>, Peter J Winch<sup>1</sup>, Elli Leontsini<sup>1</sup>, Kristyna RS Hulland<sup>1</sup>, Pavani K Ram<sup>2</sup>, Leanne Unicomb<sup>3</sup> and Stephen P Luby<sup>3,4</sup>

- Aimed to maximize uptake: an efficacy study
- 2 years!  
iterative intervention piloting and revision



Peter Winch  
Professor, Director,  
Social and Behavioral  
Interventions Program



# Project co-creators



## UC Berkeley

Jack Colford  
Ben Arnold  
Jade Benjamin-Chung  
Lia Fernald  
Audrie Lin  
Ayse Ercumen  
Patricia Kariger

## UC Davis

Christine Stewart  
Kay Dewey

## University at Buffalo

Pavani Ram

## Emory University

Tom Clasen

## ICDDR,B

**AWESOME** field team

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Mahbubur Rahman  
Sania Ashraf  
Faruqe Hussain  
Fosiul Nizame  
Shaila Arman  
Farzana Begum  
Abu Naser  
Sarker Masud Parvez  
Fahmida Tofail  
Kishor Das  
Solaiman Doza  
Rashidul Haque  
Tahmeed Ahmed  
Rubhana Raqib  
Mahfuza Sheuli

## In memoriam

Mothaher Hossain

## Johns Hopkins

Peter Winch  
Elli Leontsini



## Stanford

Amy Pickering  
Jessica Grembi  
Laura Kwong

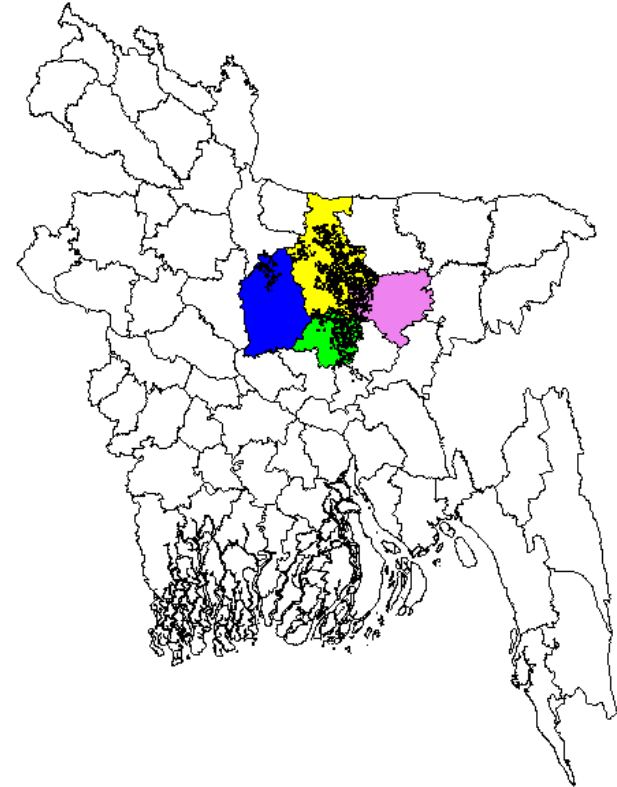
# Community Promoters

- Merit based hiring
- Trained by supervisors
  - 5 day initial session
  - Monthly 6 hour meetings
    - Grouped by interventions
    - Develop promoter's problem solving skills
    - Built *esprit d'corps*
- Payments via mobile phones



# Participant enrollment

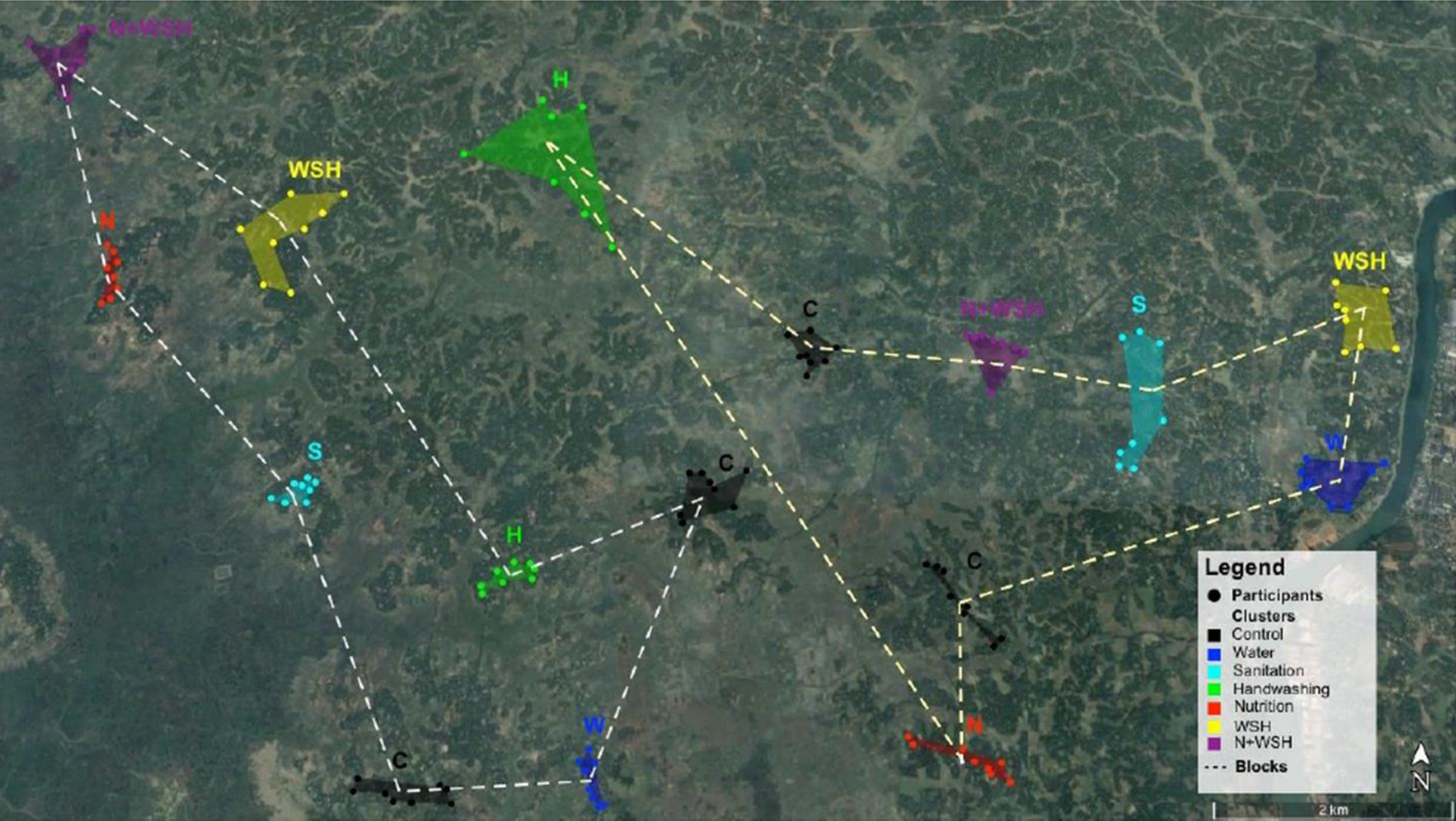
- Canvassed study area seeking women in their 1<sup>st</sup> or 2<sup>nd</sup> trimester of pregnancy.
- Mapped the location of pregnant women
- Identified cluster of 8 pregnant women
  - who could be reached by a single health promoter on foot
  - Separated from nearest cluster by a 1 kilometer buffer zone
- After 8 clusters identified
  - Cluster ID numbers assigned
  - Off site statistician randomly assigned each cluster to one of 6 interventions; with 2 clusters assigned to control



Thanks to Sania Ashraf!



