Summary Brief: Pathogen Pathways Study for Children Under Two Years in the FIOVANA Intervention Areas of Southeastern Madagascar

Introduction

In Madagascar, almost 50% of children under five are stunted[1], with inadequate water, sanitation, and hygiene (WASH) being one of the key factors negatively impacting child growth and overall health. Various pathways, such as hand-to-mouth contact, drinking water, food, soil, flies, and fomites (objects that children put in their mouths), can lead to increased fecal pathogen exposure and health risks among young children. Understanding the degree to which each of these pathways contributes to infection risks would allow designing targeted interventions to improve the health of young children. This study complements and strengthens the work of the FIOVANA activity, a five-year (2019-2024) multisectoral activity implemented by ADRA, which aims to achieve sustainable improvement of food and nutrition security and resilience of vulnerable populations in southeastern Madagascar.

Figure 1: Map showing the study regions: Vatovavy, Fitovinany, and Atsimo Atsinanana regions.

Research Objectives

The primary objective of this research was to identify the most important pathway(s) for fecal pathogen exposure among children under two in three regions of South East Madagascar (Figure 1). The second objective was to identify potential interventions for interrupting these transmission pathways that take into account the specific cultural and social norms of South East Madagascar.

Methods

We divided fieldwork into two phases (Figure 2). Phase I consisted of 35 structured child observations and one-hour caregiver surveys to identify key exposure routes in this context. Phase II included 185 fifty-minute caregiver surveys and spot observations of the household. For each household in both phases, we collected environmental samples (Figure 2) and analyzed them for *Escherichia Coli (E. coli),* an indicator of fecal contamination, using the Compartment Bag Test (CBT) method. We also collected another batch of environmental samples (Figure 2) in a subset of 26 households for pathogen analysis.

Using these data, we performed a Quantitative Microbial Risk Assessment (QMRA) to determine the most important exposure pathways by age category (0-6 months, 7-12 months, and 13-24 months), using pathogenic *E. coli* O157:H7 as an illustration. We focused on four exposure pathways: child hand-to-mouth contact (which was more frequent than caregiver hand-to-mouth contact according to our observations), drinking water, soil, and food ingestion.

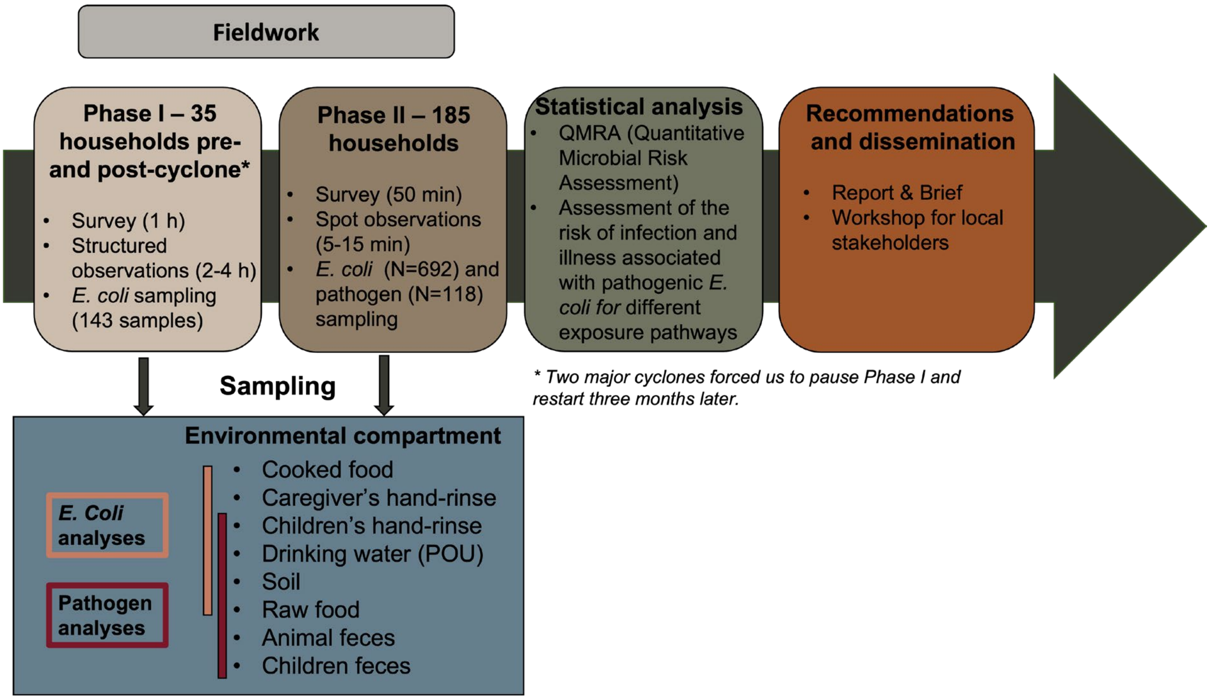

Figure 2: Summary of study progression, methods, and sampling for E. coli and pathogen analysis.

