Applying implementation science methods for the control of food and waterborne infections

Swiss TPH - IMPACT

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HEALTH

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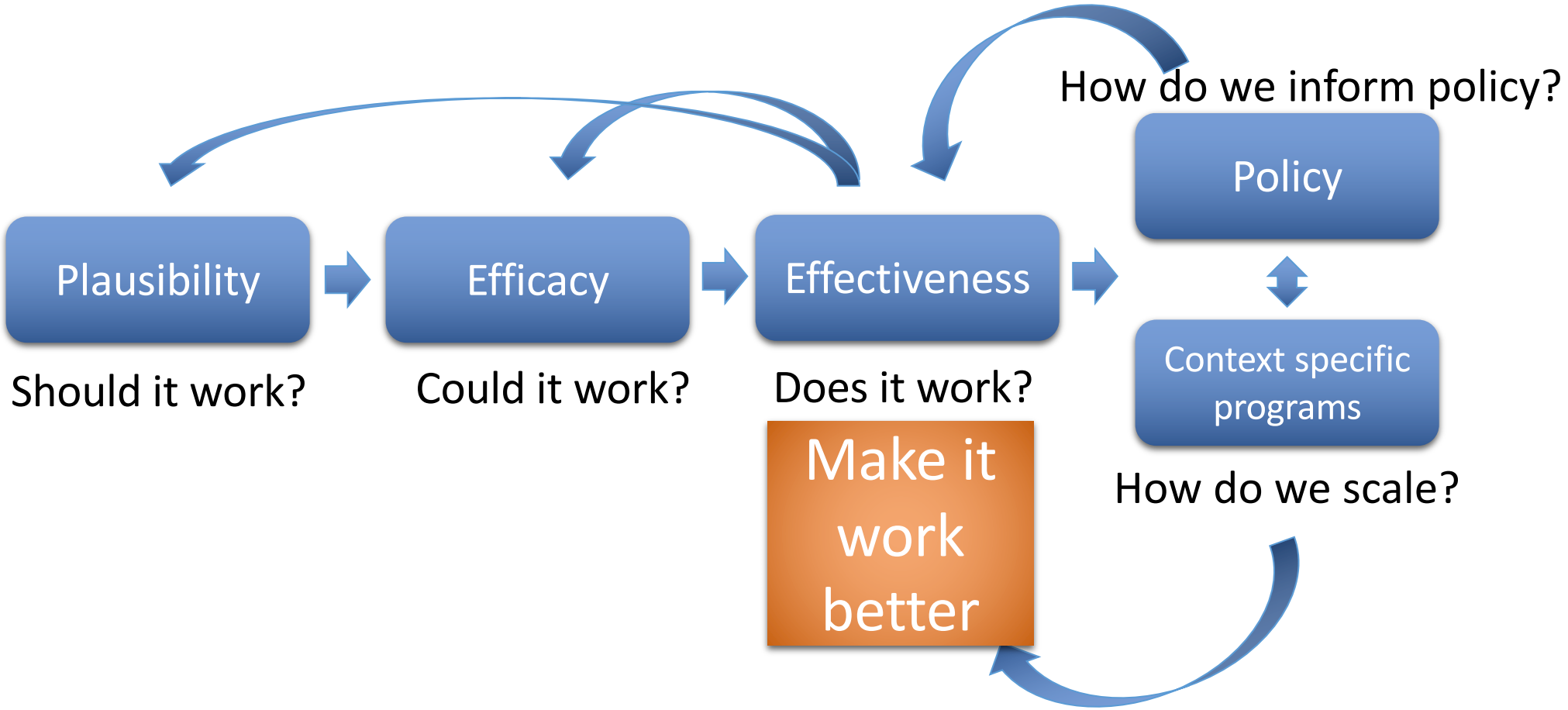
Successful delivery of at-scale interventions to reach impact



Adapted from Glasgow et al. 2012

Talk objectives

1. What is WASH and what are the key challenges facing the sector?
2. How can implementation science be applied for the control of food and waterborne disease in low and middle-income countries
3. What are the priority challenges and opportunities to WASH implementation research

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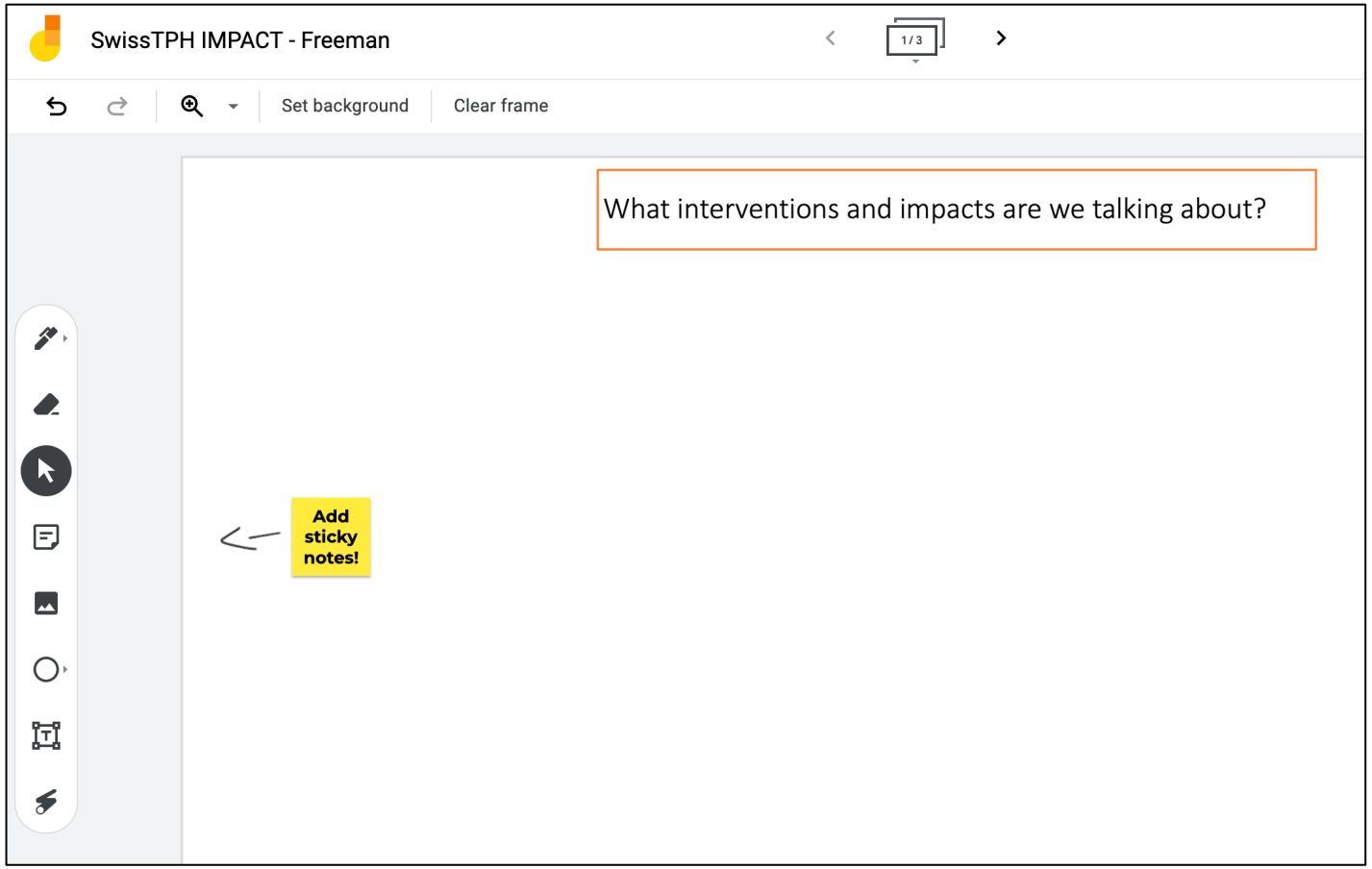
What interventions and impacts are we talking about?

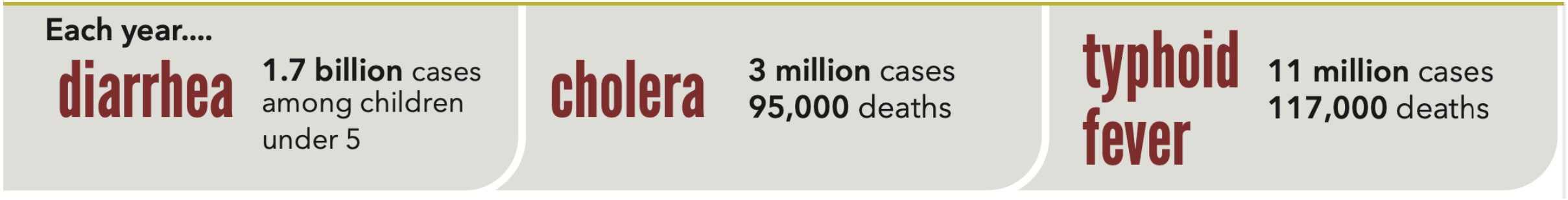
SCAN ME



https://l.ead.me/bd6rSh

Diarrhea caused 1.3 million deaths in 2015

- ~500,000 deaths in children < 5 year old
- 3rd leading cause of death in children

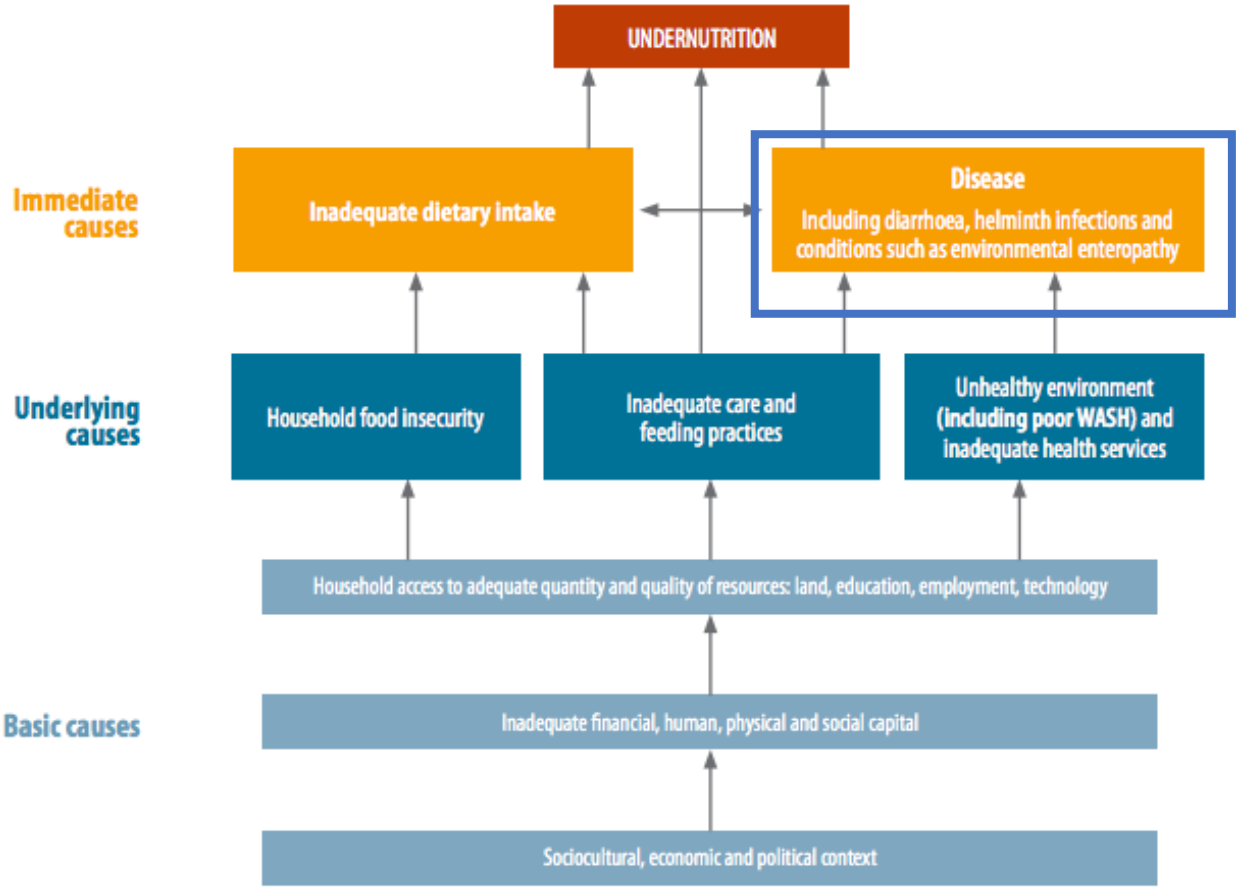


GBD 2015 Mortality and Causes of Death Collaborators. *Lancet.* 2016;**388**:1459–1544.

Undernutrition is a major public health problem

- ~690 million people globally are undernourished
- 21.3% children stunted in 2019
- Avoiding fecal exposure and enteric infection is critical

Fig. 3. Conceptual framework of the causes of undernutrition, including aspects of WASH and diarrhoea (adapted from UNICEF, 2013)



State of Food Insecurity and Nutrition in the World 2020

WASH-related disease

Meta-analyses

International Journal of Hygiene and Environmental Health 220 (2017) 928–949

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh

Review

The impact of sanitation on infectious disease and nutritional status: A systematic review and meta-analysis

Matthew C. Freeman[a,*], Joshua V. Garn[a], Gloria D. Sclar[a], Sophie Boisson[b], Kate Medlicott[b], Kelly T. Alexander[a], Gauthami Penakalapati[a], Darcy Anderson[a], Amrita G. Mahtani[a], Jack E.T. Grimes[c], Eva A. Rehfuess[d], Thomas F. Clasen[a,e,*]

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PLOS | MEDICINE

Water, Sanitation, Hygiene, and Soil-Transmitted Helminth Infection: A Systematic Review and Meta-Analysis

Eric C. Strunz[1]*, David G. Addiss[1], Meredith E. Stocks[2], Stephanie Ogden[1,2,3], Jürg Utzinger[4,5], Matthew C. Freeman[2]

Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression

Jennyfer Wolf[1,2,3], Annette Prüss-Ustün[1], Oliver Cumming[4], Jamie Bartram[5], Sophie Bonjour[1], Sandy Cairncross[4], Thomas Clasen[6], John M. Colford Jr[7], Valerie Curtis[4], Jennifer De France[1], Lorna Fewtrell[8], Matthew C. Freeman[6], Bruce Gordon[1], Paul R. Hunter[9,10], Aurelie Jeandron[4], Richard B. Johnston[1,11], Daniel Mäusezahl[2,3], Colin Mathers[12], Maria Neira[1] and Julian P. T. Higgins[13,14]

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PLOS | MEDICINE

Effect of Water, Sanitation, and Hygiene on the Prevention of Trachoma: A Systematic Review and Meta-Analysis

Meredith E. Stocks[1,2], Stephanie Ogden[1,2,3], Danny Haddad[4], David G. Addiss[3], Courtney McGuire[1], Matthew C. Freeman[1]*

1 Department of Environmental Health, Emory University, Atlanta, Georgia, United States of America, 2 International Trachoma Initiative, Taskforce for Global Health, Decatur, Georgia, United States of America, 3 Children Without Worms, Taskforce for Global Health, Decatur, Georgia, United States of America, 4 Emory Eye Center, Emory University, Atlanta, Georgia, United States of America

RESEARCH ARTICLE

PLOS | NEGLECTED TROPICAL DISEASES

The Effect of Hygiene-Based Lymphedema Management in Lymphatic Filariasis-Endemic Areas: A Systematic Review and Meta-analysis

Meredith E. Stocks[1,2], Matthew C. Freeman[2], David G. Addiss[1]*

Trans R Soc Trop Med Hyg
doi:10.1093/trstmh/tru056

Human diarrhea infections associated with domestic animal husbandry: a systematic review and meta-analysis

Laura D. Zambrano, Karen Levy, Neia P. Menezes and Matthew C. Freeman*

WASH-related disease
Meta-analyses

Table 1
Adverse health outcomes that are at least partly attributable to inadequate water, sanitation and hygiene behaviours.

Global WASH-attributable disease burden not quantified	Global WASH-attributable disease burden estimates available	
Health outcomes	Health outcomes	Main WASH exposure
Arsenicosis	**Ascariasis**	sanitation
Cyanobacterial toxins	Cancer (bladder)	drinking water
Fluorosis	Dengue	water resource management/water bodies
Hepatitis A, E	**Diarrhoeal diseases**	drinking water, sanitation, hygiene behaviours*
Lead poisonings	Drowning[d]	recreational water/water bodies
Legionellosis	**Hookworm disease**[a]	Sanitation
Leptospirosis	Japanese Encephalitis	water resource management/agricultural practices
Methaemoglobinaemia	Lymphatic filariasis	water resource management/water bodies
Neonatal conditions and maternal outcomes	**Malaria**[d]	water resource management/water bodies
Poliomyelitis	Musculoskeletal diseases	drinking water
Scabies	Onchocerciasis	water resource management
Spinal injury	**Protein-energy malnutrition**[a,b,c]	drinking water, sanitation, hygiene behaviours*
	Respiratory infections[c]	hygiene behaviours*
	Schistosomiasis[a,b,c,d]	drinking water, sanitation, hygiene behaviours*, water resource management/ agricultural practices/recreational water
	Trachoma[a,c]	sanitation, hygiene behaviours*
	Trichuriasis[a]	Sanitation

The listed diseases are based on prior work (Prüss-Ustün et al., 2016, 2008). Health outcomes quantified in this article are written in bold. *hygiene behaviours include hand hygiene(diarrhoeal diseases, protein-energy malnutrition, trachoma), face hygiene (trachoma), food hygiene (hookworm) and bathing (schistosomiasis).