# Geographically & temporally matched clusters



# Interventions

Children

Water quality

630



Aquatabs  
(NaDCC)

+

Safe Storage



([www.aquatabs.com](http://www.aquatabs.com))





# Interventions



Water quality

Children

630

Sanitation

630





# Interventions



Children

Water quality	630
Sanitation	630
Hand washing	630

# Interventions

	Children
Water quality	630
Sanitation	630
Hand washing	630
Water + Sanitation + Handwashing	630

# Interventions

## Nutritional Promotion

- Exclusive breastfeeding through 6 months
- Continued breastfeeding through 24 months
- Diverse nutrient dense weaning foods

+

## Daily lipid based nutrient supplement

- 6 – 24 months
- 10-gm sachet twice daily
  - 118 Kcal
  - 9.6 gm fat
  - 2.6 gm protein
  - $\geq 100\%$  RDA of 12 vitamins
  - 9 minerals

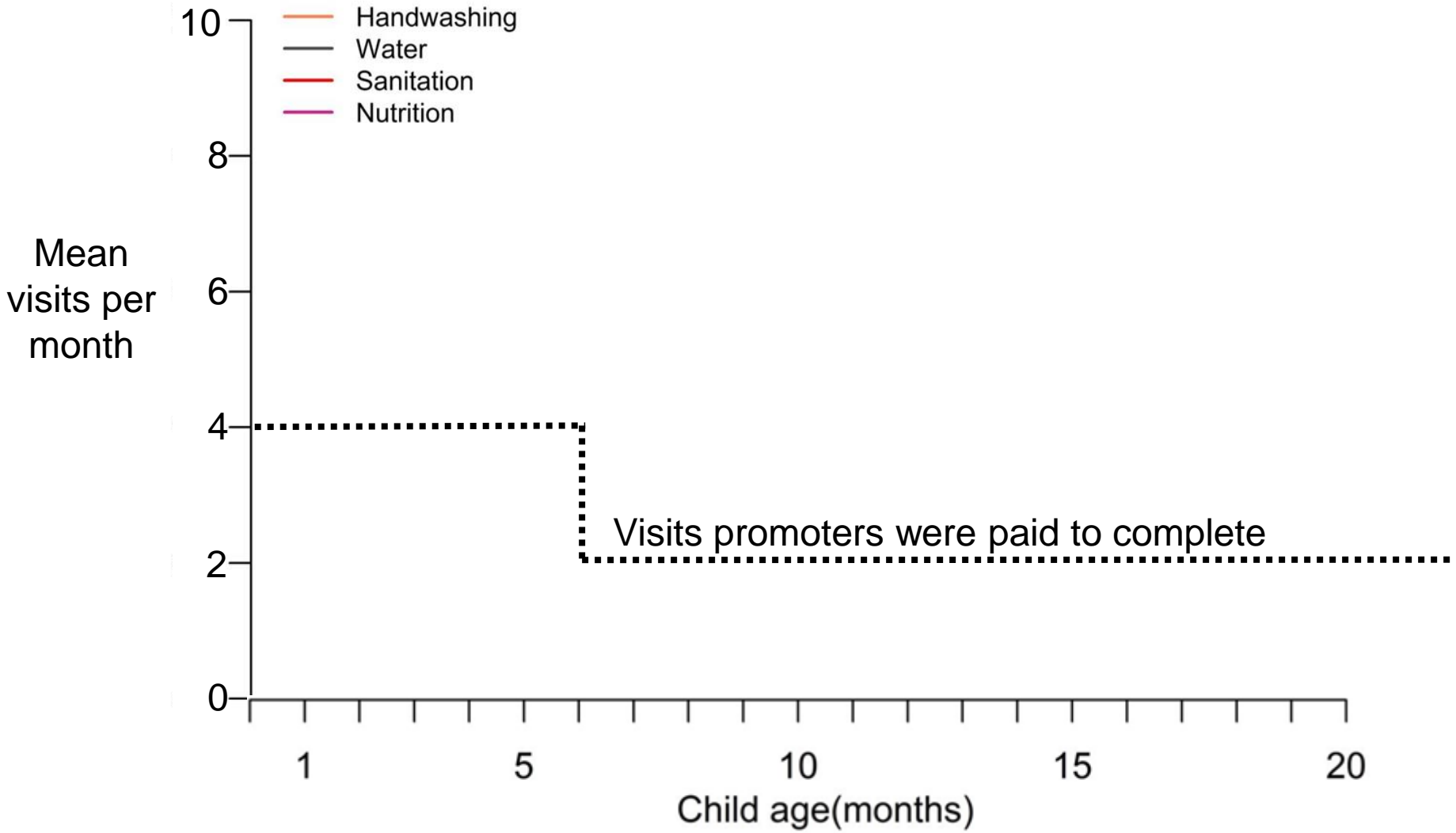


	Children
Water quality	630
Sanitation	630
Hand washing	630
Water + Sanitation + Handwashing	630
Nutrition	630

# Interventions

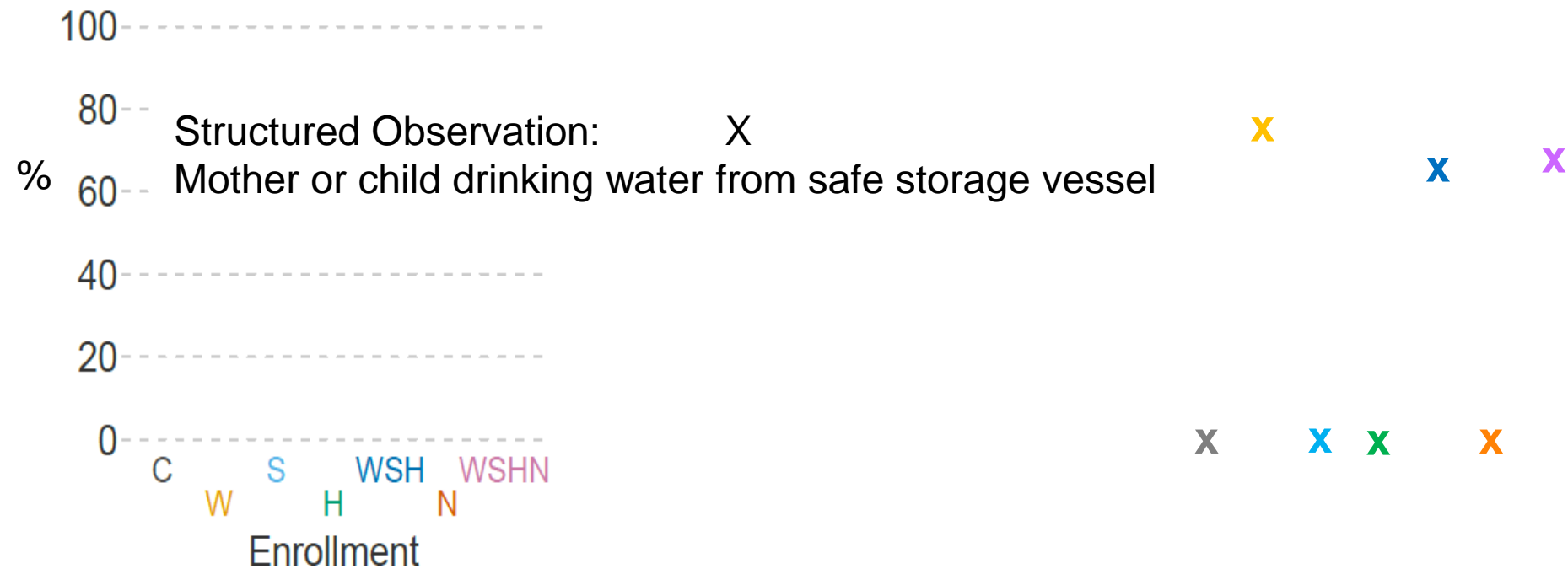
	Children
Water quality	630
Sanitation	630
Hand washing	630
Water + Sanitation + Handwashing	630
Nutrition	630
Water + Sanitation + Handwashing + Nutrition	630
Control	1260
Total	5040