Results

We surveyed a total of 220 households and analyzed 835 *E. coli* samples. Soil and drinking water were the most contaminated environmental compartments. More than 80% of soil samples had *E. coli* concentrations above 100 MPN (Most Probable Number) per gram, while more than 60% of water samples collected at the POU contained above 100 MPN per 100 mL. Approximately 25% of caregivers' and children's hand rinse samples contained above 100 MPN per two hands (Figure 3). Food samples were difficult to collect because of food shortages after the two cyclones and also because eating raw food is uncommon in these regions. We found that half of the cooked food samples were safe.

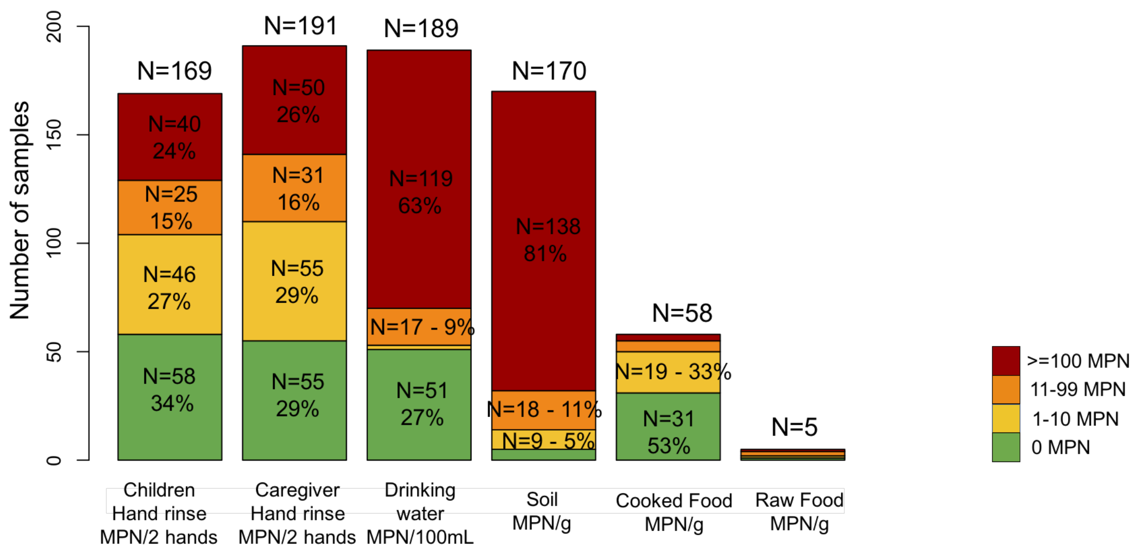

Figure 3: Level of *E. coli* contamination among six environmental compartments. Only the samples collected after the two cyclones are presented in this figure.

Pathogen analysis showed slightly different results (Figure 4): the most contaminated environmental compartments (represented by the grey bar in Figure 4) were children's hand-rinse (46%), followed by soil (31%) and drinking water (26%). Among our two types of fecal samples (i.e., potential sources of contamination) we detected pathogens more often in animal feces (67%) than in children's feces (26%). *Campylobacter* was the pathogen found most frequently (present in 33% [39/118] of all samples and in 90% [39/43] of samples positive for any pathogens), while we did not find any presence of *Salmonella* or *Entamoeba Histolytica*. We found Adenovirus only in drinking water and children's feces, suggesting that human feces might be a source of viral contamination in drinking water, while bacterial infections seemed to come directly from animal feces via direct or indirect (hand-to-mouth contact) ingestion. These possibilities can act as hypotheses to test in future research, as we cannot draw definitive conclusions from this limited number of samples and the non-quantitative nature of results.