WASH-related disease

Not just infectious outcomes

PLOS WATER

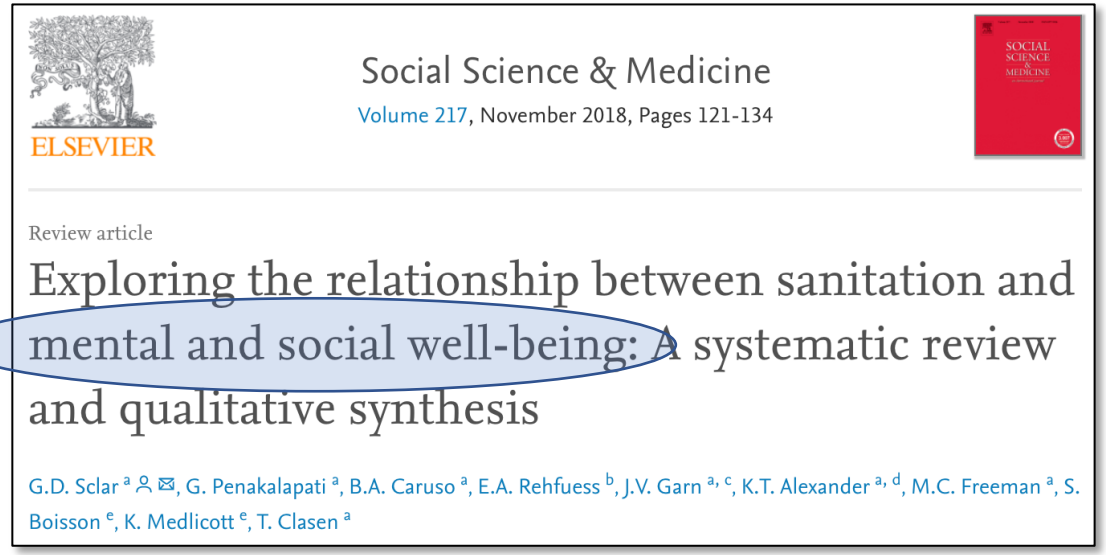
OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Water, sanitation, and women's empowerment: A systematic review and qualitative metasynthesis

Bethany A. Caruso, Amelia Conrad, Madeleine Patrick, Ajilé Owens, Kari Kviten, Olivia Zarella, Hannah Rogers, Sheela S. Sinharoy

Published: June 7, 2022 • https://doi.org/10.1371/journal.pwat.0000026



ELSEVIER

Social Science & Medicine

Volume 217, November 2018, Pages 121-134

Review article

Exploring the relationship between sanitation and mental and social well-being: A systematic review and qualitative synthesis

G.D. Sclar [a], G. Penakalapati [a], B.A. Caruso [a], E.A. Rehfuess [b], J.V. Garn [a, c], K.T. Alexander [a, d], M.C. Freeman [a], S. Boisson [e], K. Medlicott [e], T. Clasen [a]

CORRESPONDENCE | VOLUME 7, ISSUE 12, E1617, DECEMBER 01, 2019

Gender data gaps represent missed opportunities in WASH

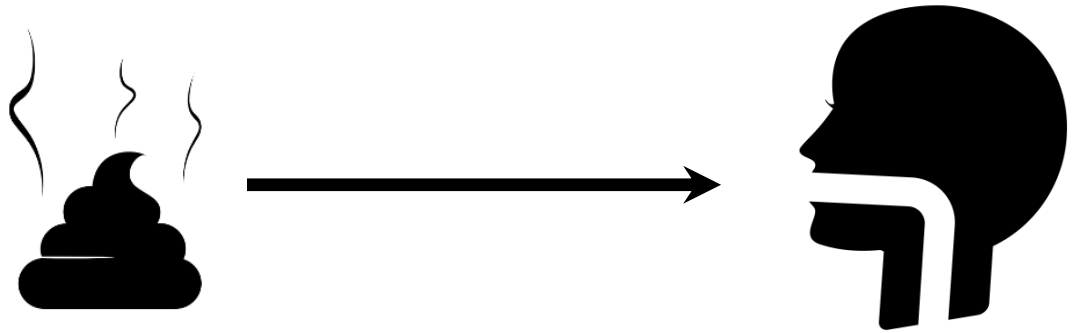
Bethany A Caruso • Sheela S Sinharoy

THE LANCET Global Health

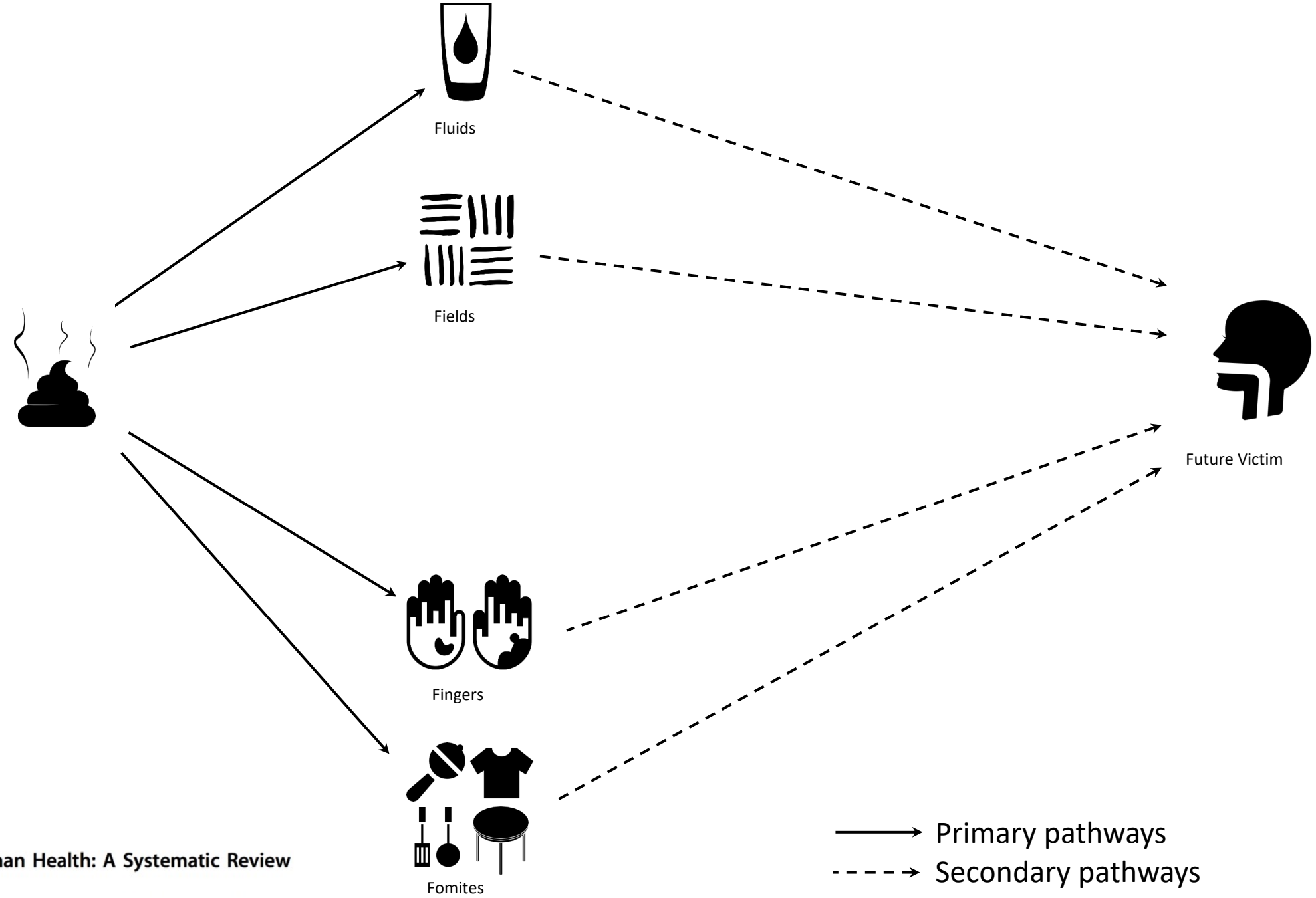
Open Access • Published: December, 2019 • DOI: https://doi.org/10.1016/S2214-109X(19)30449-8

Food and waterborne diseases

How do children get exposed to fecal pathogens?

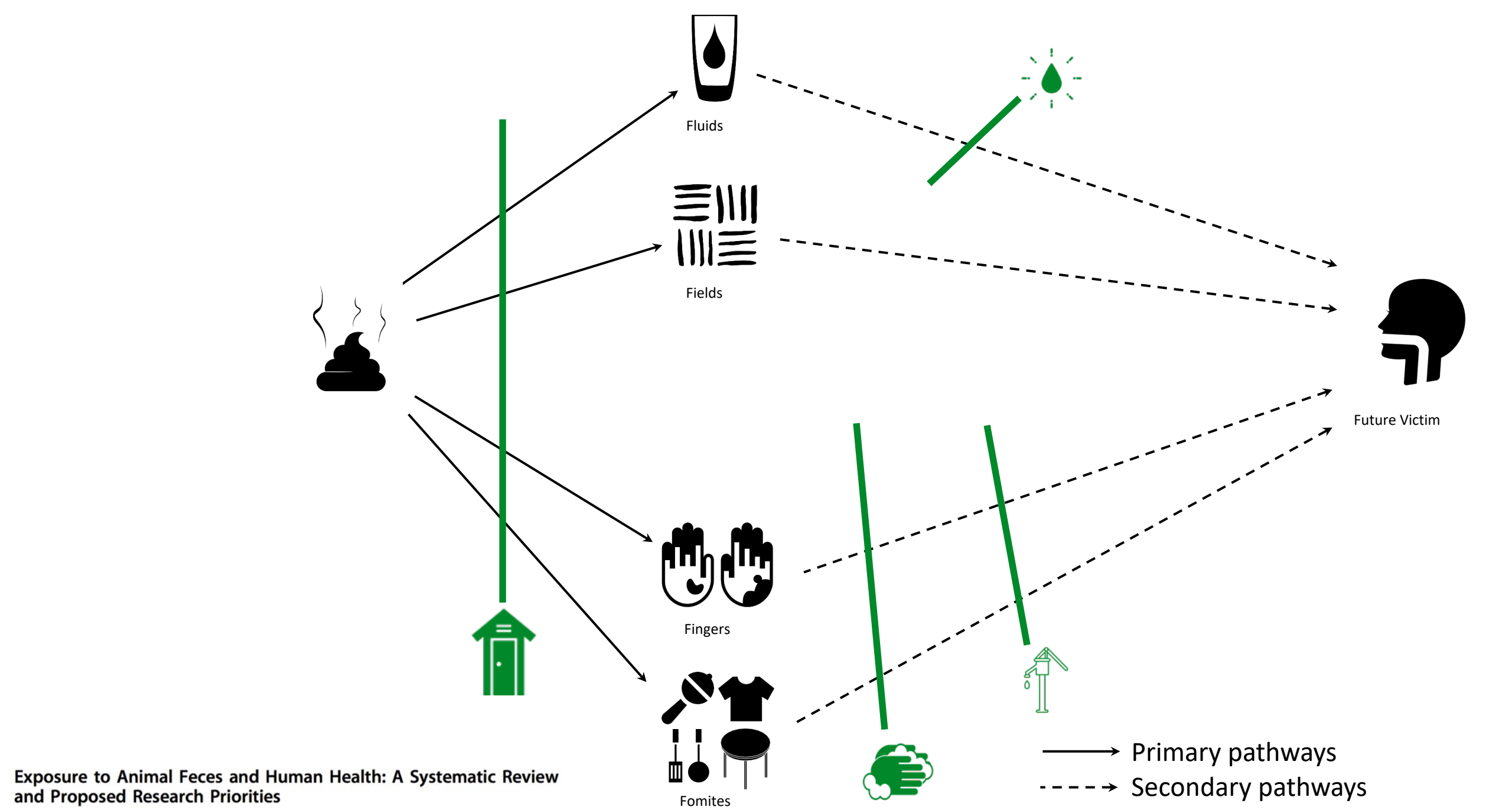


Future Victim



Exposure to Animal Feces and Human Health: A Systematic Review and Proposed Research Priorities

Gauthami Penakalapati, Jenna Swarthout, Miranda J. Delahoy, Lydia McAliley, Breanna Wodnik, Karen Levy, and Matthew C. Freeman*



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WASH-related illness

Improved WASH can prevent diarrheal diseases

Communities

Identifying WASH challenges and implementing solutions in households, schools, and other community settings can help prevent diarrhea, cholera, typhoid fever, or some antibiotic resistant infections.

Improve access to safe community water systems and household water treatment

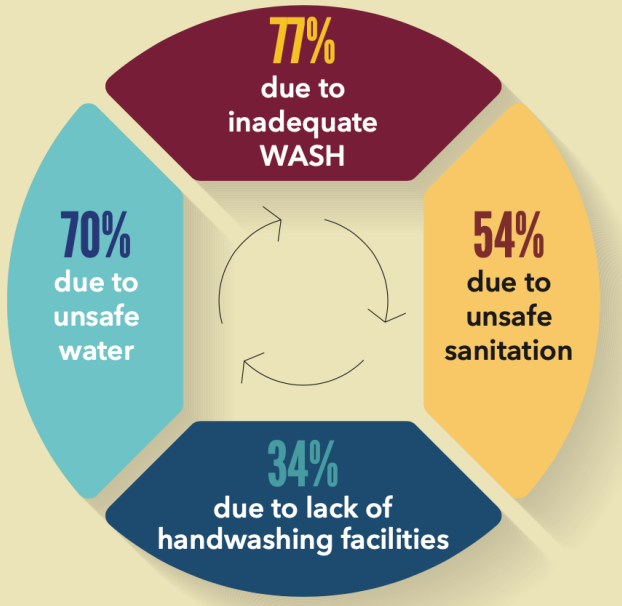
Safe Water

Manage fecal waste using new approaches

Sanitation

Increase access to and use of handwashing facilities

Hygiene



Source: GBD 2016 Diarrhoeal Disease Collaborators, Lancet estimates

WASH Benefits & SHINE RCTs

*What **pathways** are most effective at reducing diarrhea and stunting?*

		WASH-B Bangladesh	WASH-B Kenya	SHINE Zimbabwe
Stunting	IYCF	YES	YES	YES
	WASH	NO	NO	NO
Anemia	IYCF	YES	YES	YES
	WASH	NO	NO	NO
Diarrhea	IYCF	YES	NO	NO
	WASH	YES	NO	NO

IYCF: integrated young child feeding

Slide adapted from ASTMH 2017 SHINE session

What are the issues with WASH delivery?

And which can be addressed with IS?

1. **Hypothesis is incorrect**?
   - But we think the biological plausibility is strong
2. **Coverage: Is higher coverage needed, due to the role of indirect transmission**
   - Household-level targeted interventions do not account for infection pressure
3. **Adherence: Interventions must have higher uptake and consistent use/behavior**
   - Interventions are poorly designed and delivered for the communities they are trying to serve
4. **Completeness: WASH as commonly delivered is necessary but not sufficient for impact**
   - Interventions were insufficient to clean up highly contaminated environments enough to impact health
   - Need greater control of pathways to see health gains

What are the issues with WASH impact?

And which can be addressed with IS?