# Community promoter visits per month



Unannounced spot checks to assess physical presence of intervention materials

# Stored drinking water has free chlorine



C – Control

W – Water

S – Sanitation

H – Handwashing

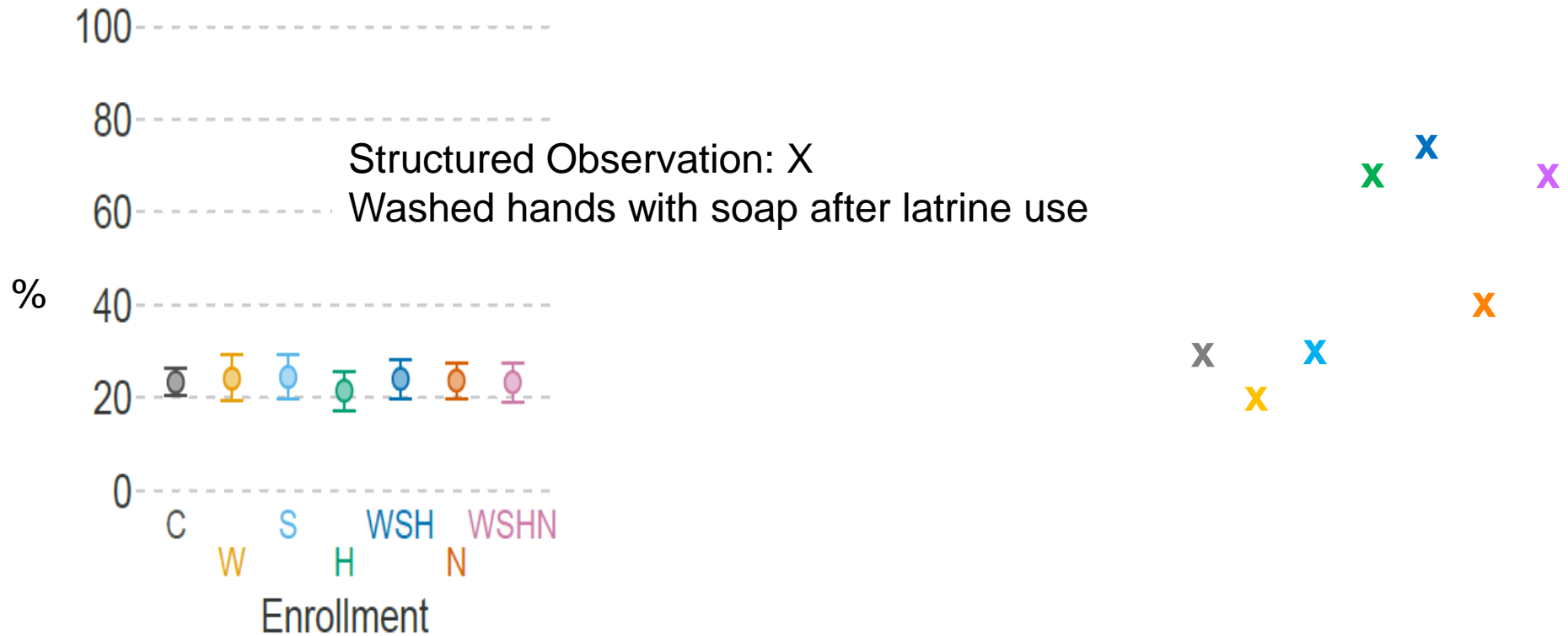
WSH -- Water + Sanitation + Hygiene

N – Nutrition

WSHN – Water + Sanitation + Hygiene + Nutrition



# Handwashing location has soap



C – Control

W – Water

S – Sanitation

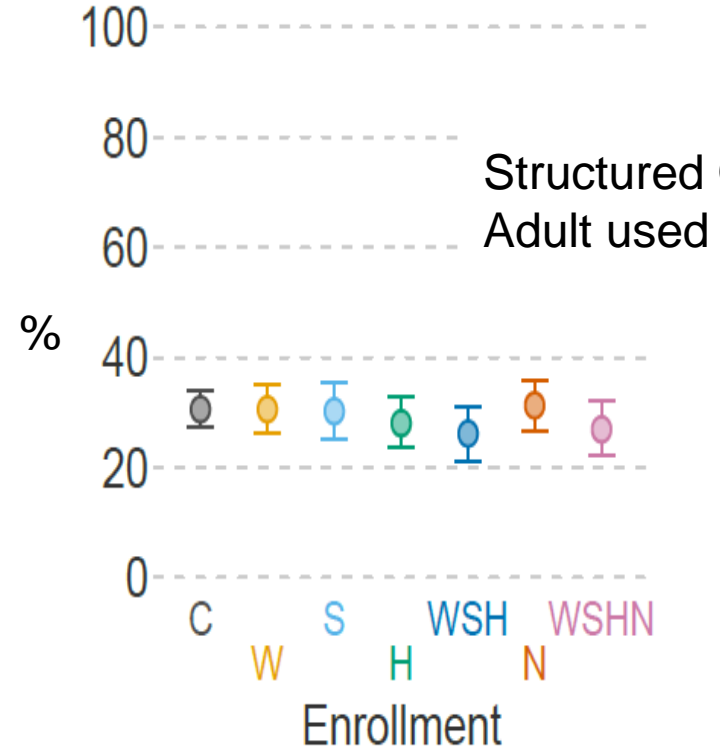
H – Handwashing

WSH -- Water + Sanitation + Hygiene

N – Nutrition

WSHN – Water + Sanitation + Hygiene + Nutrition

# Latrine has a functional water seal



C – Control

W – Water

S – Sanitation

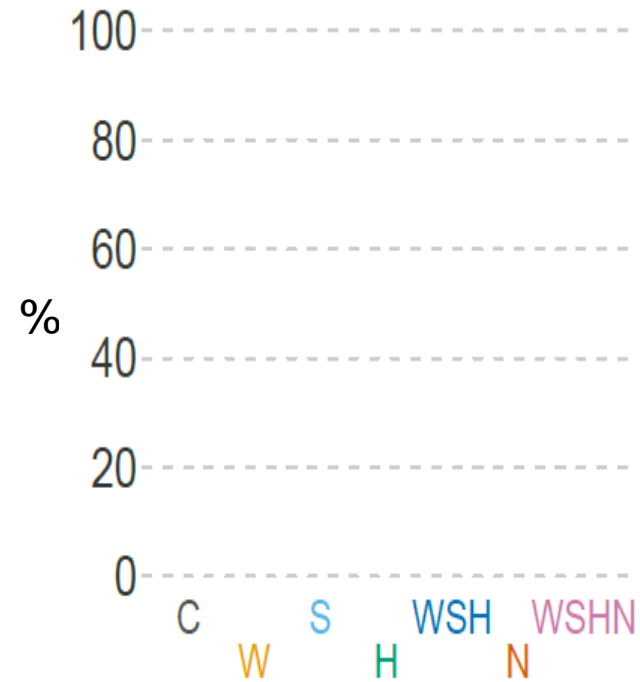
H – Handwashing

WSH – Water + Sanitation + Hygiene