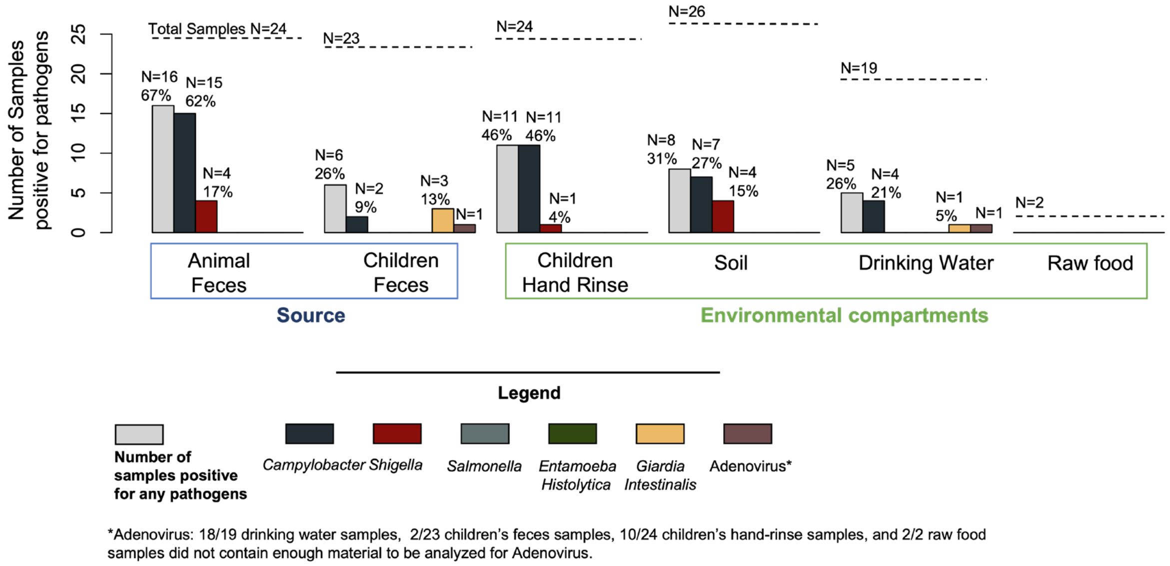

Figure 4: Results of the pathogens analysis for two sources and four environmental compartments. All these samples were collected between May and June 2022.

Based on our exposure assessment results, the total daily amount of *E. coli* ingested increased with a child's age: when a child becomes older, that child consumes more food, drinks more water, and interacts more with the environment and with potential pathogens if the environment is contaminated (Figure 5). The daily *E. coli* ingestion increases from 10 MPN/day (IQR:[1] 12-186) for the 0-6 months category to 188 MPN/day (IQR: 61-273) for the 7-12 months category and to 213 MPN/day (IQR: 61-390) for the 13-24 months category.

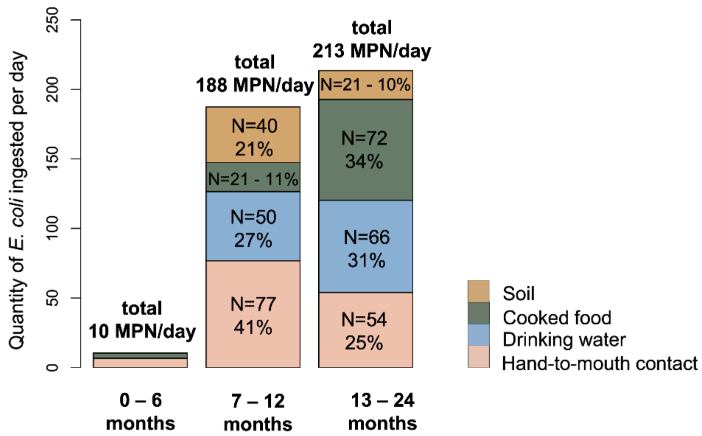

Figure 5: Quantity of E. coli ingested by a child per day by age category and by exposure pathway.

[1] IQR= Inter Quartile Range

The main pathway for *E. coli* intake also varied across age groups: for children 0-6 months old, the main pathway was hand-to-mouth contact (70% of total ingestion), while three main pathways were important for each of the two other categories. Among children 7-12 months old, hand-to-mouth contact, drinking water and soil pathways contributed substantial portions of *E. coli* exposure (Figure 5). For the 13-24 months category cooked food, drinking water and hand-to-mouth contact were the main pathways. Risks associated with pathogenic *E. coli* O157:H7 alone were acceptable compared with WHO guidelines, but exposure to additional fecal pathogens would likely increase the level of risk.

Recommendations
We recommend prioritizing the 7-24 months category for future interventions as they ingest more pathogens compared to the 0-6 months, and thus all the recommendations provided below should focus on the 7-24 months. Across all exposure pathways, we recommend strengthening FIOVANA awareness campaigns by developing Sustainable and Behavior Change (SBC) programs that will focus on key behaviors and social norms, and will operate at three levels: advocacy to increase resources and political commitment, community mobilization for wider participation, and individual behavior change communication.[2] Implementing a SBC program involves the 5 steps presented in Figure 6, with this study falling under the first step. Based on consultations with ADRA, future implementers of a SBC program should focus on i) conducting a Barrier Analysis to identify bottlenecks in behavior change (e.g., using the RANAS [Risks, Attitudes, Norms, Abilities, and Self-regulation] method[3]), ii) developing community dialogue to promote communities' own solutions, and iii) supporting household action planning, a process aiming to address each household's specific needs (Figure 6). Finally, we suggest prioritizing and targeting the behaviors listed in Figure 6 to interrupt each of the four main exposure pathways.