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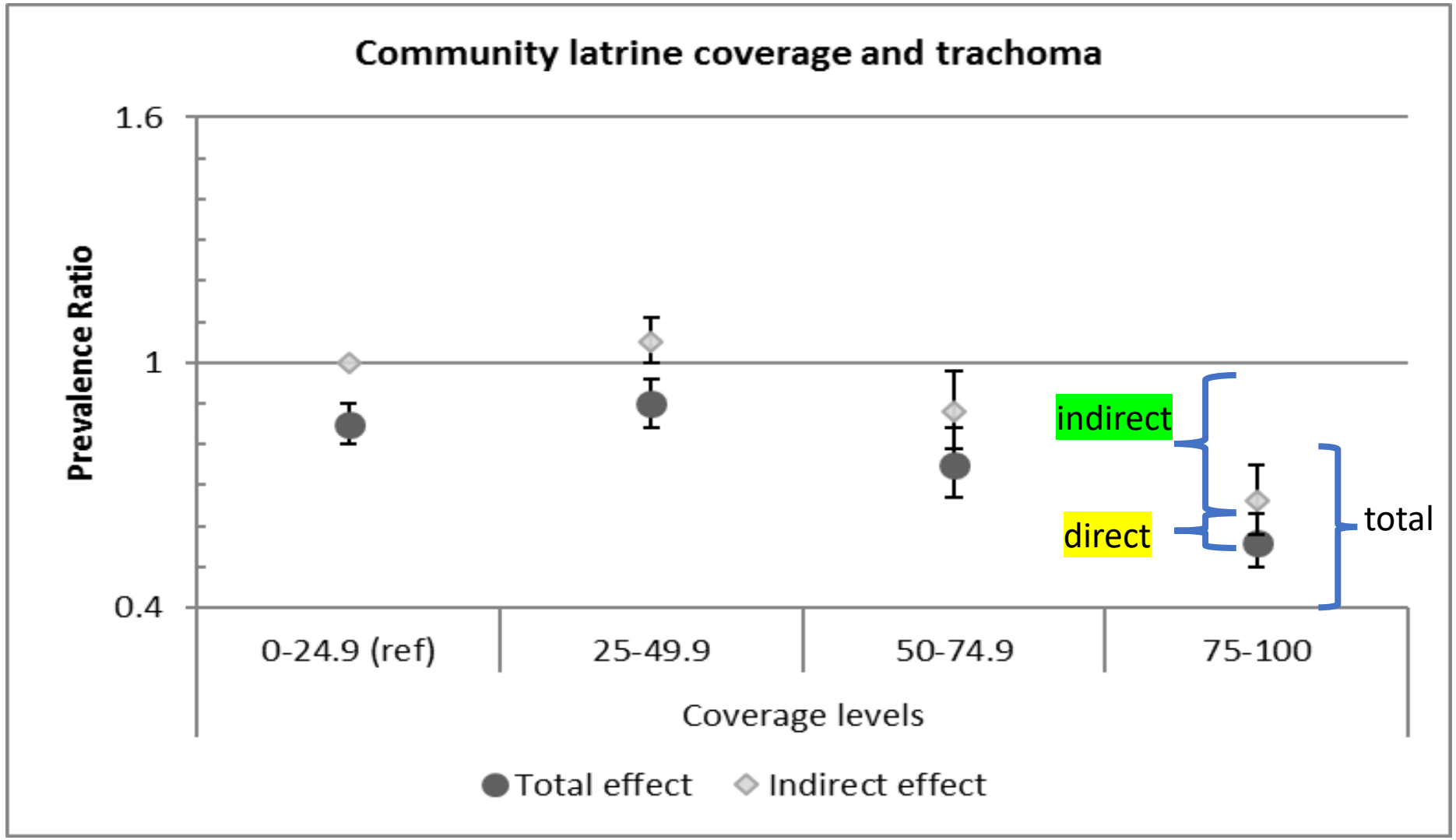
   - Interventions were insufficient to clean up highly contaminated environments enough to affect linear growth?
   - Need greater control of pathways to see health gains

Coverage Impact of sanitation on trachoma

Indirect effects are more important!
Coverage > 50% leads to decreased trachoma



- Indirect effects: community coverage of toilets
- Direct effects: household owning a toilets

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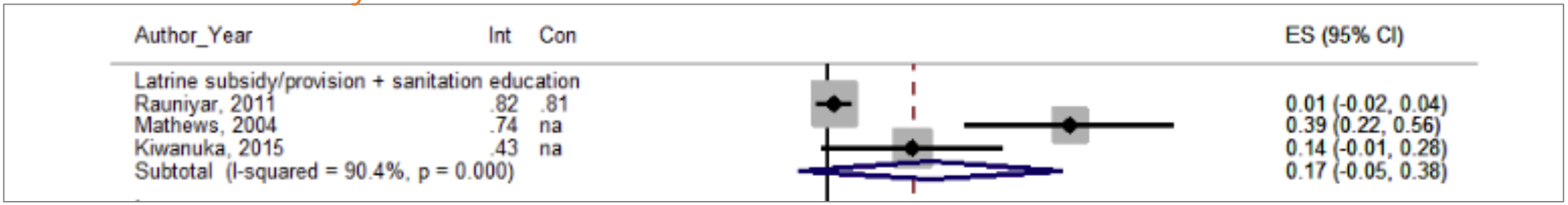
Challenges to adherance

Systematic review of the evidence



ELSEVIER

International Journal of Hygiene and Environmental Health

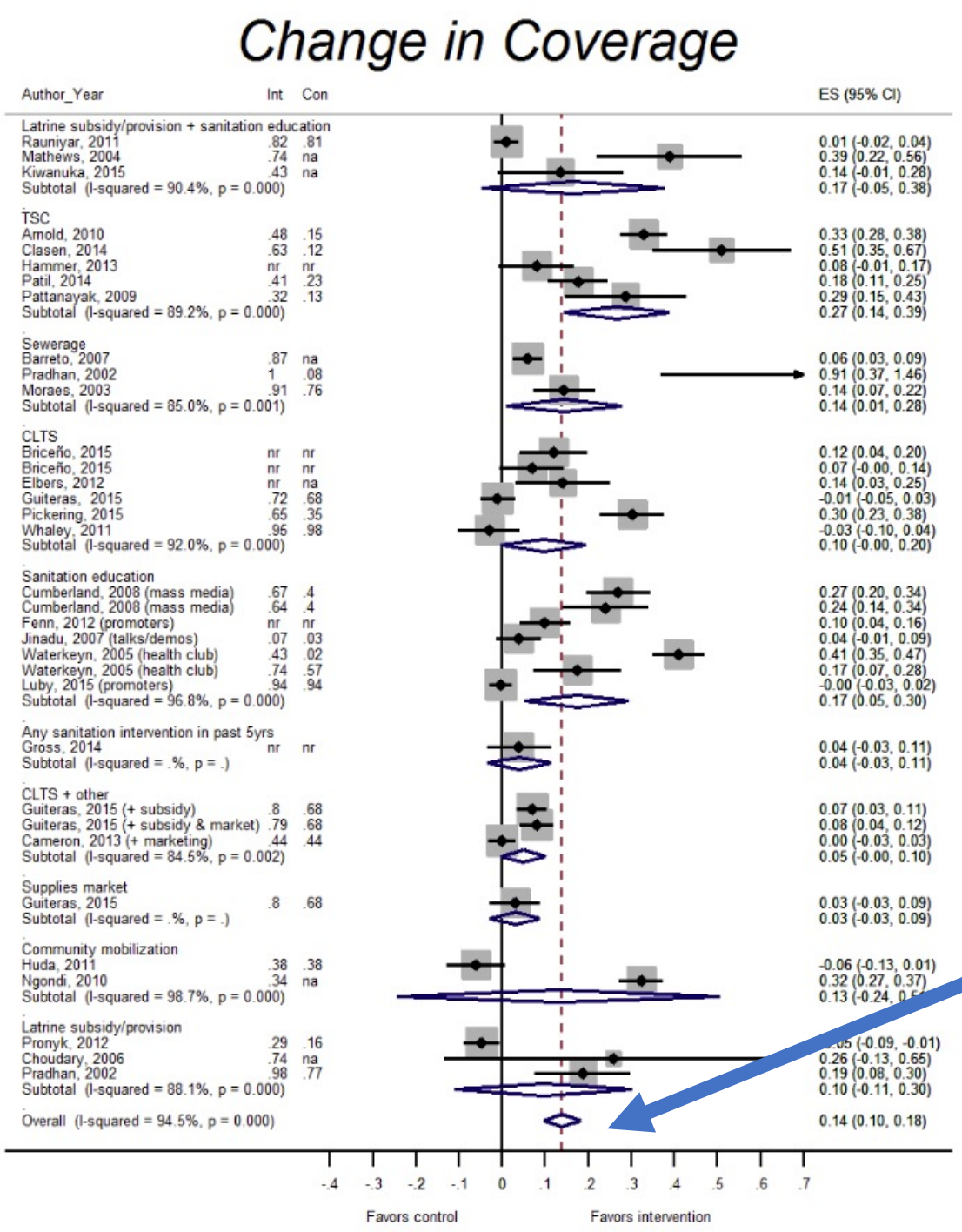
Volume 220, Issue 2, Part B, April 2017, Pages 329-340

Review

The impact of sanitation interventions on latrine coverage and latrine use: A systematic review and meta-analysis ☆

Joshua V. Garn [a], Gloria D. Sclar [a], Matthew C. Freeman [a], Gauthami Penakalapati [a], Kelly T. Alexander [a], Patrick Brooks [a], Eva A. Rehfuess [b], Sophie Boisson [c], Kate O. Medlicott [c], Thomas F. Clasen [a]

N= 28 studies



Adherence challenges with sanitation interventions

International Journal of Hygiene and Environmental Health
Volume 220, Issue 2, Part B, April 2017, Pages 329-340

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Overall difference: 14% (95% CI: 10%, 18%)

N= 28 studies

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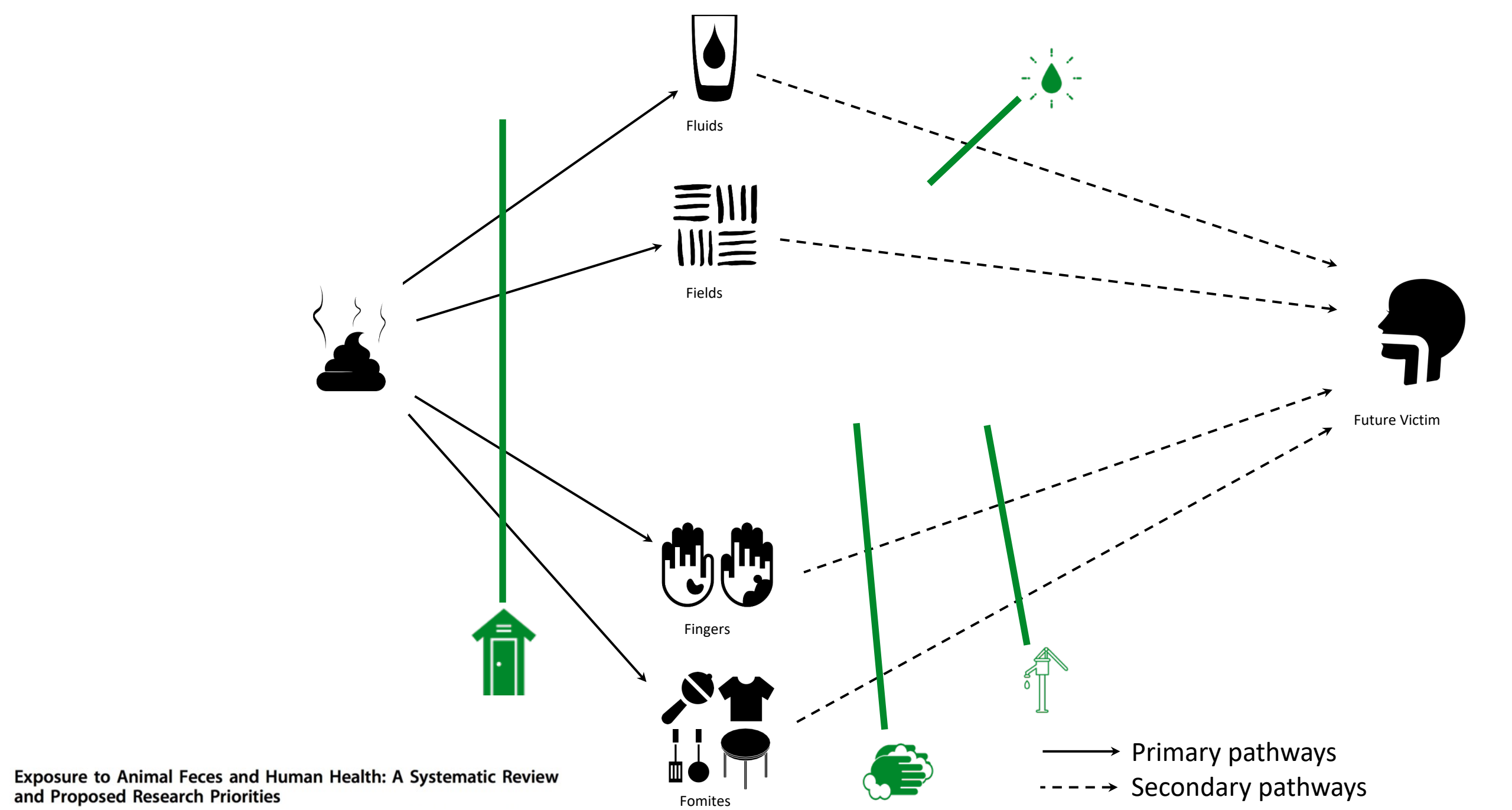

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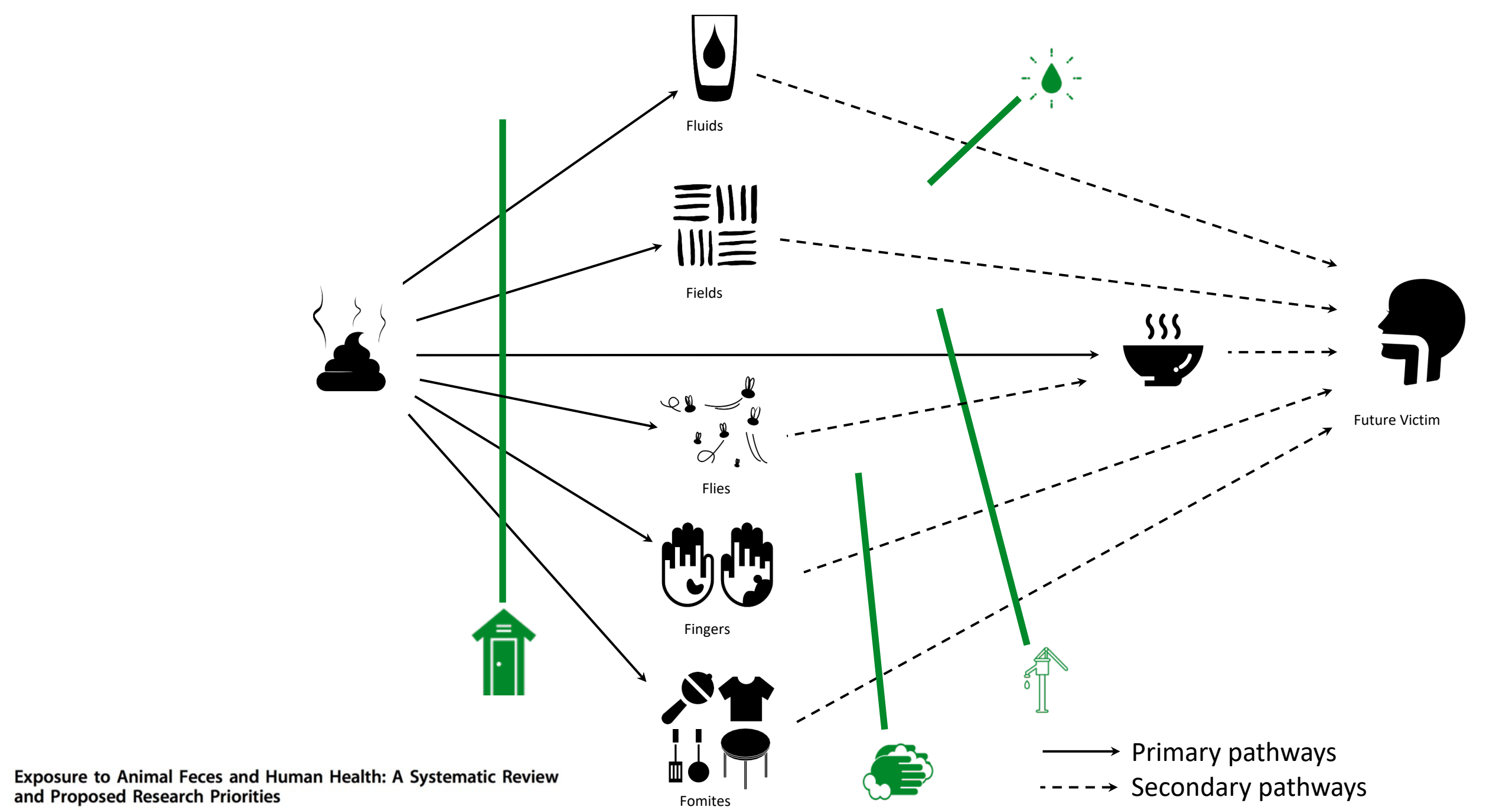
Gauthami Penakalapati,* Jenna Swarthout, Miranda J. Delahoy, Lydia McAliley, Breanna Wodnik, Karen Levy, and Matthew C. Freeman*



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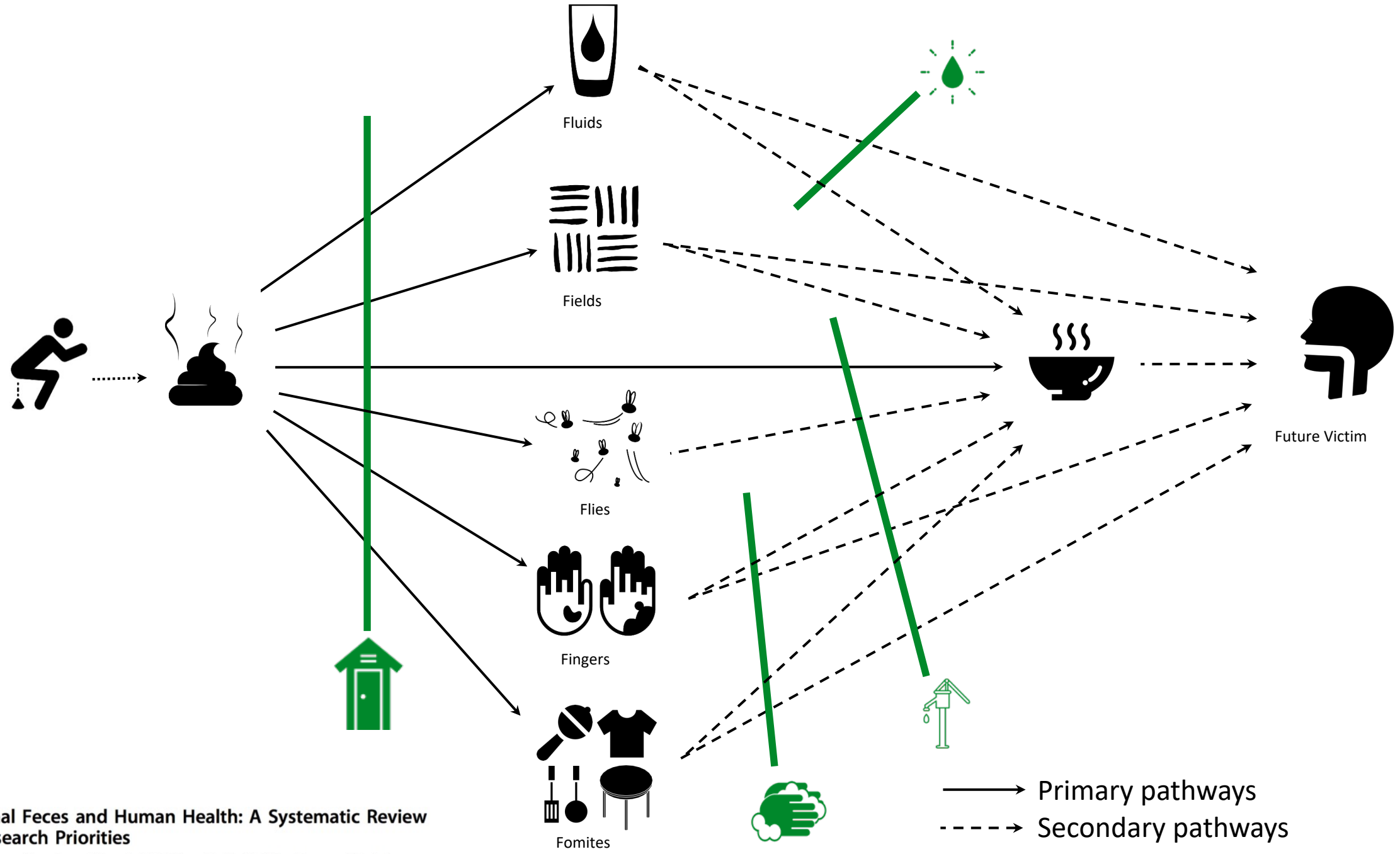