N – Nutrition

WSHN – Water + Sanitation + Hygiene + Nutrition

# % of expected nutrient supplement sachets consumed



C – Control

W – Water

S – Sanitation

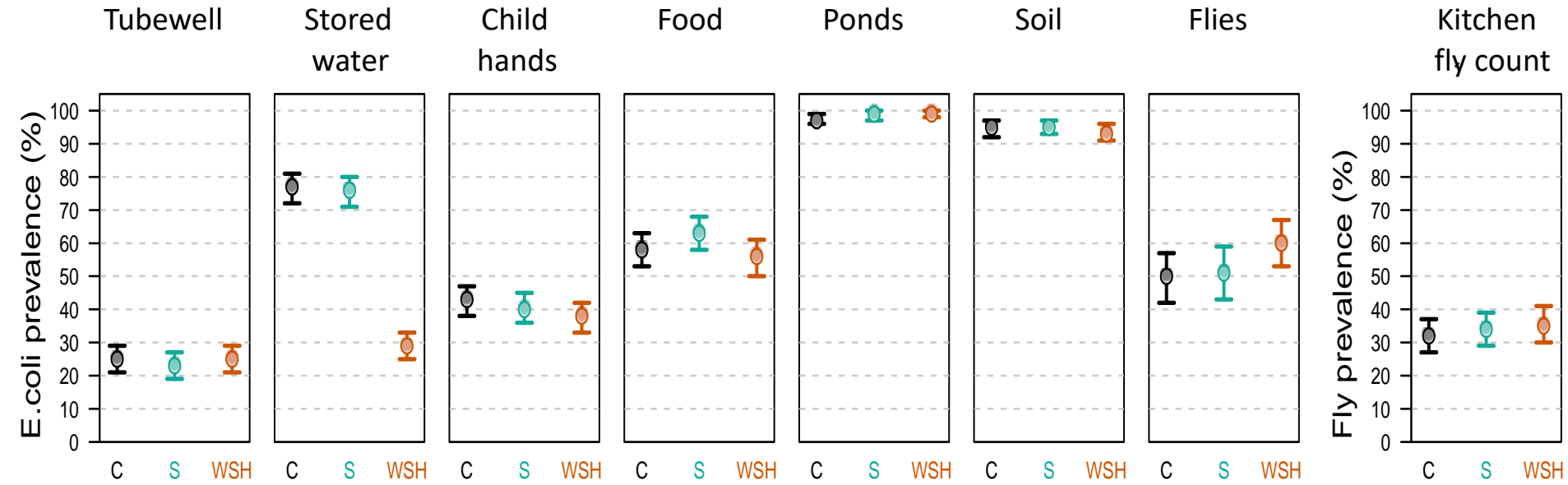
H – Handwashing

WSH -- Water + Sanitation + Hygiene

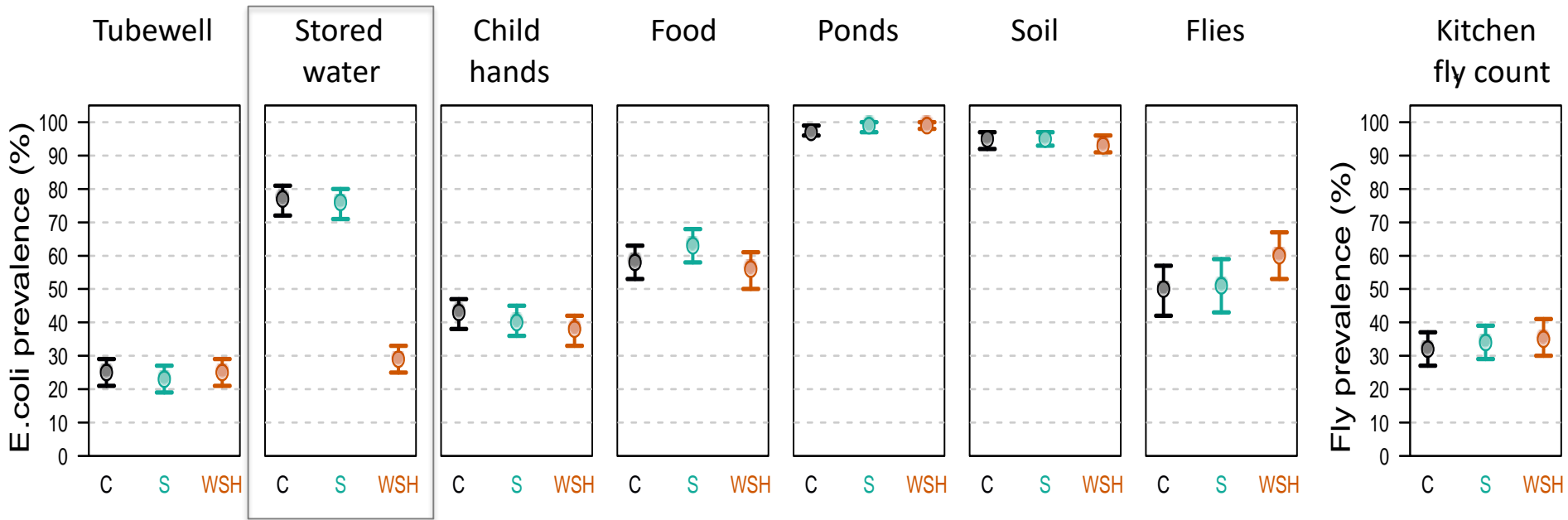
N – Nutrition

WSHN – Water + Sanitation + Hygiene + Nutrition

# environmental findings



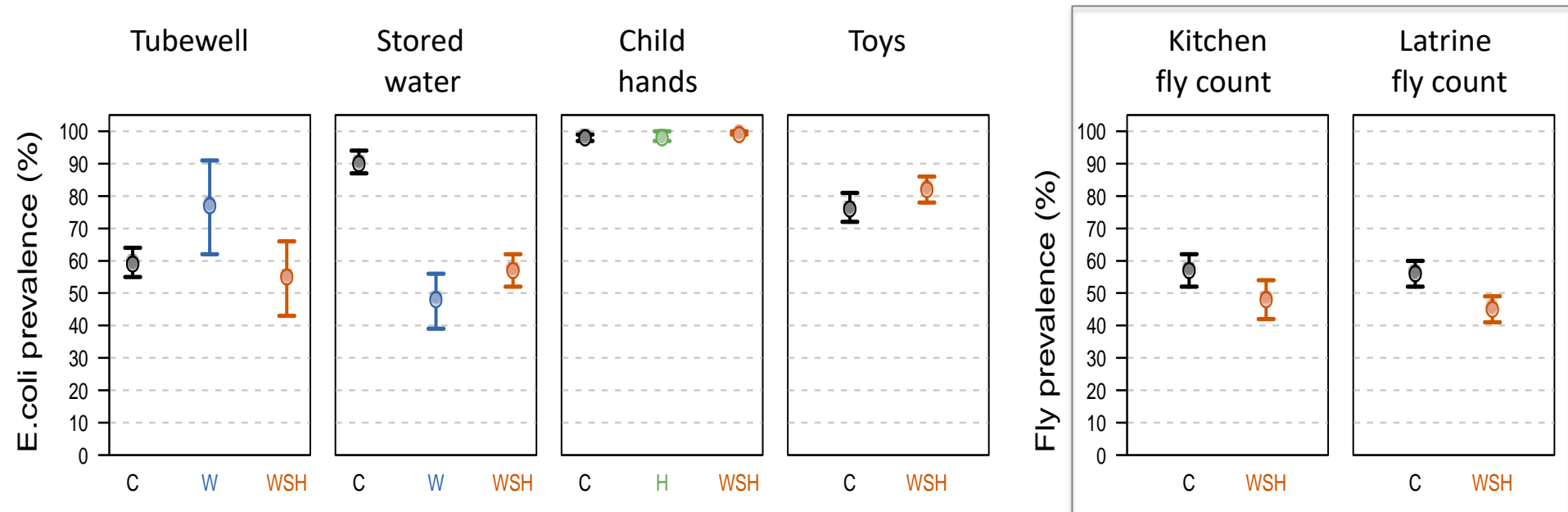
# Six-month environmental findings



No environmental impact from sanitation

62% reduction in stored water *E. coli* in WSH arm

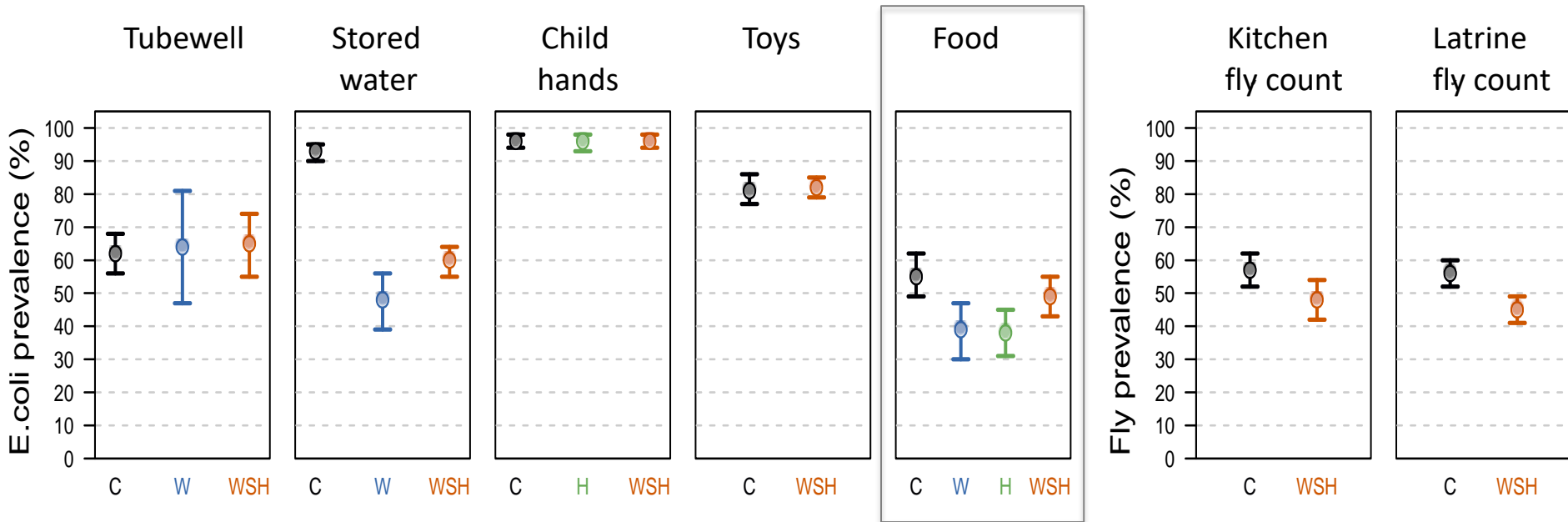
# One-year environmental findings



37-47% reduced in stored water *E. coli* in water and WSH

16-19% reduced flies near latrine and kitchen in WSH