To limit contamination via drinking water, we recommend encouraging households to use improved water sources and to develop safe water management practices, such as safe storage (Figure 6). Even though water treatment at POC might be challenging to implement in these poor and remote settings, this is the most effective way to reduce pathogen loads in water,[4] and scalability and sustainability are often higher for water treatment at the POC as compared to the POU.[5,6] Overall, however, low-cost WASH interventions are often not sufficient to reduce the pathogen load in the environment as a whole.[7,8] In addition we recommend separate animal feces from human (and children) by developing animal fencing interventions and/or play-pens for children, reducing open defecation, and improving flooring by using "balotoms", a small piece of fabric easy to wash that can prevent or reduce children's contact with soil or dirty mats. This last recommendation comes from our local partner as an approach that suits the local context and practices and is especially appropriate for the 7-12 months category. Finally, improving access to handwashing stations will help reduce contamination via hand-to-mouth contact, and developing safe food hygiene practices would reduce the food exposure pathways.

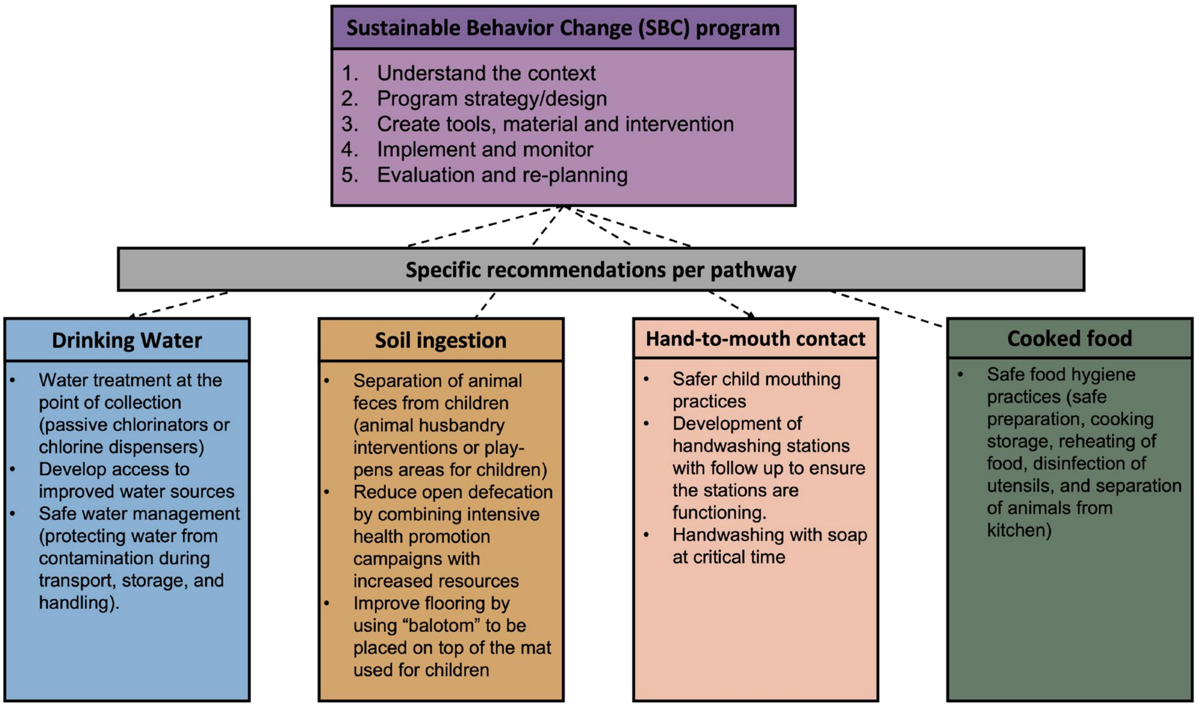

Figure 6: General and specific recommendations to stop the four main exposure pathways.

In conclusion, this study showed that children's environment in rural areas of southeastern Madagascar has high levels of fecal contamination, which can negatively impact their health. Investments in WASH infrastructures, SBC programs, and animal husbandry interventions may help reduce environmental contamination and improve health among young children.

References

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