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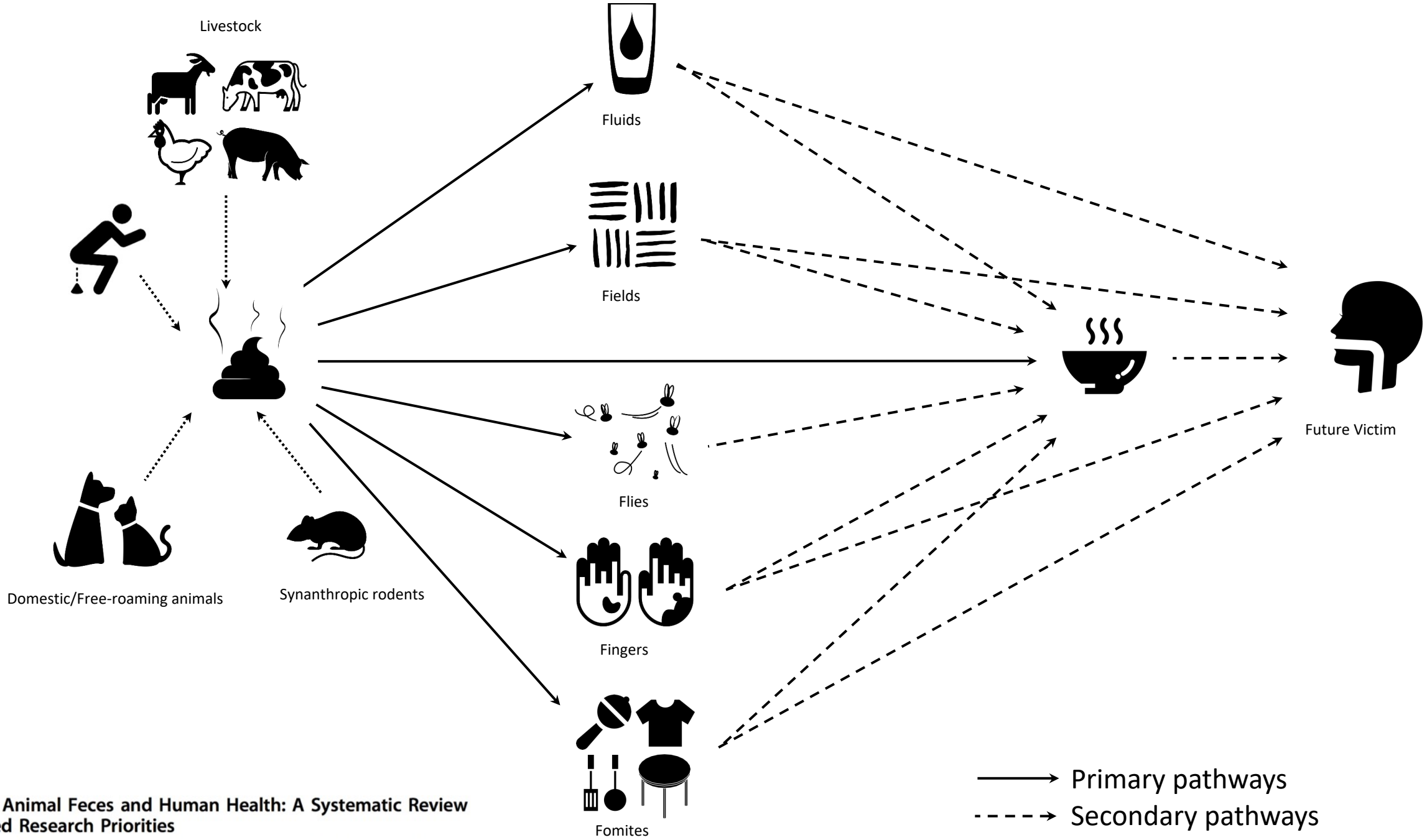

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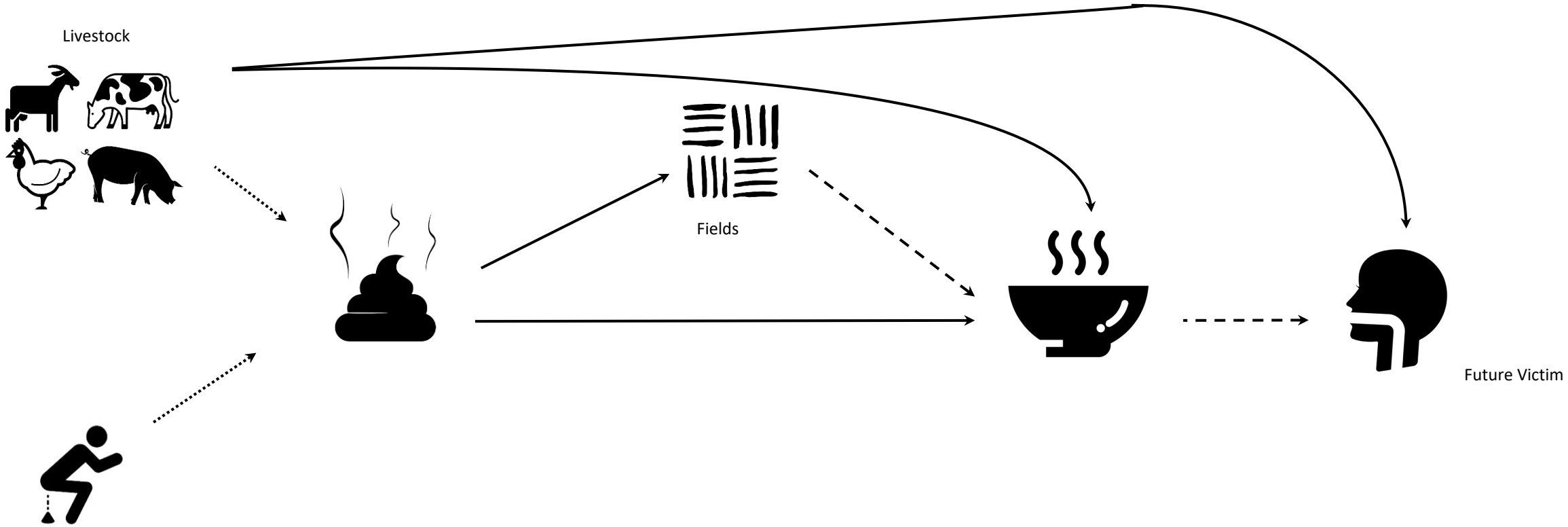
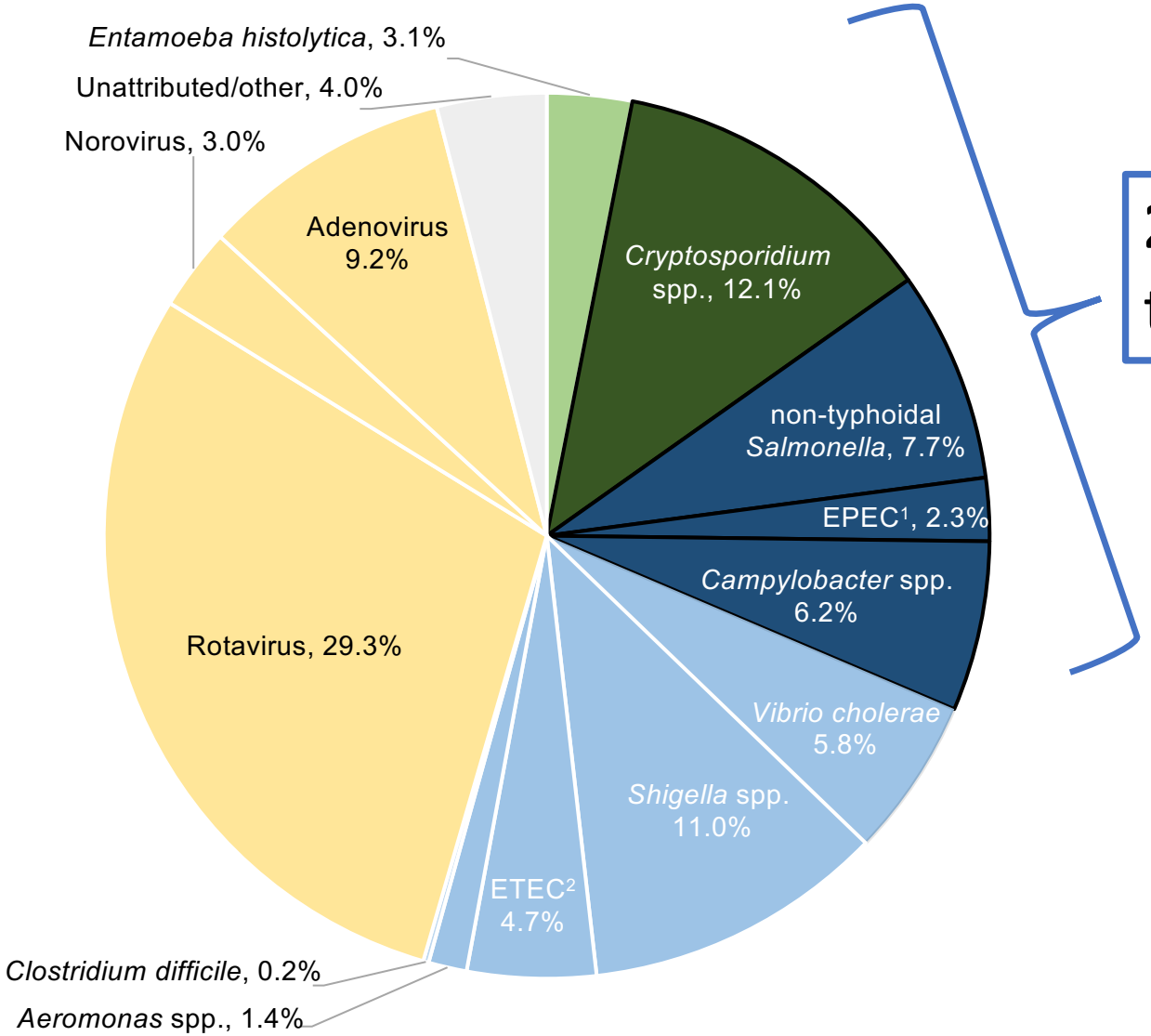

Livestock
Fields
Future Victim
Primary pathways
Secondary pathways

Attributable fraction of diarrhea deaths in children <5



28.3% of pathogens potentially transmitted via animals

LEGEND

Transmitted in animal feces

Bacteria Protozoa

Minimal/no transmission in animal feces*

Bacteria Protozoa Viruses

*or transmitted only by primates/aquatic animals

1. Typical and atypical Enteropathogenic *E. coli (*EPEC) combined; only atypical EPEC is transmitted in animal feces
2. Enterotoxigenic *E. coli* (ETEC) has animal hosts; zoonotic strains are not infectious to humans

International Journal of Hygiene and Environmental Health
Volume 221, Issue 4, May 2018, Pages 661-676

Review

Pathogens transmitted in animal feces in low- and middle-income countries

Miranda J. Delahoy, Breanna Wodnik, Lydia McAliley, Gauthami Penakalapati, Jenna Swarthout, Matthew C. Freeman, Karen Levy*

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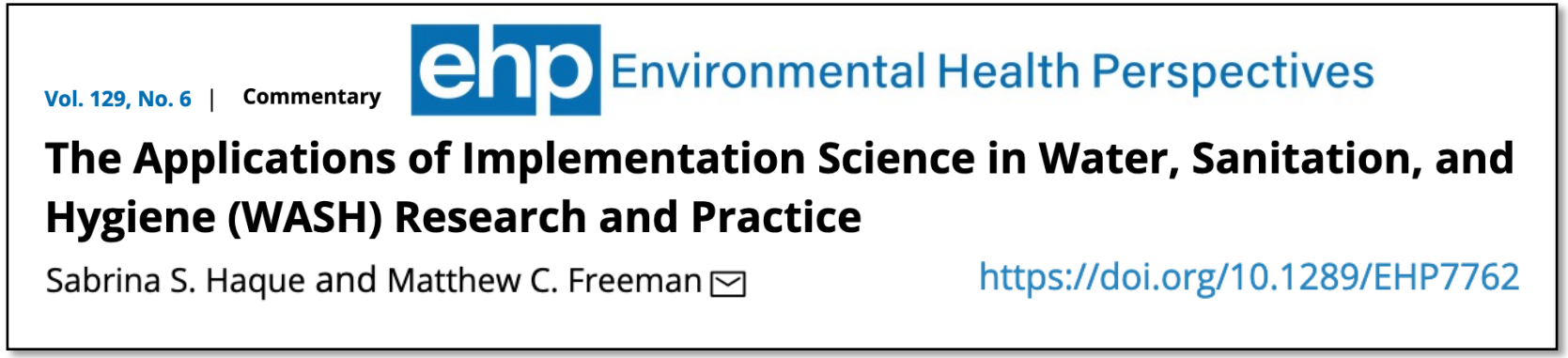
WASH and its many challenges

- An intervention in search of an impact?

1. Complex innovation and implementation requirements;
2. Limited external validity of interventions;
3. Inconsistent development sector objectives; and
4. Diverse service providers working at multiple levels



Based on what you know so far, what do you think are the key implementation challenges?

How do you think these challenges can be addressed with implementation science?

➡ https://l.ead.me/bd6rSh

What IS offers: Theories and Frameworks

- Application of a range of theory and frameworks in intervention design, evaluation, and knowledge translation and adaptation
- Promotes structure and shared language
- 5 categories IS theories/frameworks/models (Nilson 2015):