# Two-year environmental findings

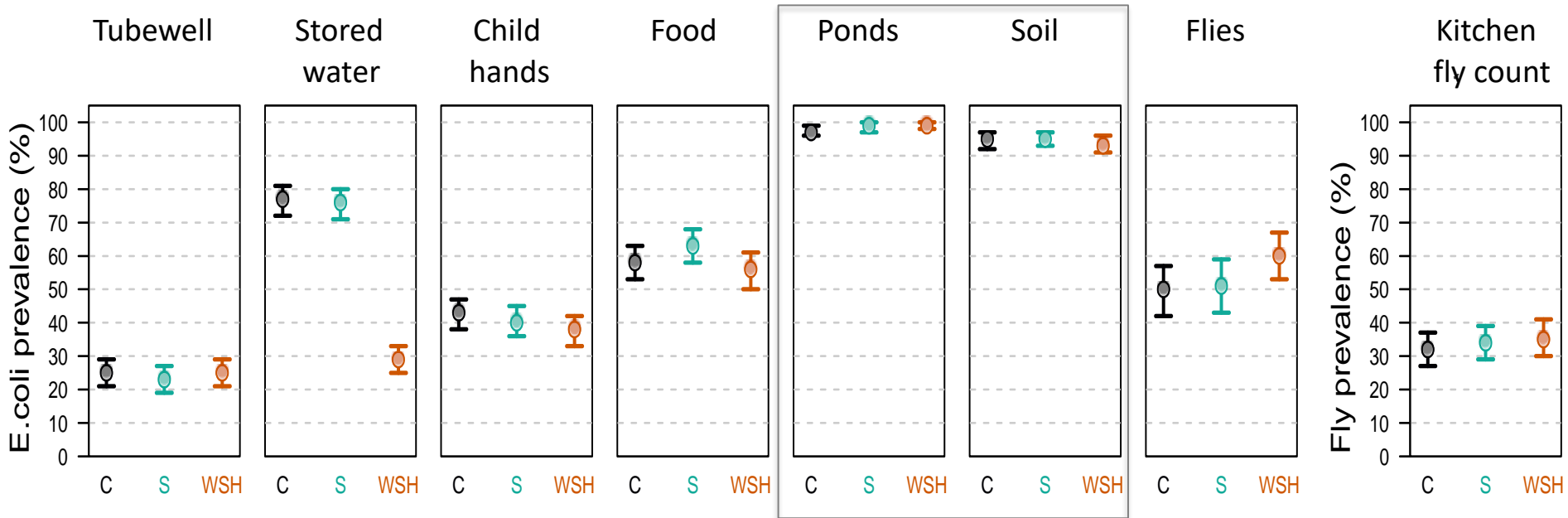


35-49% reduced stored water *E. coli* in water and WSH

30-32% reduced food *E. coli* in water and handwashing

11% borderline reduced food *E. coli* in WSH

# Six-month environmental findings



No environmental impact from sanitation

62% reduction in stored water *E. coli* in WSH arm

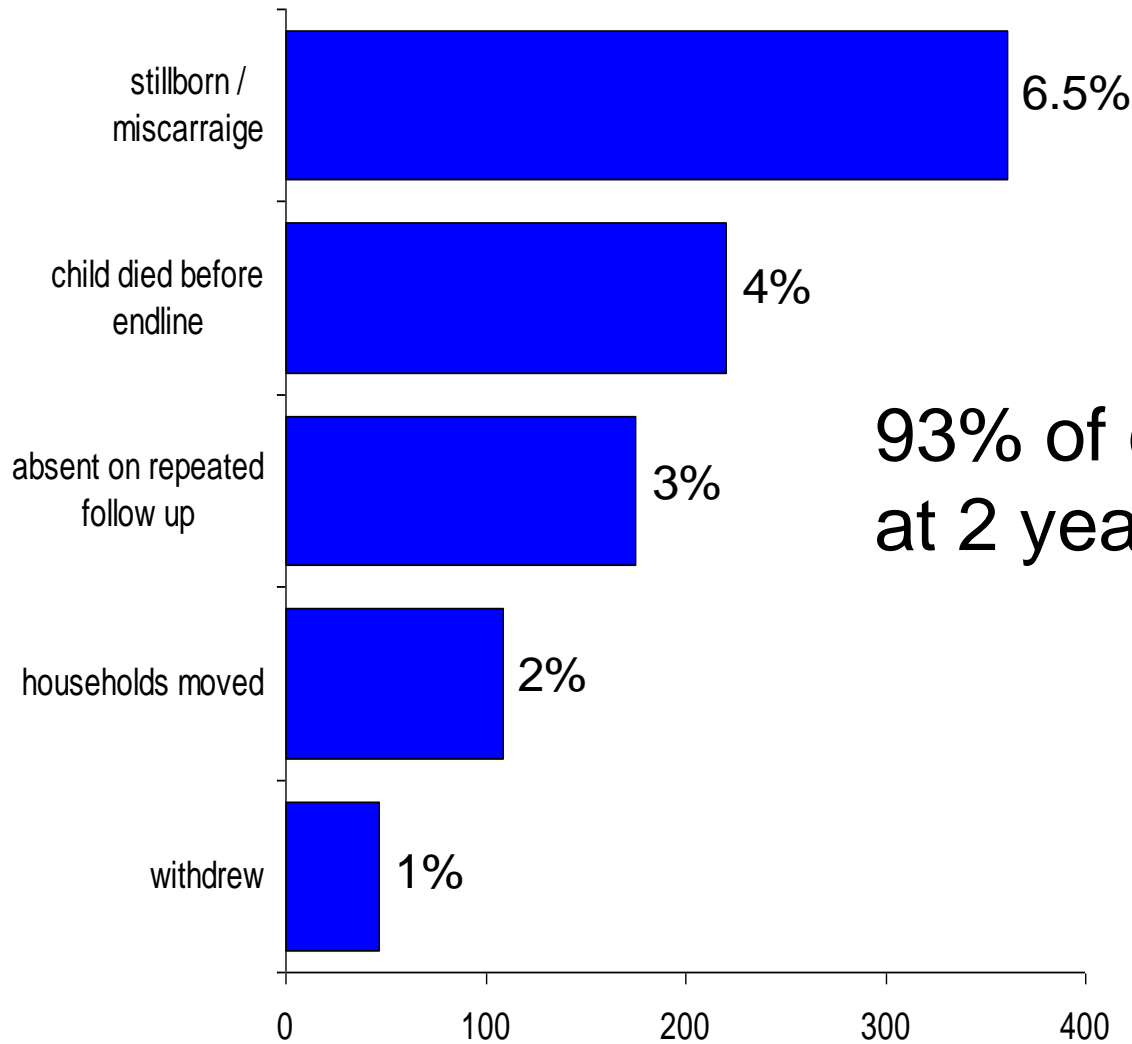
High levels of contamination in ambient environment

- Soil >120,000 MPN *E. coli* per dry gram
- Ponds >5,000 MPN *E. coli* per 100 mL



# 5551 pregnant mothers enrolled

4639 (84%) children completed 2 years follow-up



93% of children alive at 2 years assessed

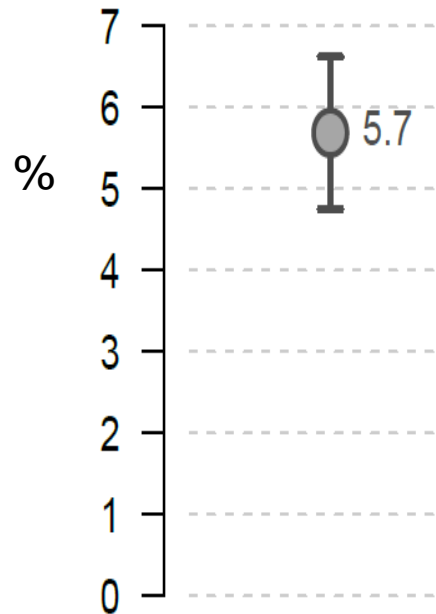
Children dropped out before 2 year follow up