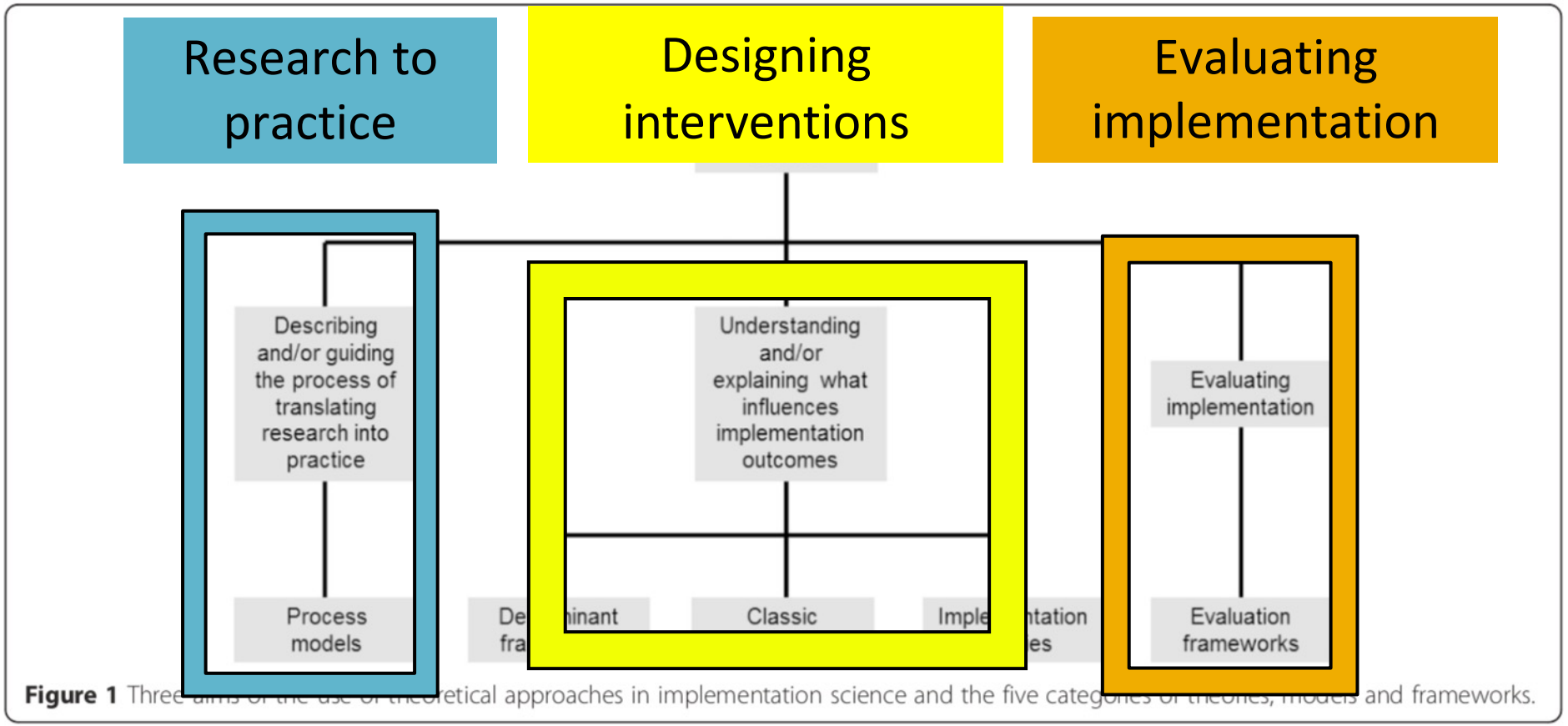
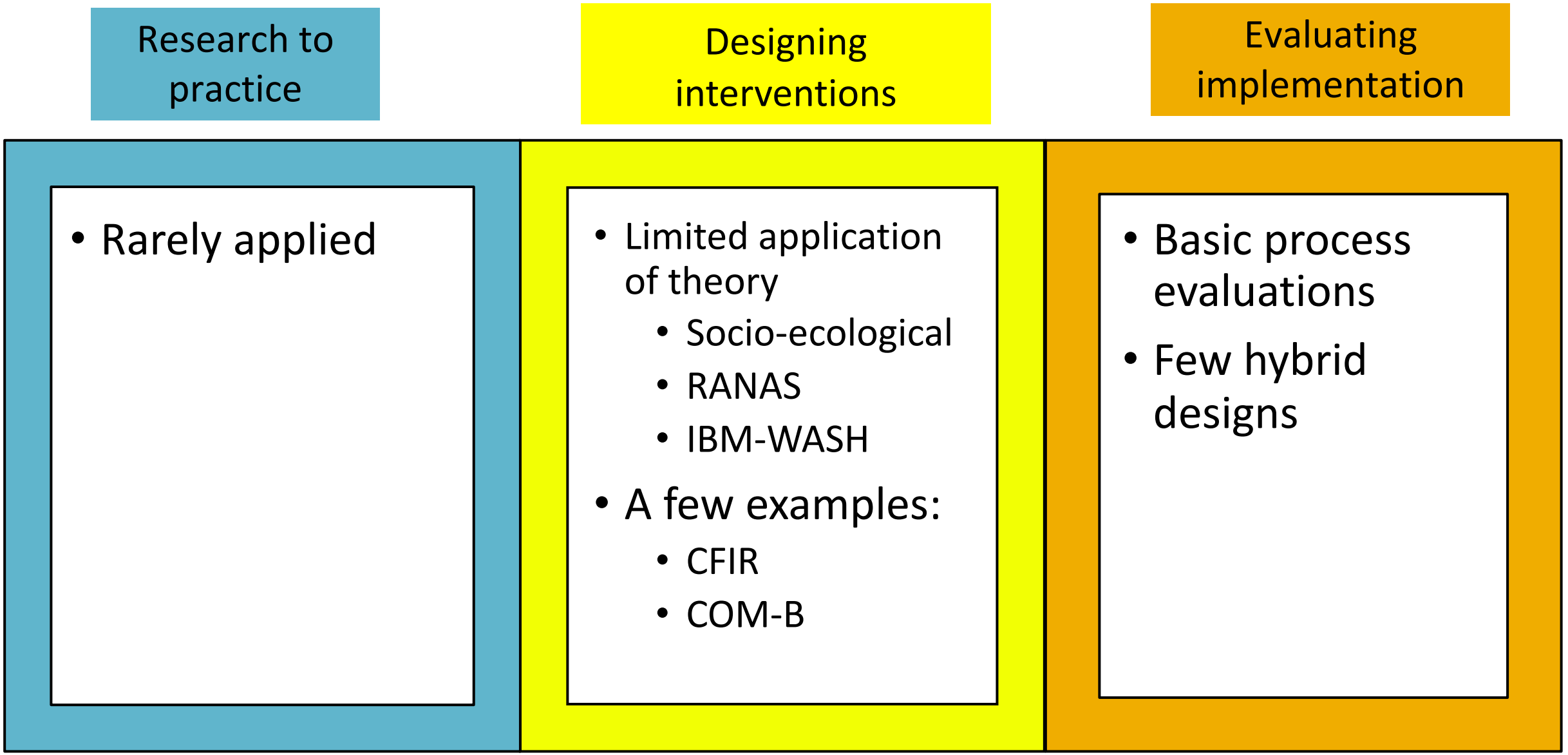


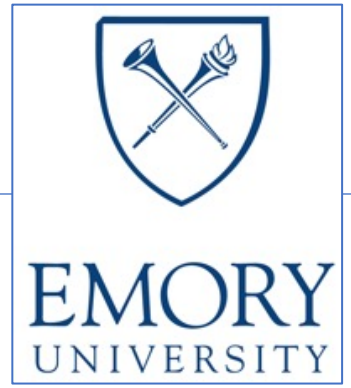
Figure 1 Three aims of the use of theoretical approaches in implementation science and the five categories of theories, models and frameworks.

Theories and Frameworks for WASH



Two quick examples

Designing and testing an integrated WASH interventions



Chakrouk Makare: Designing and testing an integrated WASH and nutrition intervention

- Location: Western Kenya
- Design a behaviour-centered package of integrated behavior change messages and low-cost interventions
- Test its effectiveness on **sustained behaviour change**.

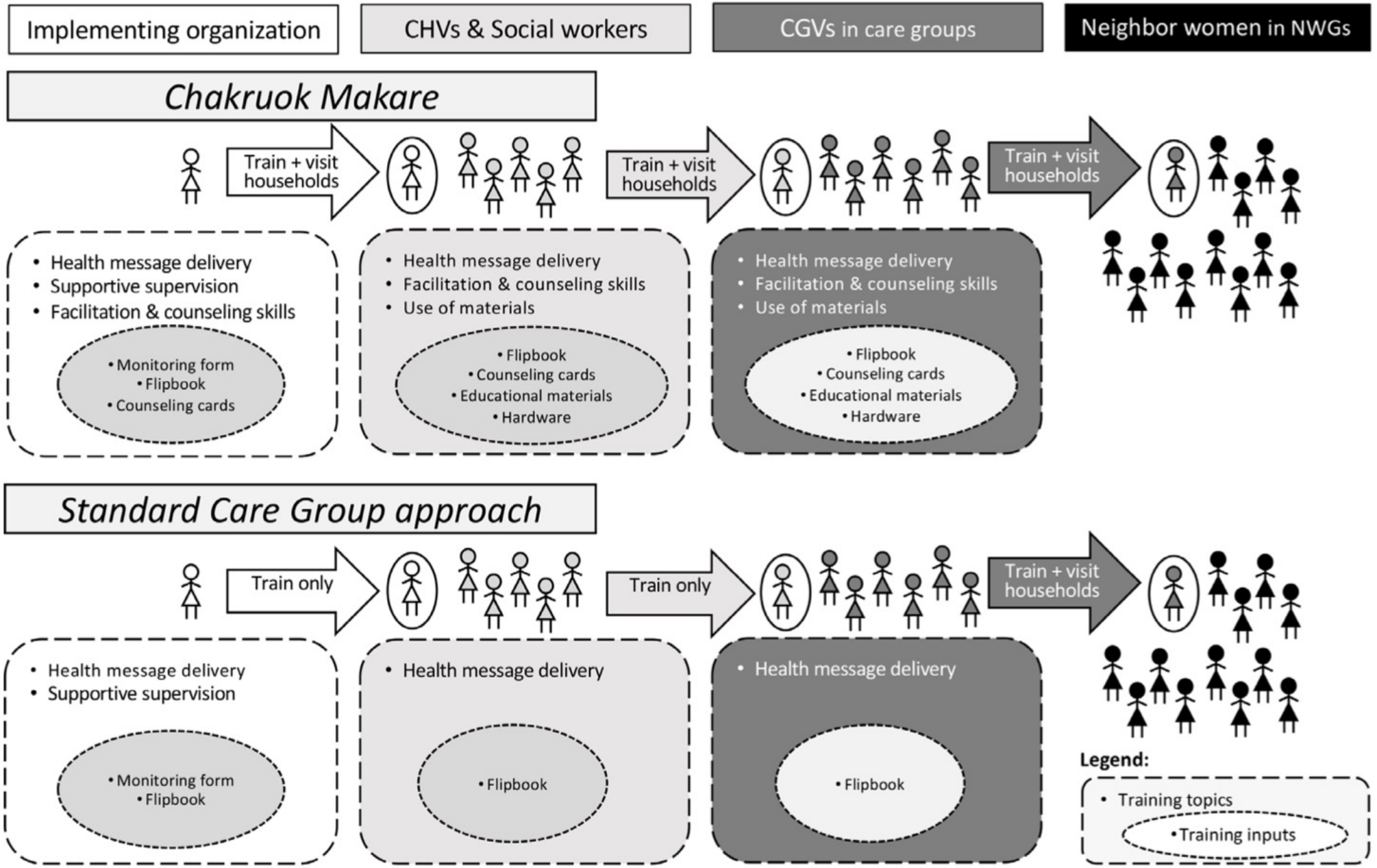
CHAKRUOK MAKARE
Ngima nyathiwa, mwanduwa

EMORY UNIVERSITY

BMJ Global Health

Impact of a demand-side integrated WASH and nutrition community-based care group intervention on behavioural change: a randomised controlled trial in western Kenya

Matthew C Freeman ,[1,2] Anna S Ellis,[1] Emily Awino Ogutu,[2] Bethany A Caruso ,[2] Molly Linabarger,[2] Katie Micek,[1] Richard Muga,[3] Amy Webb Girard ,[2] Breanna K Wodnik ,[2] Kimberly Jacob Arriola [4]



CHV: Community health volunteers; CGVs: care group volunteers; NWGs: neighbor women groups

Chakrouk Makare: Designing and testing an integrated WASH and nutrition intervention

Table 4 The impact of the intervention on primary behavioural outcomes

Primary outcomes	Baseline Int. N=134	Baseline Control N=133	Endline Int. N=126	Endline Control N=121	Risk double difference %, (95% CI)*
1. Households with hygienic food prep area	5 (4)	3 (2)	45 (36)	12 (10)	21 (4 to 39)
2. Households who store food hygienically	13 (34)	17 (52)	22 (43)	14 (34)	27 (0 to 55)
3. Households with a functional handwashing station	4 (3)	12 (9)	44 (40)	0 (0)	44 (30 to 58)
4. Households with a safe play environment for children 6–24 months of age	15 (24)	23 (32)	40 (69)	24 (47)	31 (37 to 58)
5. Pregant and lactating women who consumed 5+ food groups in previous 24 hours	22 (27)	17 (21)	34 (52)	17 (32)	15 (–5 to 35)
6. Children 6–24 months who consumed 4+ food groups in previous 24 hours	20 (30)	23 (32)	32 (55)	19 (37)	21 (–4 to 45)
7. Caretaker fed thickened porridge to child	1 (2)	2 (3)	82 (68)	14 (12)	57 (47 to 68)

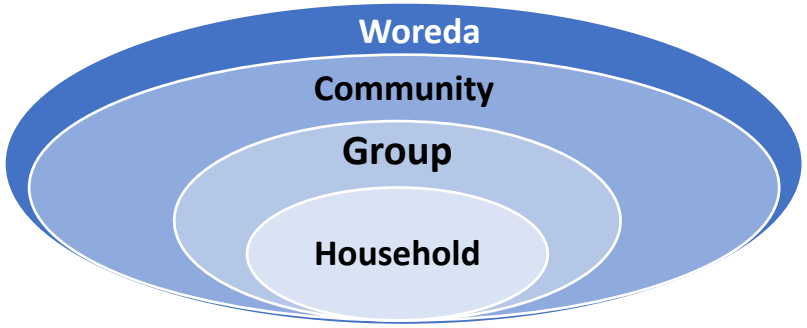
*Risk double difference calculated using generalised estimating equations is the difference between treatment ar[illegible] at endline, controlling baseline values, accounting for community-level clustering.

Andilaye: Designing and testing a sanitation and hygiene intervention

- **Design for scale** a behaviour-centered package of **holistic** preventive sanitation and hygiene interventions
- **Test** its effectiveness on **sustained behaviour change** and **health**.

Outcomes

- Mental well being
- Focus on sustaining behaviors
- Sanitation & water security security



- Complimented the existing health extension program of the MoH

THE WORLD BANK
International Initiative for Impact Evaluation
AMHARA REGIONAL Health Bureau
CIFF CHILDREN'S INVESTMENT FUND FOUNDATION
WSSCC WATER SUPPLY & SANITATION COLLABORATIVE COUNCIL

Andilaye intervention

3 Key behaviours of Interest / 11 practices

Theme 1: **Sanitation**

1. Construct a long-lasting latrine that is comfortable and hygienic
2. All household members use a latrine every time they defecate
3. Immediately dispose of children's feces into the latrine
4. **Repair your latrine** whenever it is damaged
5. Upgrade your latrine so it becomes more long lasting, comfortable, and hygienic
6. Close your pit when it becomes full and reconstruct a new latrine

Theme 2: **Personal hygiene**

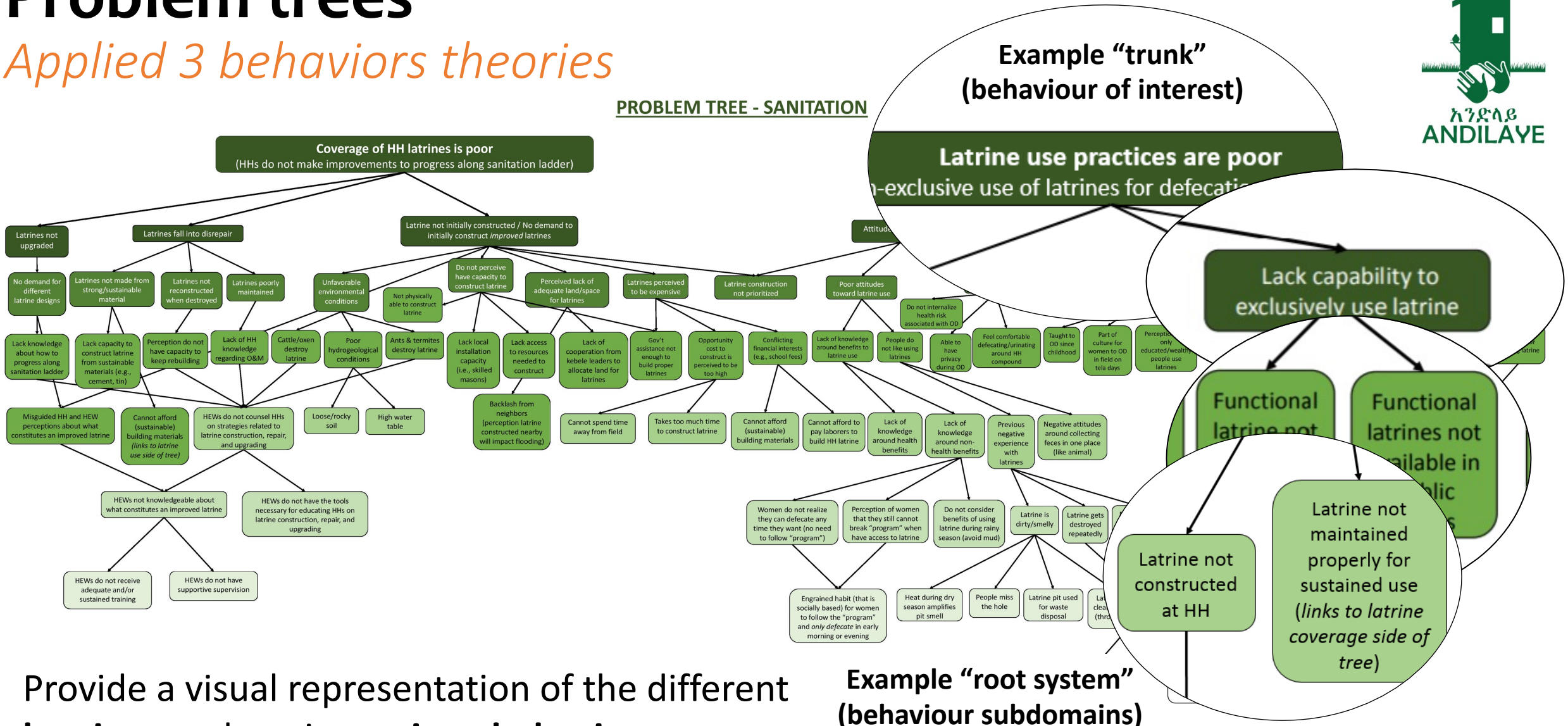
7. All household members wash their hands with water and soap or soap substitute AFTER handling animal and human feces, even children's feces
8. All household members wash their hands with water and soap or soap substitute BEFORE handling food
9. All household members **wash their faces** with water whenever they are dirty and use soap when it is available

Theme 3: **Household environmental sanitation**

10. Keep **all animals separated from the house**
11. Keep the household compound clean by **disposing of all animal feces** and other waste on a DAILY basis

Problem trees

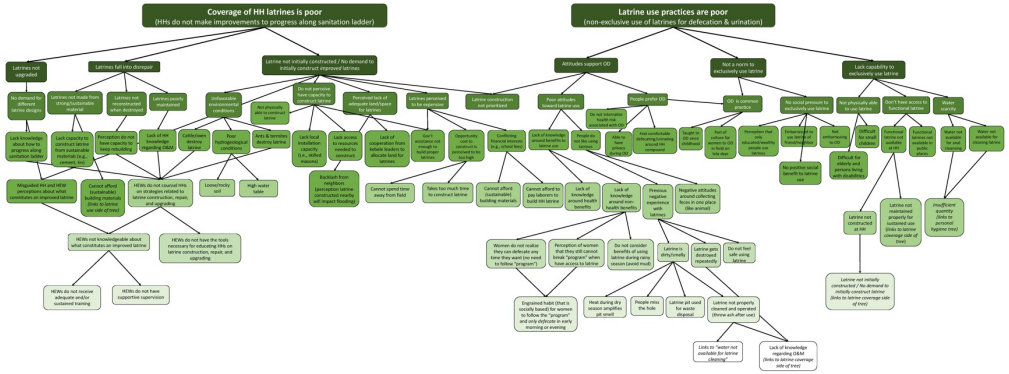
Applied 3 behaviors theories



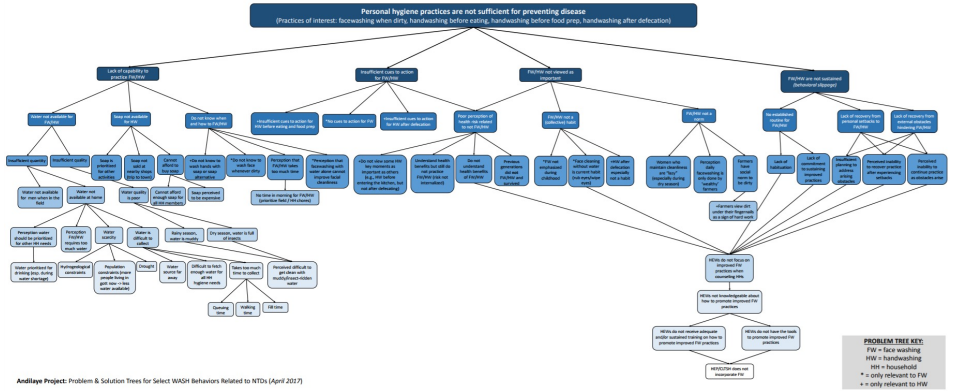
Provide a visual representation of the different **barriers** to changing **a given behavior**

Problem trees

1. Sanitation

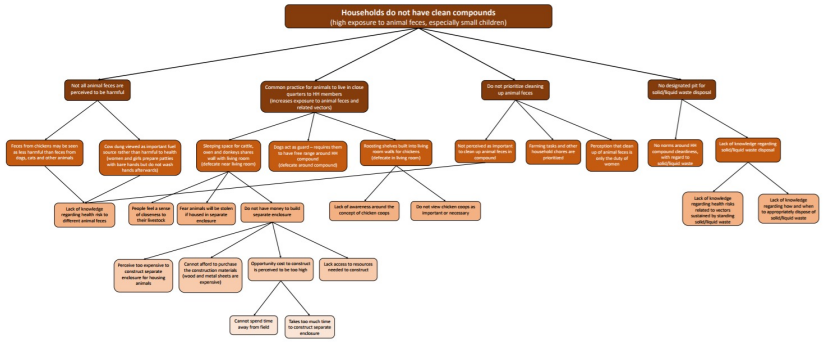


2. Personal Hygiene



Andilaye Project: Problem & Solution Trees for Select WASH Behaviors Related to NTDs (April 2017)

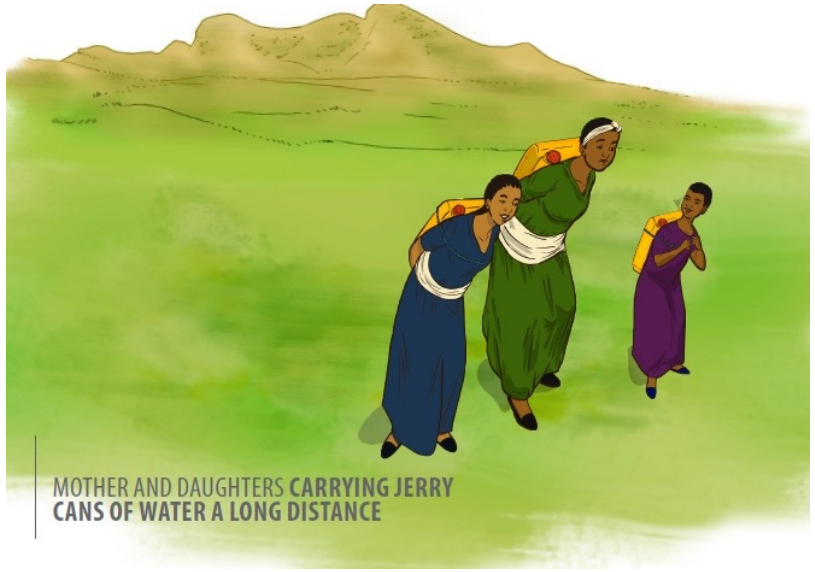
3. Household Environmental Sanitation



Andilaye intervention

WDAL ‘Good Job!’ Flipbook – Example ‘facewashing’

❖ **Recognition of barriers (barrier identification)**



Face-washing requires collecting more water, which is a burden

❖ **Solutions to barriers (barrier planning, action knowledge)**

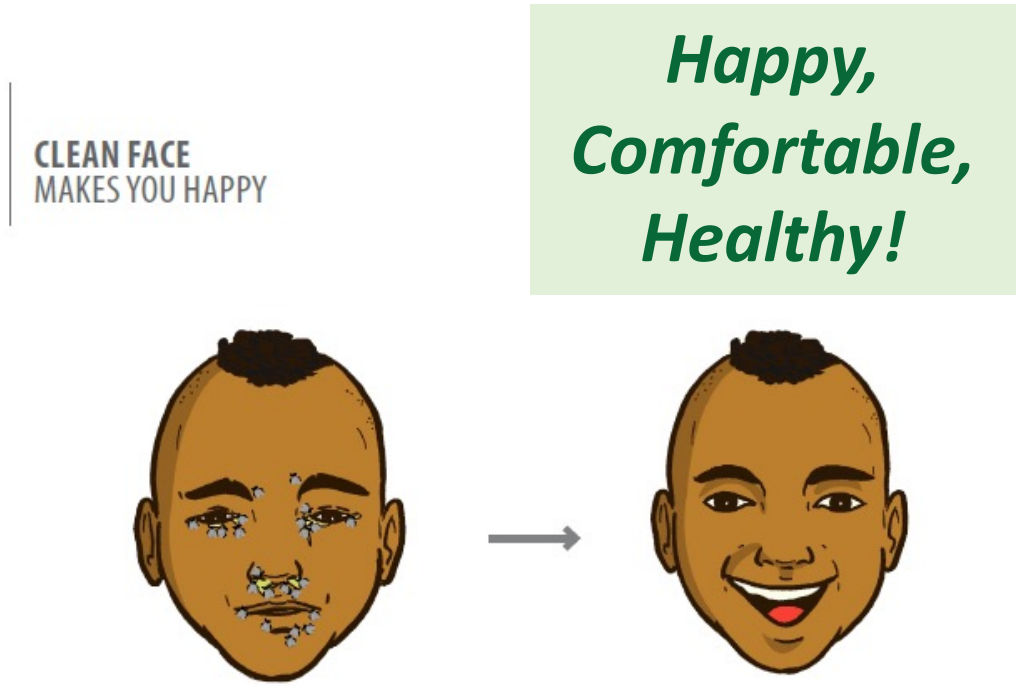
Face-washing only requires a handful of water! (break the barrier misconception)

Empirically derived drivers and barriers

Andilaye intervention

WDAL 'Good Job!' Flipbook – Example 'facewashing'

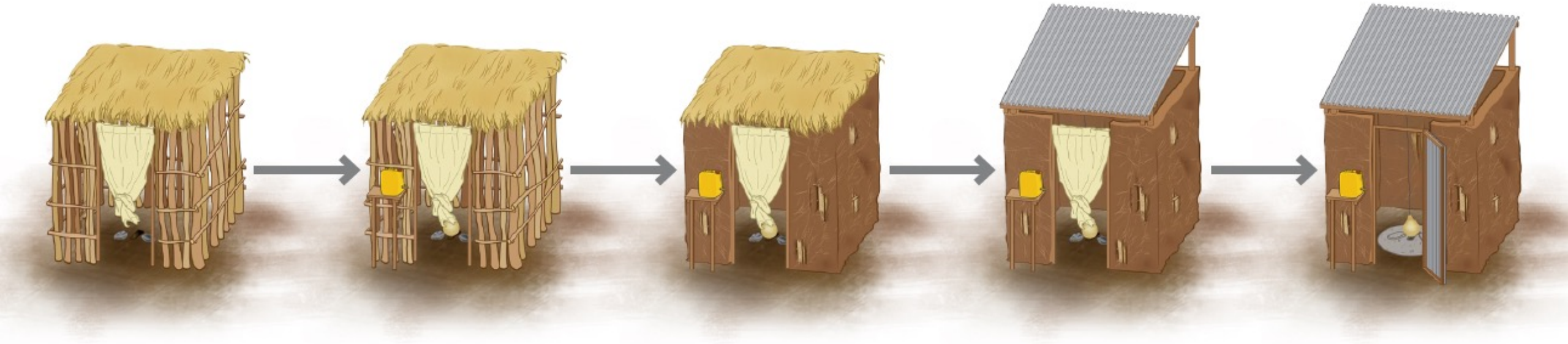
❖ **Benefits to the behaviour (health and <u>non-health</u> motives)**



Empirically derived drivers and barriers

Andilaye intervention

AWDAL ‘Good Job!’ Flipbook – Example ‘latrine upgrades’



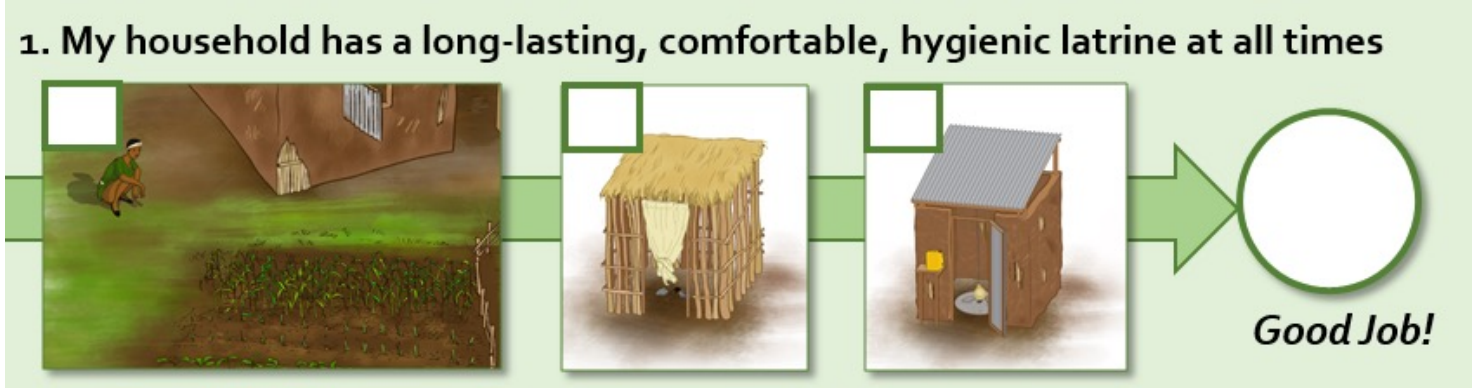
1) ***Comfort***
2) ***Hygiene***
3) ***Durability***

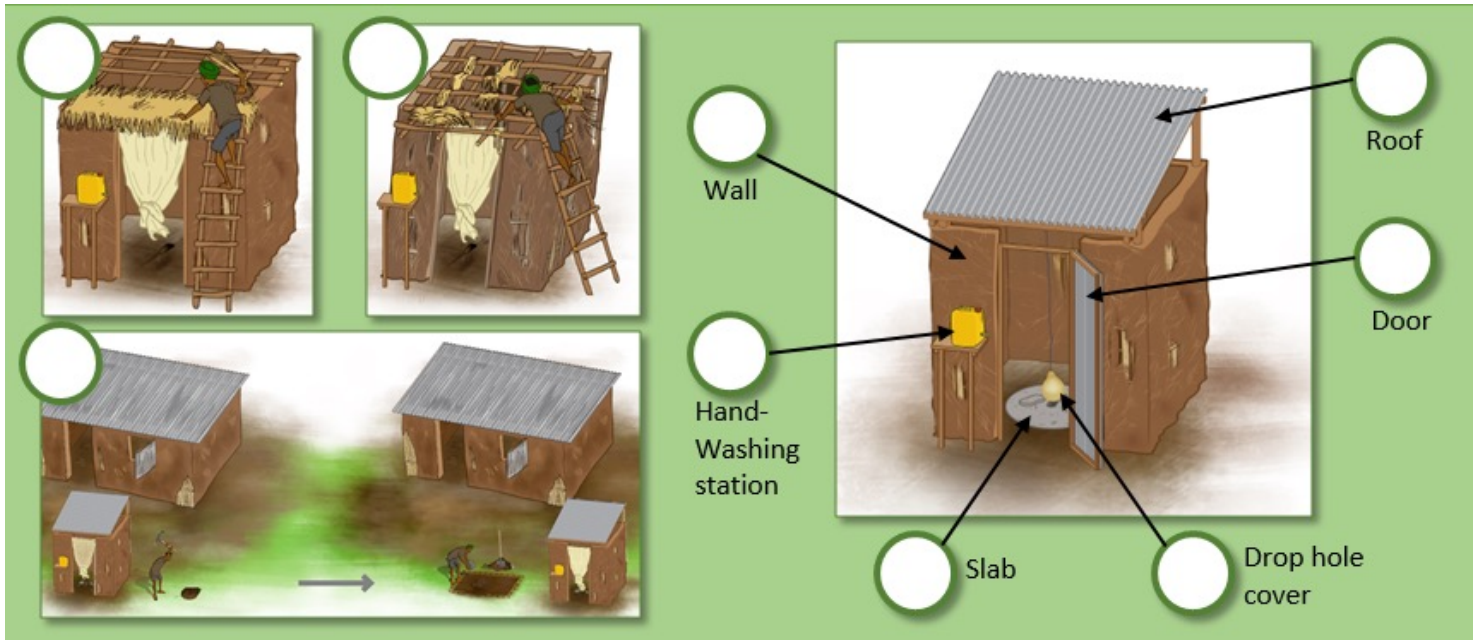
Incremental improvement: upgrading latrine

Andilaye intervention

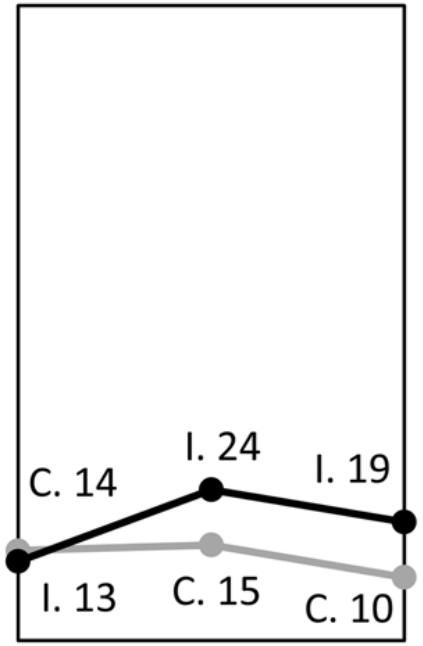
Andilaye Household Goal Card

- Used by caregiver during counseling visit to set household goals towards achieving WASH behaviours
- Goal card acts as commitment and reminder
- Promotes accomplishing goals through incremental improvements





(S3) Presence of drop hole cover in the latrine



Legend:

B = Baseline
(March to April 2017)

M = Midline
(March to April 2018)

E = Endline
(March to May 2019)