# Diarrhea prevalence

among children <36 months age at enrollment

Control

ref



# Impact on *Giardia* Prevalence at 2.5-year Follow-up

Control

Water

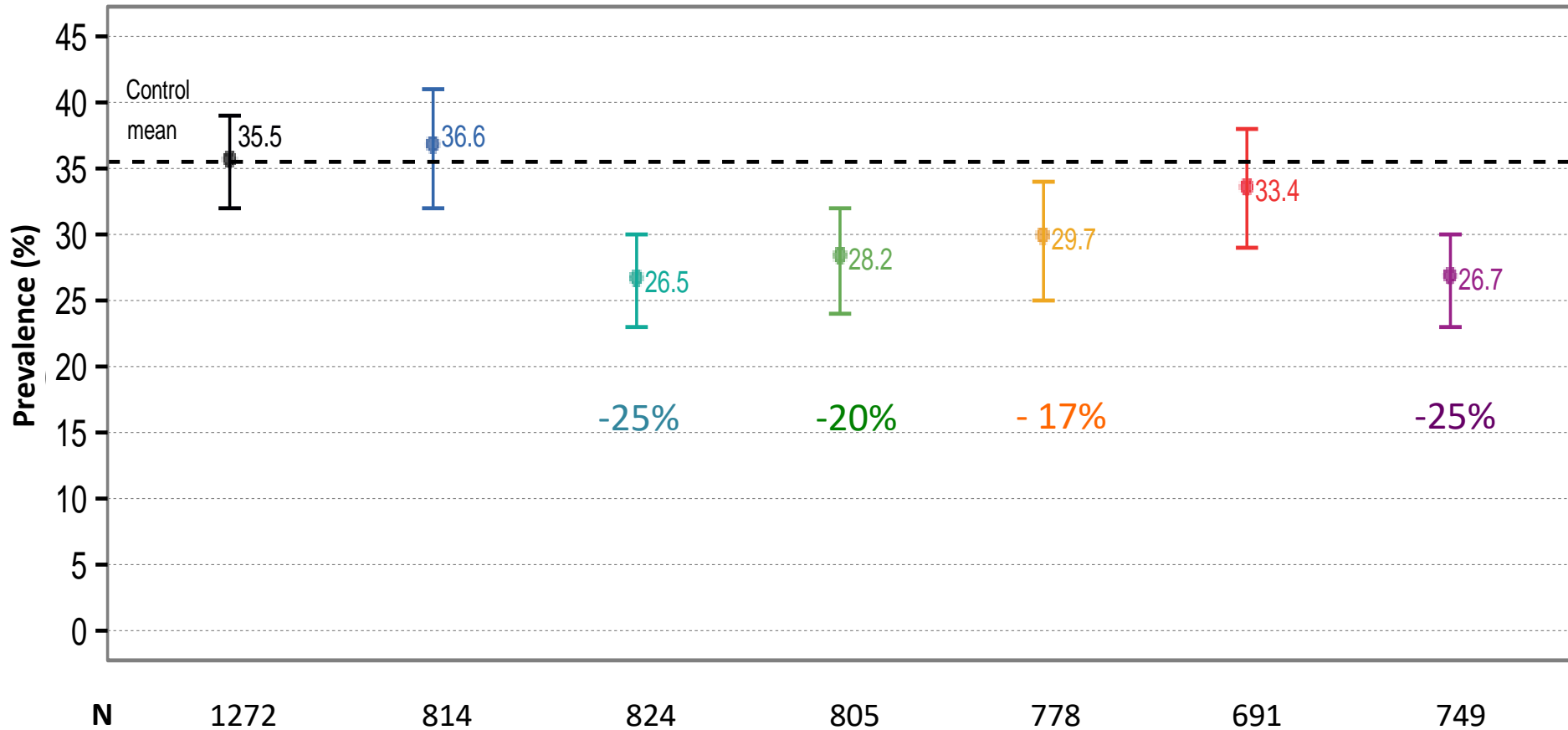
Sanitation

Handwashing

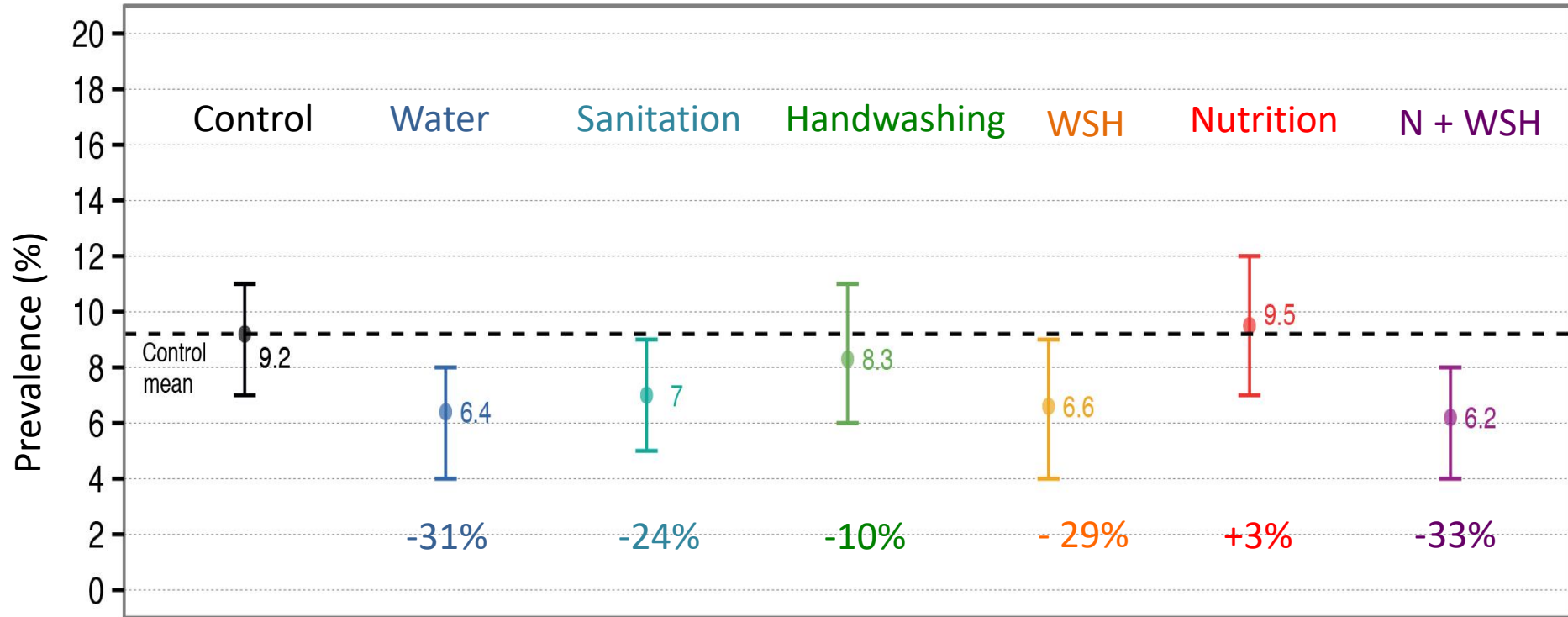
WSH

Nutrition

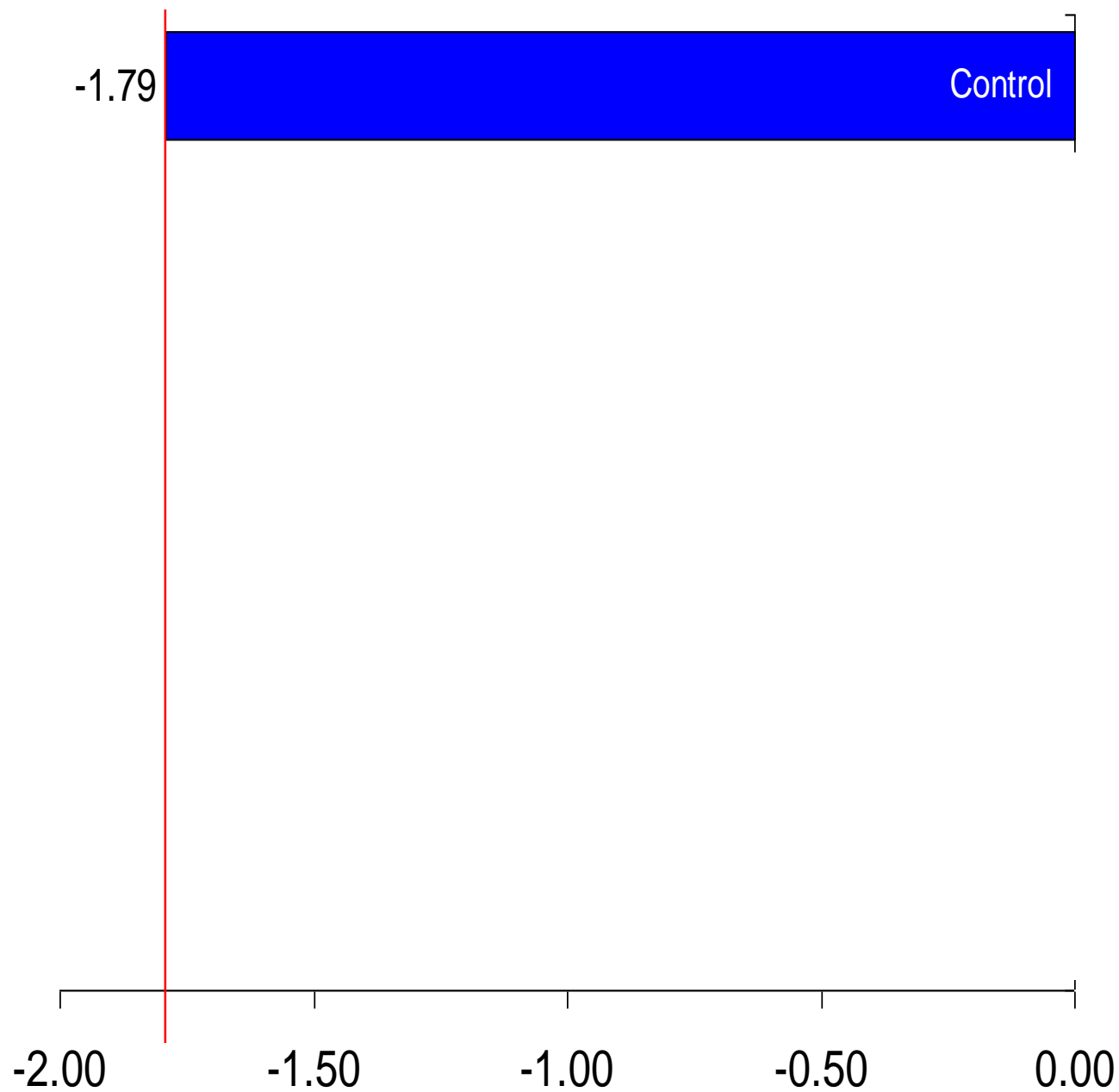
N+WSH



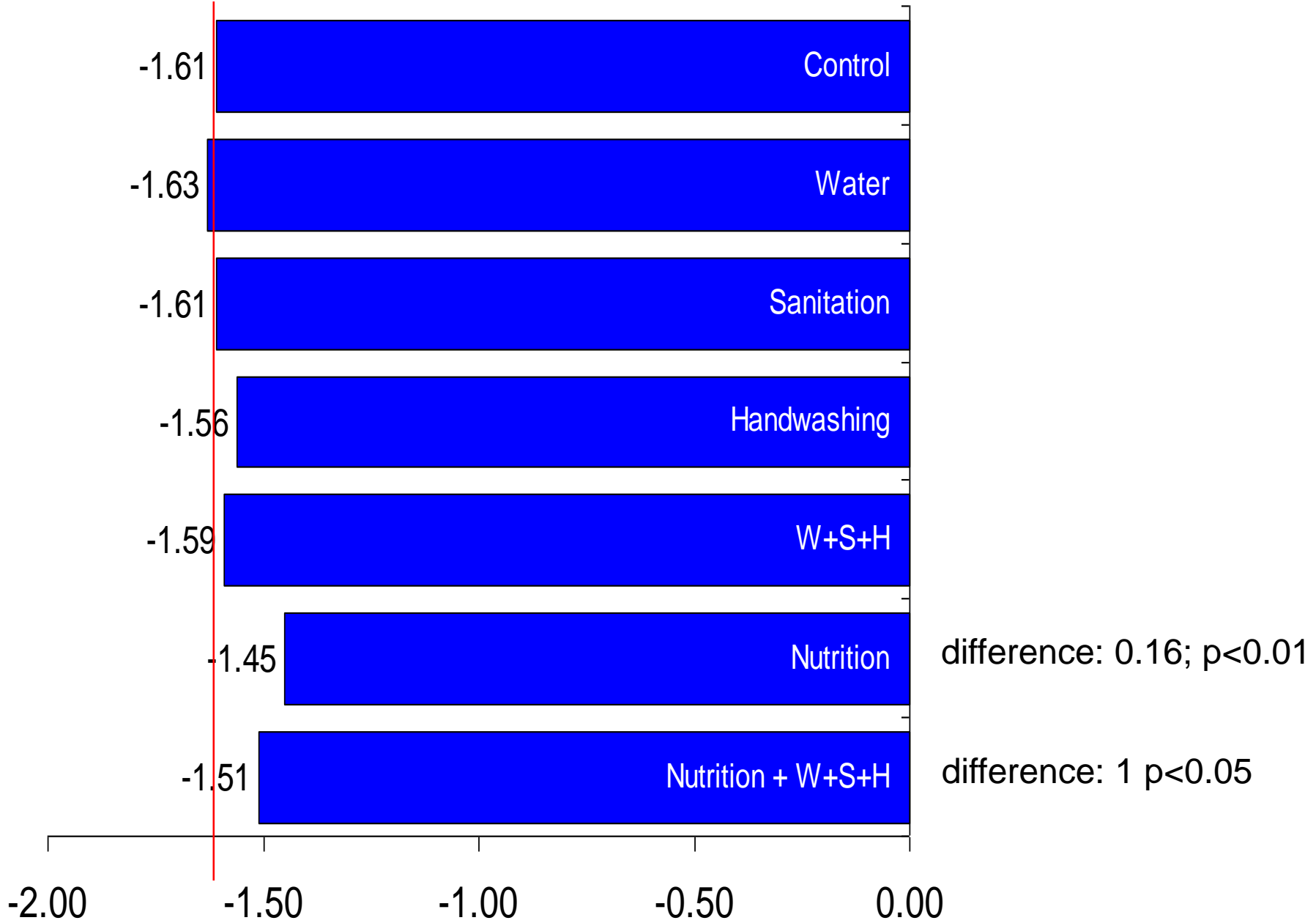
# Intervention impact on hookworm



# Length for age Z-score after 2 years



# Head circumference for age Z-score after 2 years



# Potential explanations of lack of impact of WASH interventions on growth

- ~~1. Low uptake of interventions~~
2. Environmental fecal contamination is not a major contributor to growth faltering in Bangladesh
3. Environmental fecal contamination does contribute to growth faltering, but WASH Benefits Bangladesh interventions did not reduce environmental fecal contamination enough

A microscopic view of soil particles and organic matter, showing various shapes and sizes of particles, including what appears to be a nematode and several circular spores or eggs.

Soil: 120,000 MPN *E. coli* per dry gram

Child age in months	mg/day soil consumed
<6	81
6-11	180
12-23	165

Laura Kwong



# Child Development

- Fieldworkers read each item to parent
- Record responses as
  - Yes
  - Sometimes
  - Not yet
- Some observational items
- Scores adjusted for
  - Child sex, child age, mother age, parents education, number of household members, number of household rooms, household roof, floor, wall materials, availability of electricity, type of fuel for cooking, household asset

## **GROSS MOTOR**

Does your child jump with both feet leaving the floor at the same time?

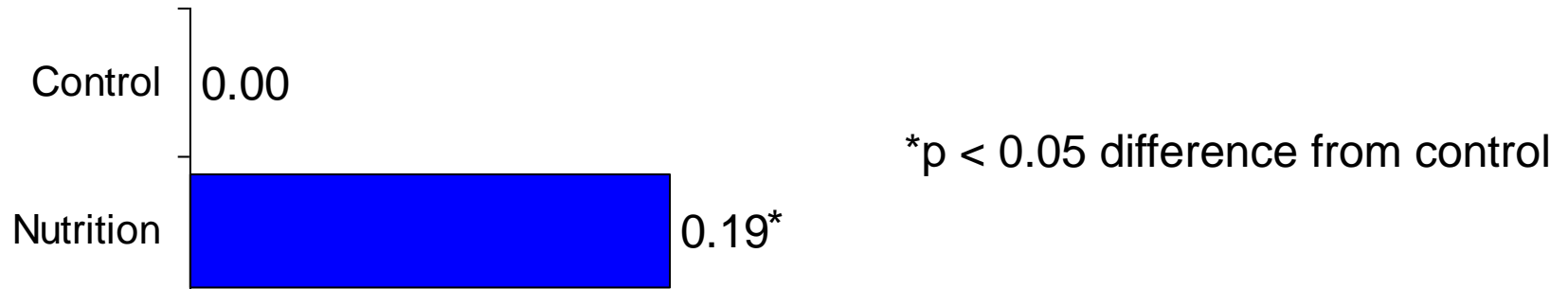


## **PERSONAL-SOCIAL**

Does your child copy the activities you do, such as wipe up a spill, sweep, shave, or comb hair?