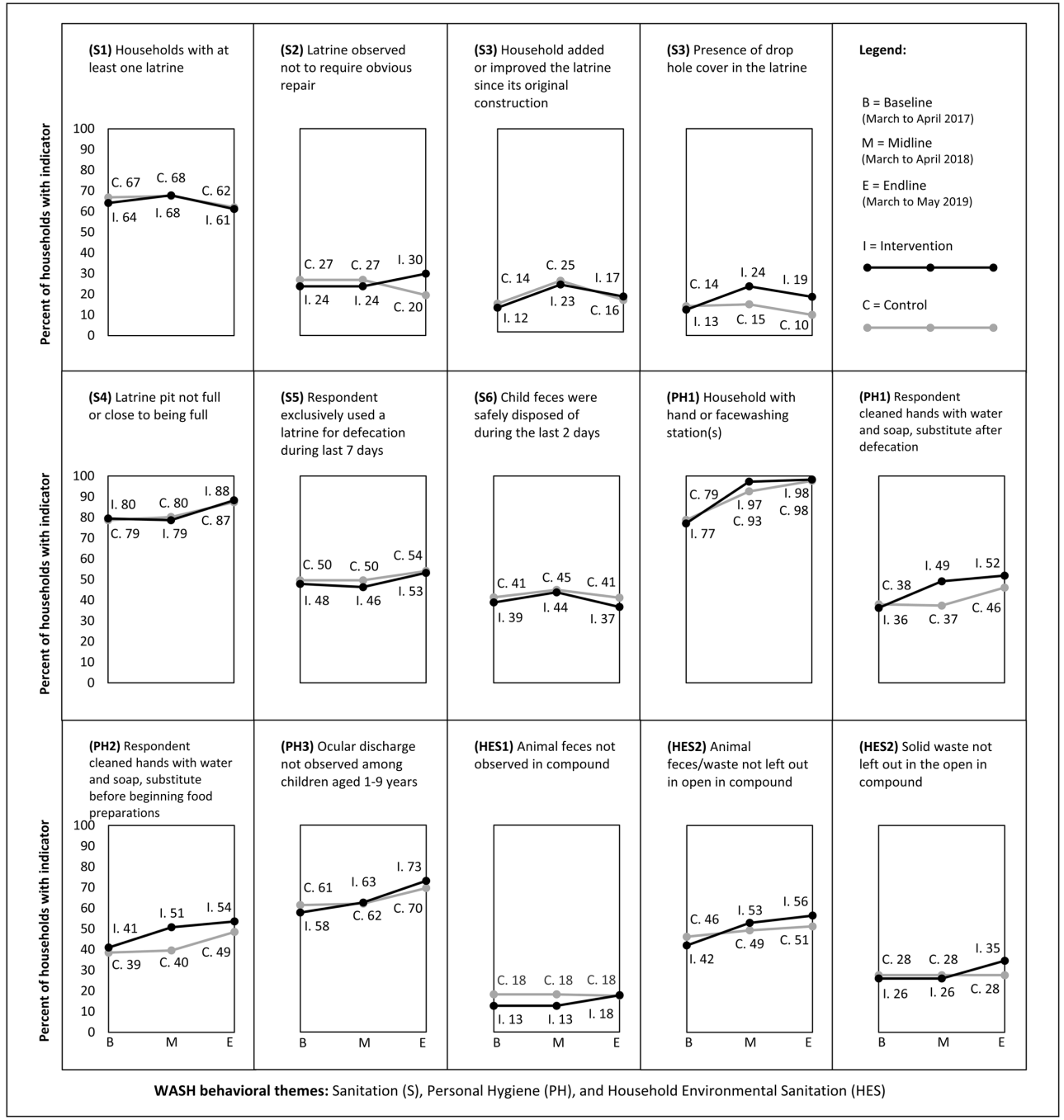
I = Intervention

C = Control

RESEARCH ARTICLE PLOS GLOBAL PUBLIC HEALTH

The impact of a demand-side sanitation and hygiene promotion intervention on sustained behavior change and health in Amhara, Ethiopia: A cluster-randomized trial

Matthew C. Freeman[1]*, Maryann G. Delea[1], Jedidiah S. Snyder[1], Joshua V. Garn[2], Mulusew Belew[3], Bethany A. Caruso[4], Thomas F. Clasen[1], Gloria D. Sclar[1], Yihenew Tesfaye[5], Mulat Woreta[3], Kassahun Zewudie[3], Abebe Gebremariam Gobezayehu[3,6]



Basically no effect on anything!

RESEARCH ARTICLE **PLOS GLOBAL PUBLIC HEALTH**

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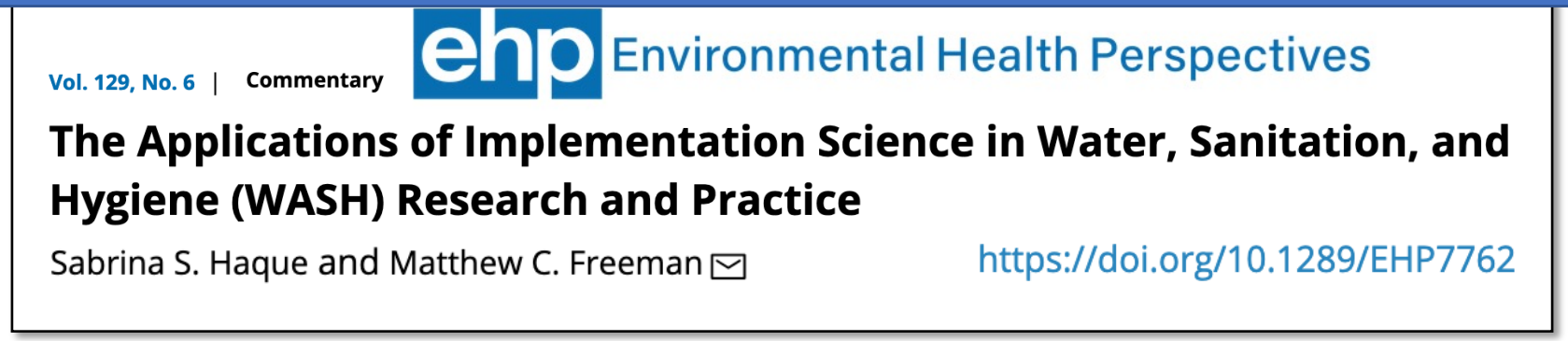
Talk objectives

1. What is WASH and what are the key challenges facing the sector?
2. How can implementation science be applied for the control of food and waterborne disease in low and middle-income countries
3. What are the priority challenges and opportunities to WASH implementation research

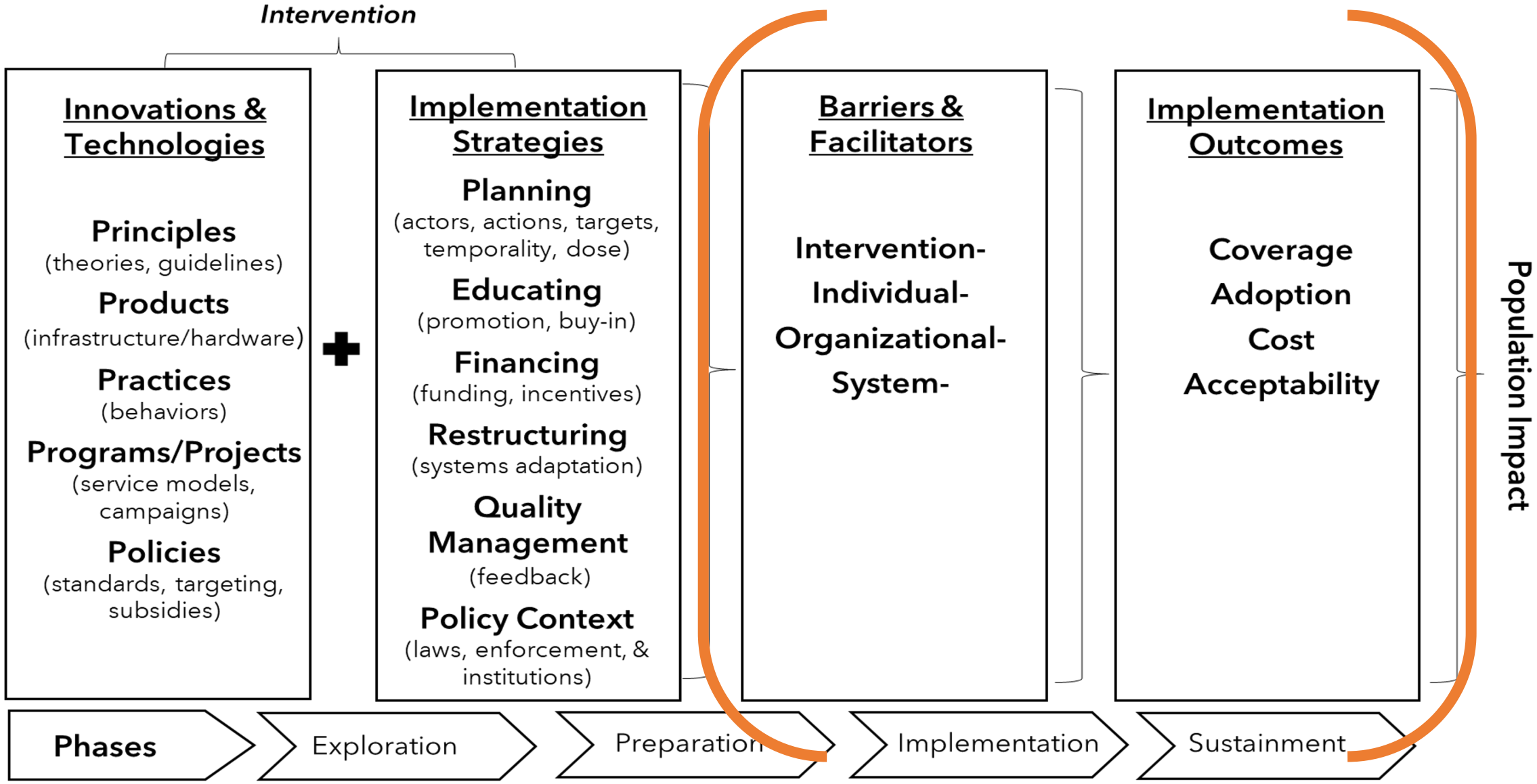
WASH and its many challenges

- An intervention in search of an impact?

1. Complex innovation and implementation requirements;
2. Limited external validity of interventions;
3. Inconsistent development sector objectives; and
4. Diverse service providers working at multiple levels



Focus on intervention development?



Haque and Freeman et al. 2021 - adapted from Proctor et al. 2009 and builds on concepts from Brown et al. 2017; Powell et al. 2012; Powell et al. 2020

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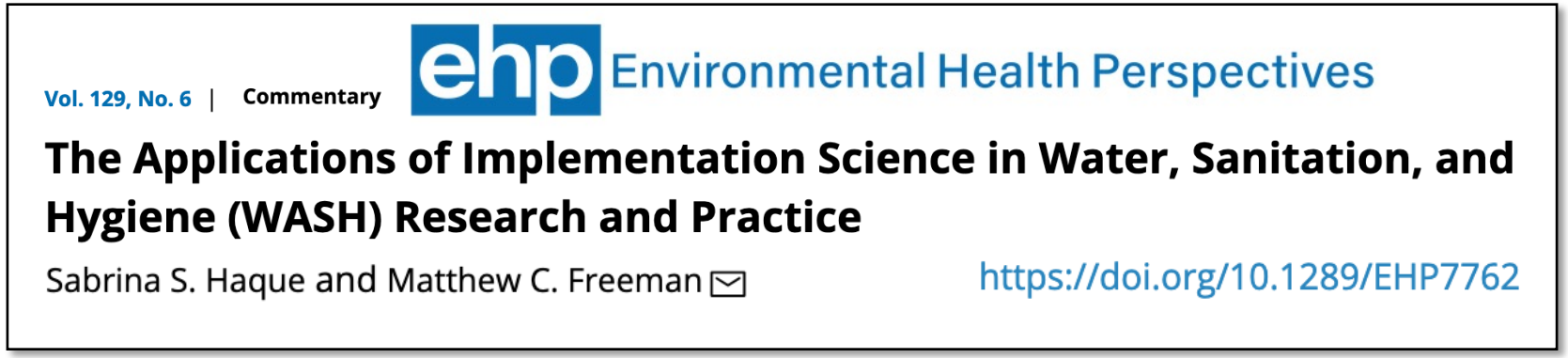
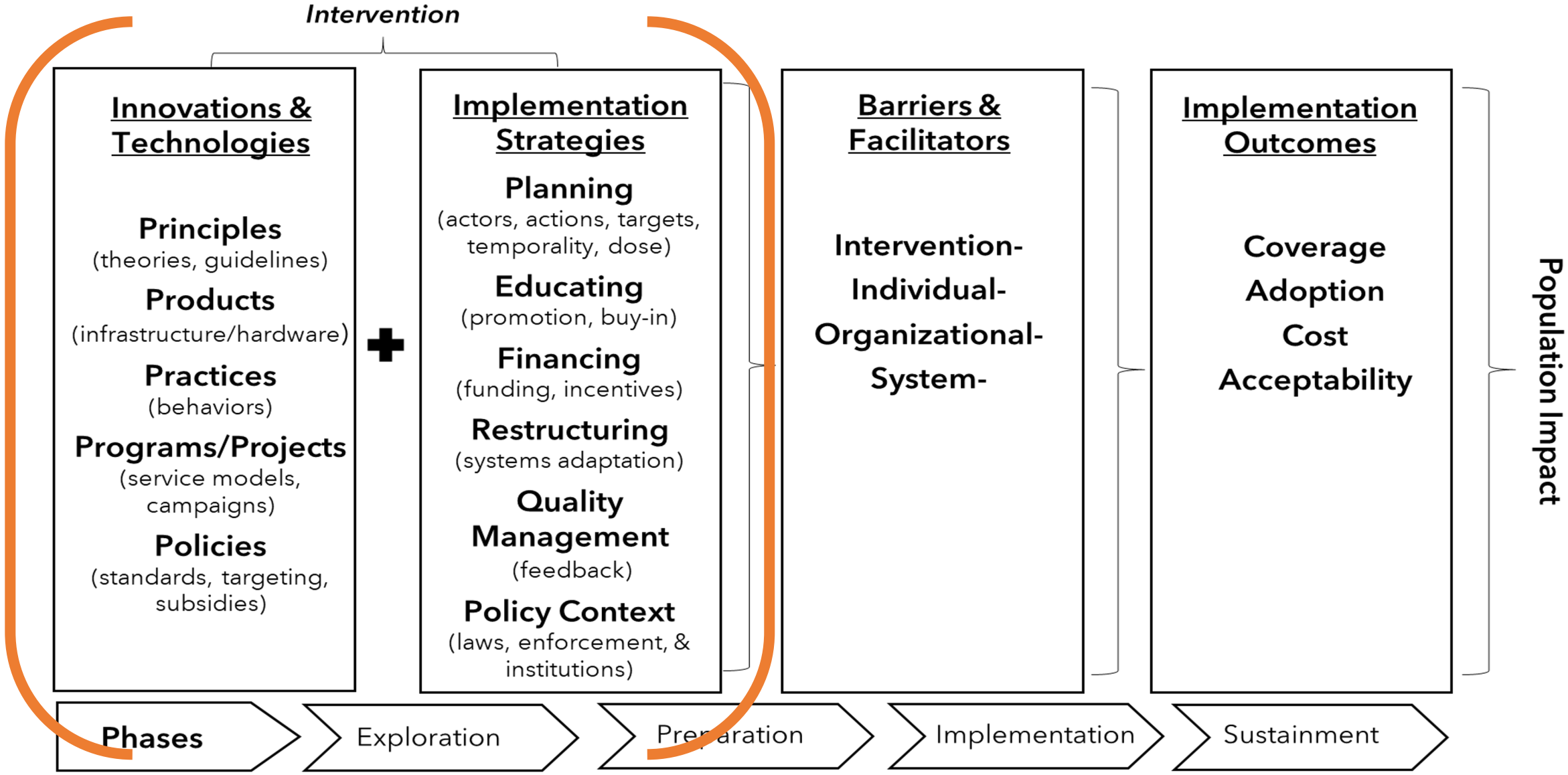


Research questions

Efficacy or effectiveness:

- *What **pathways** are most effective at reducing diarrhea and stunting?*
- What intervention(s) work ***BEST***

Focus on intervention development?



Haque and Freeman et al. 2021 - adapted from Proctor et al. 2009 and builds on concepts from Brown et al. 2017; Powell et al. 2012; Powell et al. 2020

Focus on Adaptation?

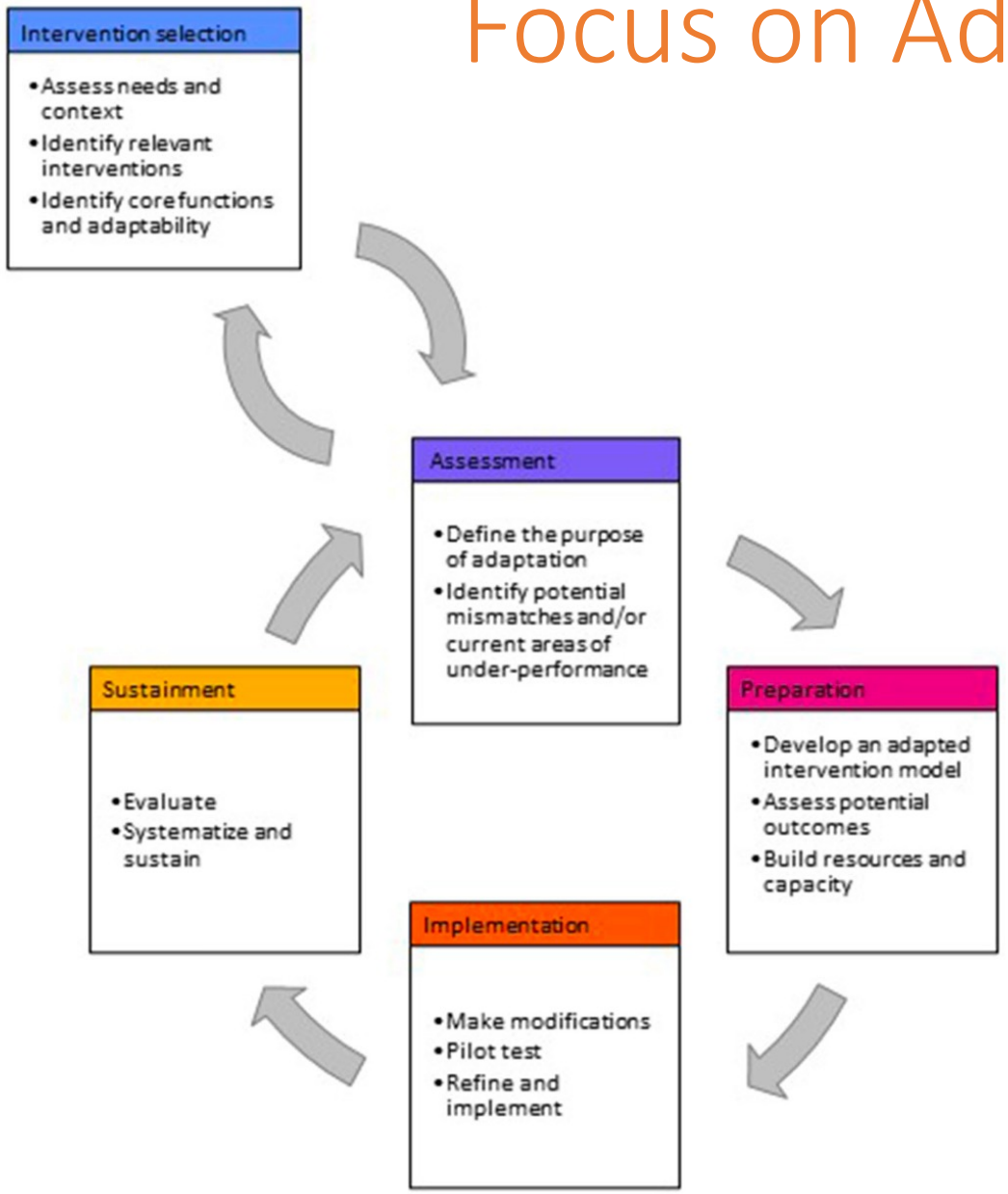


FIGURE 1 | Steps for adaptation in WaSH programs. Model is informed by adaptation models by Movsisyan et al. (15), Kirk et al. (16), and Escoffery et al. (17) and refined based on case studies of adaptation in WaSH (18–20, 41–67).

frontiers | Frontiers in Health Services

Adaptation of Water, Sanitation, and Hygiene Interventions: A Model and Scoping Review of Key Concepts and Tools

Darcy M. Anderson [1], Sarah A. Birken [2,3], Jamie K. Bartram [1,4] and Matthew C. Freeman [5]*

Focus on better evaluation approaches?