# Gross motor skills after 2 years

(Extended Ages and States Questionnaire)



0.00 0.10 0.20 0.30 0.40

Standardized age adjusted mean differences from control

# MacArthur Bates Communicative Development Inventories

## Bangladesh adapted short form

- Structured parental interview

- List of words

- Does the child:
  - Understand?
  - Understand and say?
- # of words summed

- Valid, reliable, normed, translated

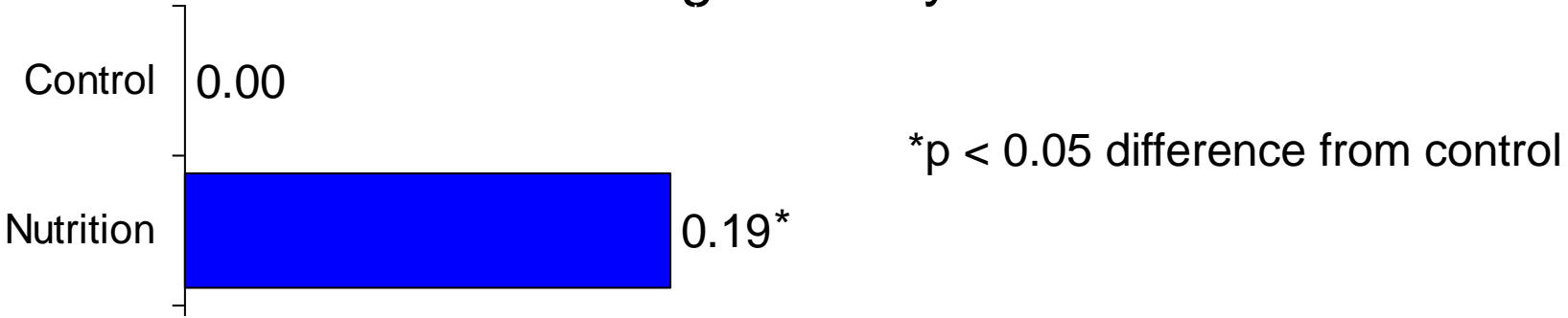
- Adjusted difference for:

- Child sex, child age, mother age, parents education, number of household members, number of household rooms, household roof, floor, wall materials, availability of electricity, type of fuel for cooking, household asset

	UNDERSTANDS	UNDERSTANDS AND SAYS
choo choo	<input type="radio"/>	<input type="radio"/>
meow	<input type="radio"/>	<input type="radio"/>
ouch	<input type="radio"/>	<input type="radio"/>
uh oh	<input type="radio"/>	<input type="radio"/>
bird	<input type="radio"/>	<input type="radio"/>
dog	<input type="radio"/>	<input type="radio"/>
duck	<input type="radio"/>	<input type="radio"/>
kitty	<input type="radio"/>	<input type="radio"/>

# Communicative Development Inventory

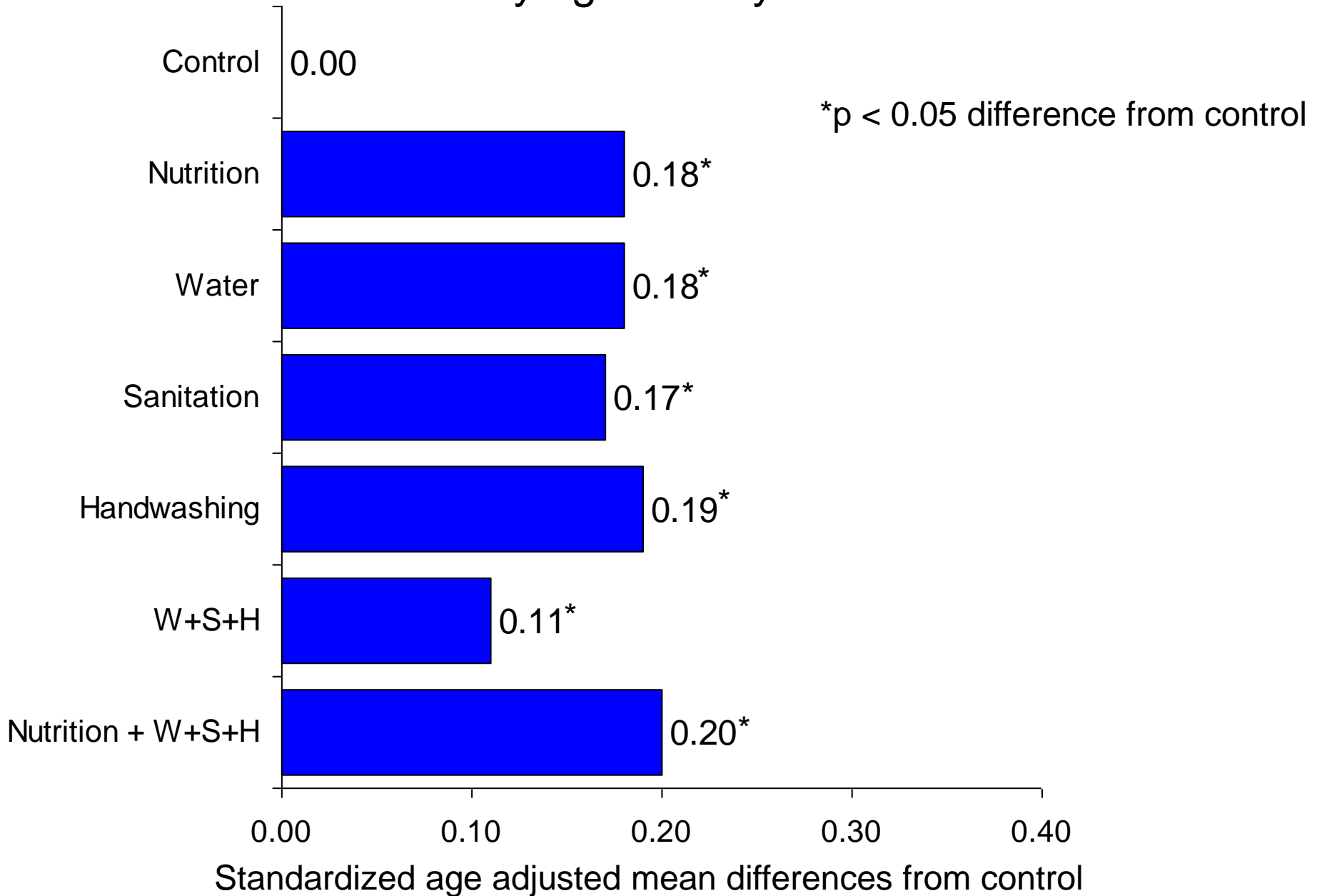
## Understanding after 2 years



0.00      0.10      0.20      0.30      0.40  
Standardized age adjusted mean differences from control

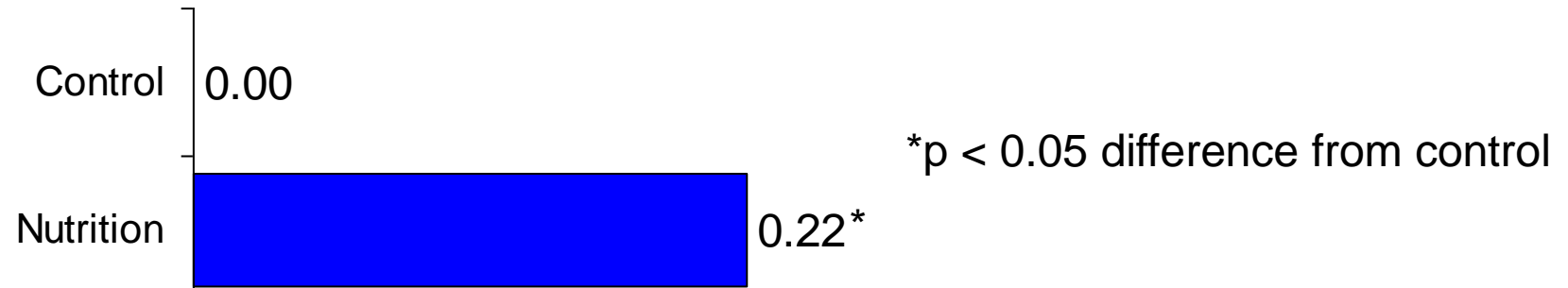
# Communicative Development Inventory

## Saying after 2 years



# Personal social skills after 2 years

(Extended Ages and States Questionnaire)



0.00 0.10 0.20 0.30 0.40  
Standardized age adjusted mean differences from control

# What might explain observed improvements in child development?

Brain development likely more sensitive to subtle insults and improvements than linear growth

- a) Reduced number of days of clinical illness
- b) Reduced metabolically demanding sub-clinical infections
- c) Psychological support to mom
- d) More attention to the index child
- e) Response bias
- f) A combination of a-e

# WASH Benefits Bangladesh summary

- High uptake of integrated interventions in an efficacy study
- No impact of WASH interventions on linear growth
- Multiple beneficial outcomes on child health
  - Reduced diarrhea in sanitation, hygiene and nutrition arms
  - Reduced protozoa, helminth, environmental enteropathy markers
  - Improved linear growth in nutrition arms, but not in water, sanitation and hygiene arms
  - Improved child language, motor development and social skills in hygiene, sanitation and nutrition arms
- Limited evidence of synergy
  - Between single and combined water, sanitation and hygiene
  - Between WASH & nutrition





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