- Evaluation methods on ***how*** an intervention works rather than just ***if*** an intervention works
  - Rigorous understanding of the "how" helps us optimize and scale interventions
  - Lower reliance on traditional randomized-control trials, more flexible evaluation designs
  - Theory vs. implementation failure

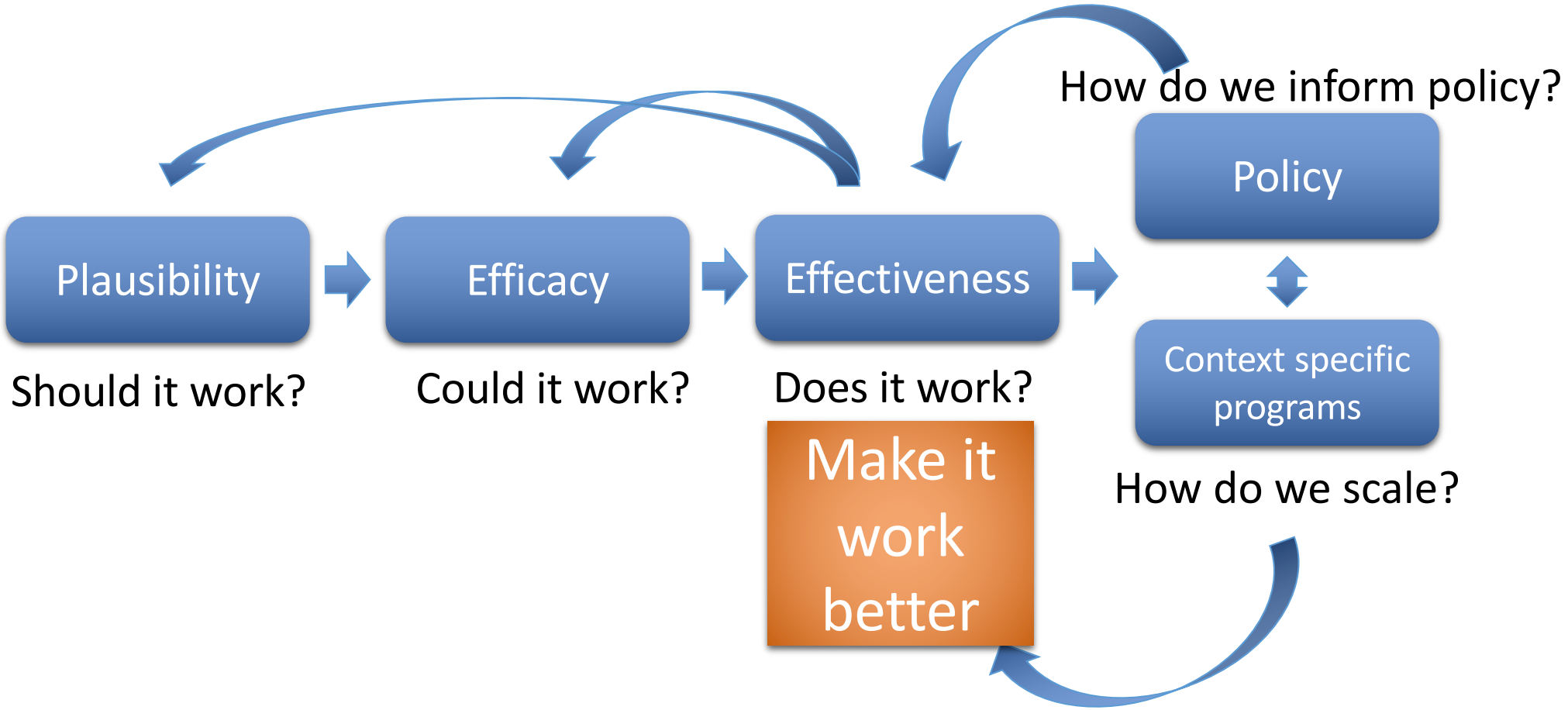
- Emphasis on context
  - Aims to improve generalizability and assessment of "contextual fit" of interventions

- Research is multi-stakeholder and demand driven
  - Research questions are aligned with interests/needs of implementers and answered under real-world conditions
  - Foster shared ownership to promote the uptake of research findings
  - Improve the transfer of scientific skills for building local organizational research capacity

Actionable challenges
related to design, delivery, evaluation, and dissemination

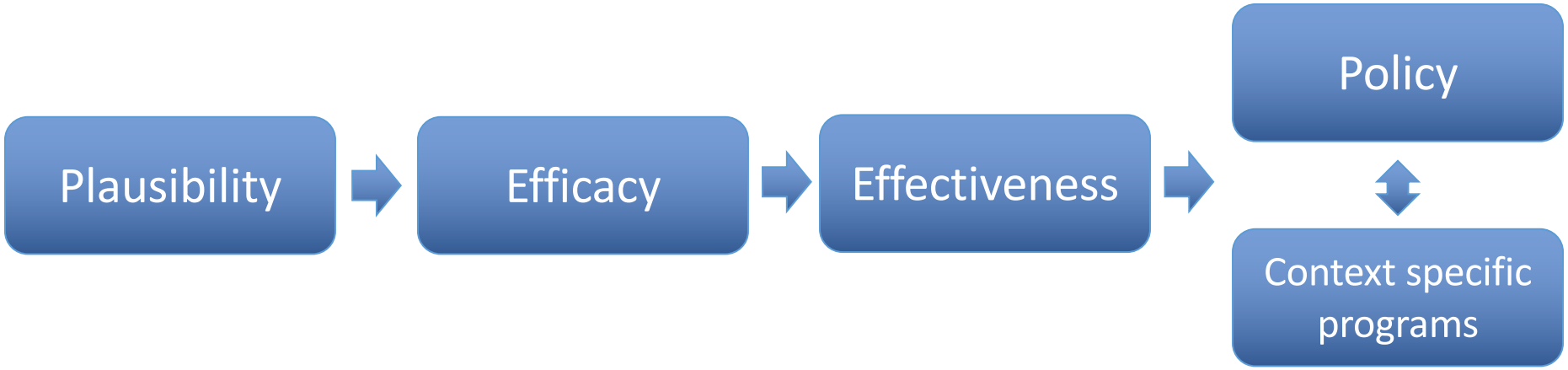
1. Poor understanding and assessment of context
2. Minimal application of behavioral theory
3. No standard approaches to document intervention strategies and delivery
4. Minimal funding implementation research

Successful delivery of at-scale interventions to reach impact



Adapted from Glasgow et al. 2012

IS priorities for WASH



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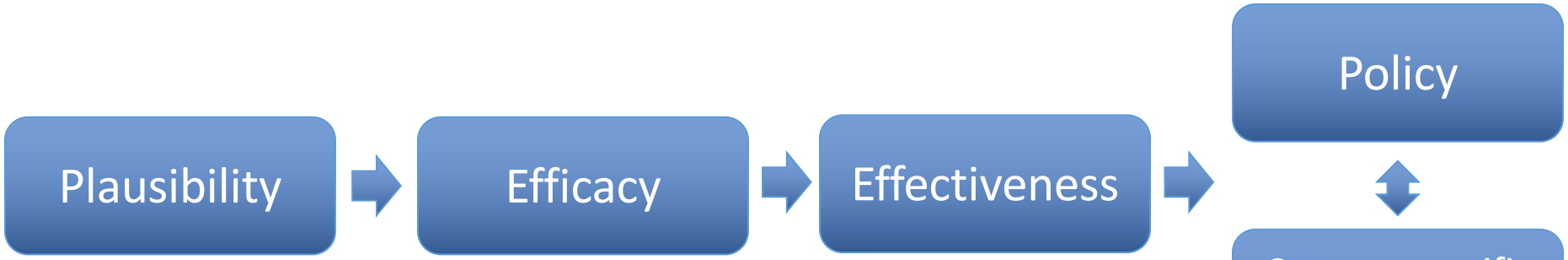
IS priorities for WASH



1. Priorities for action planning and IS methods related to setting (see CFIR framework)

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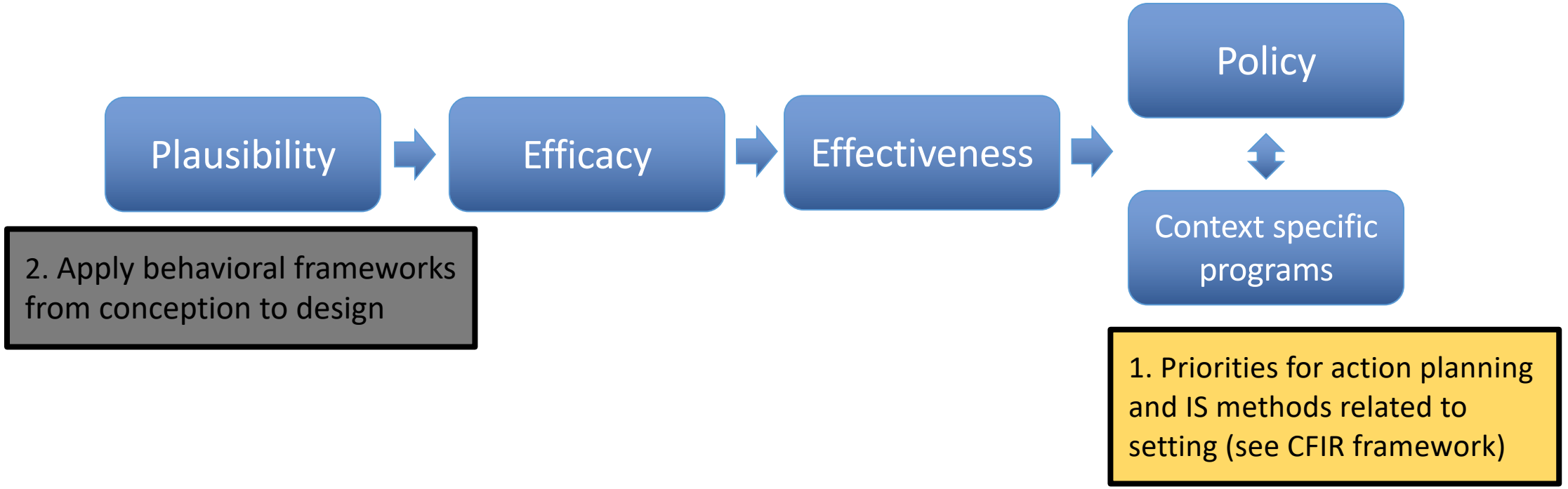

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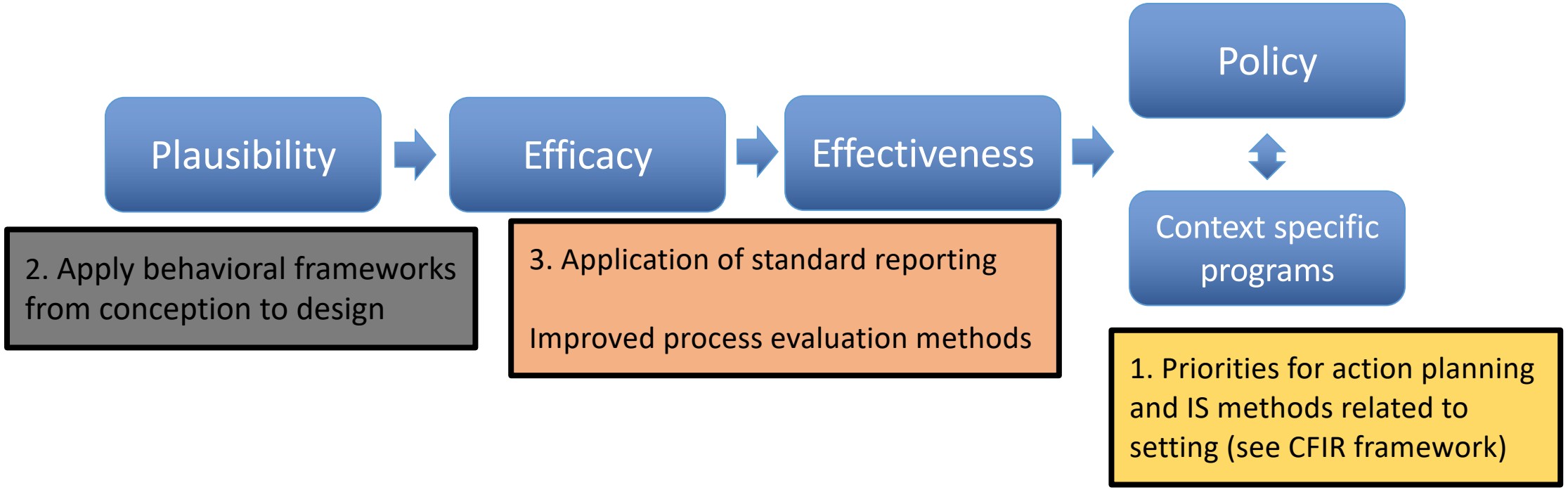

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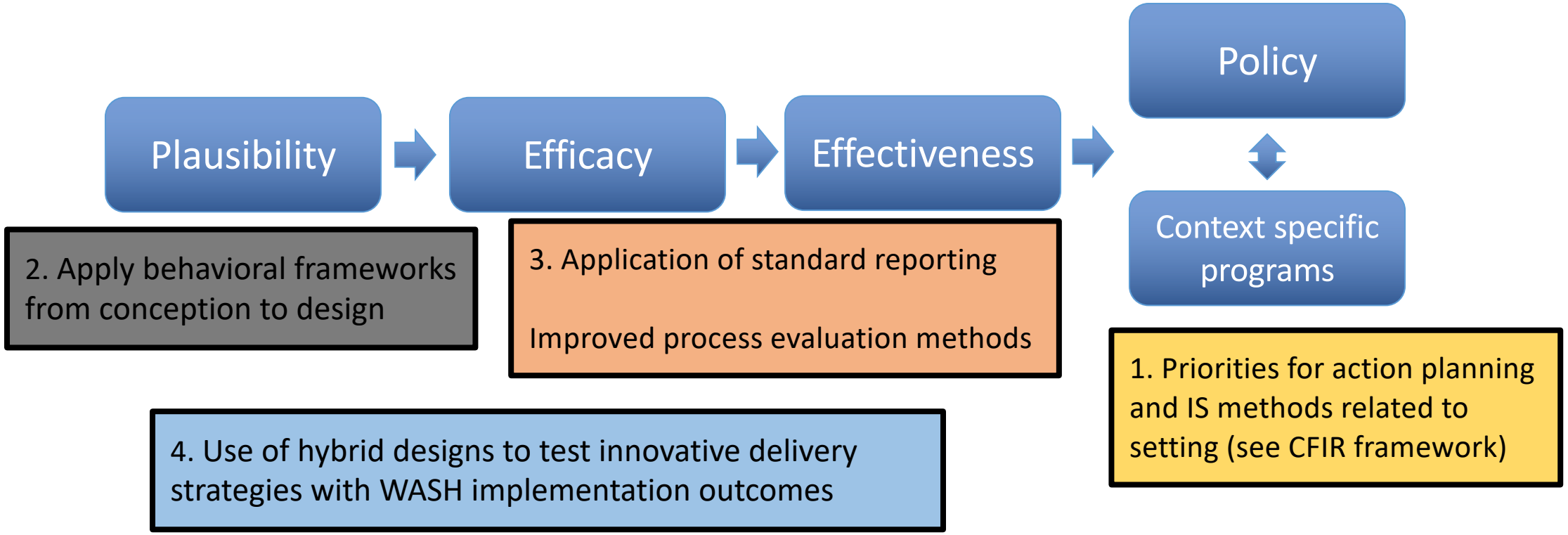

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Priority solutions to address WASH evidence gaps

1. Priorities for action planning and IS methods related to setting (see CFIR framework)

2. Apply behavioral frameworks from conception to design

3. Application of standard reporting

   Improved process evaluation methods

4. Use of hybrid designs to test innovative delivery strategies with WASH implementation outcomes

What should the sector prioritize for implementing IS for control of food and waterborne disease?

➡ https://l.ead.me/bd6rSh