

The Interaction of Soil-Transmitted Helminth Infections, Geophagy, and Pregnancy Outcomes in Sub-Saharan Africa

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Abstract:

This project aims to identify the interactions between soil-transmitted helminth infections (STH), geophagy, and pregnancy outcomes in Sub-Saharan Africa. STH infections, a type of neglected tropical disease, affect billions worldwide. Transmitted through contaminated soil or water, STH disproportionately impacts poor communities with limited sanitation and lack of clean resources, especially low and middle-income areas around Sub-Saharan Africa. Pregnant women are particularly vulnerable, especially those practicing geophagy to protect against toxins, access micronutrients, and combat hunger. This research highlights the need for further investigation into the relationship between STH infections, geophagy, and pregnancy outcomes. It also emphasizes the importance of developing culturally sensitive interventions to improve maternal and fetal health in Sub-Saharan Africa.

Introduction:

Pregnancy is a crucial period for both mother and infant, with pregnant women being particularly vulnerable to certain diseases and infections such as STH. A commonly neglected tropical disease, STH are parasitic intestinal worms that affect mainly underprivileged communities worldwide. STH is commonly passed through direct ingestion or contact with eggs in soil, water, and food contaminated with fecal matter.

The three most common types of STH infection include *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and *Necator americanus* and *Ancylostoma duodenale* (hookworms), which most commonly infect pregnant women (Hotez et al., 2006). Each type of STH infection varies by lifecycle, symptoms, transmission, and size. Significantly affecting low and middle-income areas around Sub-Saharan Africa, STH impacts poor communities with limited sanitation and lack of clean resources.

Studies have shown connections between STH infections and the practice of geophagy, which is the craving for non-food materials like clay, ice, chalk, starch, and sand. Geophagy, the practice of eating earth—particularly chalk or clay—has been practiced for two million years, not only by humans but also by primates and other vertebrates. Although the reason why humans practice geophagy is unknown, some hypotheses include protection against toxins and harmful pathogens, access to micronutrients, and ease of hunger (Miao et al., 2014). Indeed, in Sub-Saharan Africa and South Asia, geophagy is most commonly practiced by pregnant women. Cultural, spiritual, and traditional beliefs contribute to the practice, as it is often associated with different rituals, spirits, and traditional health ideals (Kwon et al., 2023).

Pregnant women tend to experience earth cravings during their iron deficiency periods and engage in these practices during their second and third trimesters in areas of Sub-Saharan Africa. This paper aims to uncover an additional connection between STH, geophagy, and pregnancy by using peer-reviewed research papers, books, and resources to investigate the potential interactions between these three elements. In addition to addressing STH in pregnant women, this research will also discuss the interventions that have been put into place to address STH infections and opportunities for further intervention.

What Are Soil-Transmitted Helminth Infections?

STH are parasitic intestinal worms that affect vulnerable communities worldwide. They are particularly prominent in Sub-Saharan Africa, China, East and South Asia, and India (Brooker et al., 2006). The most common type of STH is roundworm, also called *Ascaris lumbricoides*. *Ascaris lumbricoides* are the largest intestinal nematodes measuring approximately 250-300 millimeters in length. Their life cycle begins when eggs and larvae enter the human body upon ingestion of embryonated eggs in food, water, or soil contaminated with human feces. Then, larvae enter the bloodstream, spread to the lungs, and penetrate the alveoli, causing pulmonary symptoms. When the larvae migrate through the bloodstream or the lymphatic system, symptoms include coughing, chest discomfort, and wheezing. Once the larvae mature into adult worms in the intestines, common symptoms include nausea, diarrhea, vomiting, weight loss, and abdominal pain (Gardner & Gardner, n.d.). After ascending to the trachea and descending into the gastrointestinal tract, the adult parasite releases its eggs in the small intestine. These eggs are then excreted in feces, which can contaminate soil and infect new hosts. This cycle takes around 2-3 months, and adult worms within an infected individual can remain for 1-2 years.

Another common type of STH is whipworm, also called *Trichuris trichiura*. *Trichuris trichiura* is a nematode measuring about 30-50 millimeters in length. The life cycle begins when an individual ingests embryonated eggs in food, water, or soil contaminated with human feces. After the eggs hatch in the small intestine and release larvae, the larvae transform into adult worms that eventually mature and produce thousands of eggs in the colon. These adult worms live in the cecum and ascending colon. Eventually, these eggs are passed into human feces and form embryos. The cycle begins again when embryonated eggs are ingested again by humans. The cycle takes around 1-3 months and adult worms typically live in an infected individual for 1-3 years. Without treatment, symptoms such as diarrhea, iron-deficient anemia, and weight loss will persist in those infected (Viswanath et al., 2023).

The last most common type of STH is hookworms, also called *Necator americanus* and *Ancylostoma duodenale*. Hookworms are roundworms measuring 7-13 millimeters in length. Transmitted through skin penetration, the life cycle of these worms begins as eggs in human feces. The eggs hatch into larvae in warm soil, eventually maturing, and can survive for several weeks in the soil. These filariform larvae penetrate human skin and infect humans. They first enter the bloodstream, move to the heart, lungs, pharynx, stomach, and eventually into the small intestines. In the small intestines, the larvae mature into adult worms that lay thousands of eggs, eventually defecating in human feces. The cycle takes around 4-7 weeks and adult worms typically live in an infected individual for 1-2 years. Common symptoms include diarrhea, abdominal pain, dyspepsia, and fever ("Hookworm," 2024; Hoagland & Schad, 1978; Khurana et al., 2021; Chai et al., 2021).

STH Infection's Impact On Pregnant Women:

STH infections, specifically hookworms, significantly affect pregnant women in Sub-Saharan Africa. A study completed among pregnant populations estimated around 30% of women across multiple countries in Sub-Saharan Africa are infected with STH during pregnancy. Additionally, compared to non-pregnant women, pregnancy has been associated with increased STH infections (Garrison et al., 2021).

STH infections cause anemia in pregnant women, increase maternal mortality, low birth weight, and greater risk of preterm birth (Mengist et al., 2017). Anemia, characterized by low

hemoglobin levels, can impair egg maturation and reduce the chances of a successful pregnancy (Alene & Dohe, 2014). Helminth-induced anemia also affects insulin resistance and blood glucose, contributing to gestational diabetes. Severe anemia can also develop when a condition, such as malaria or existing nutritional deficiencies, occurs in addition to the STH. For example, a study exploring the effect of comorbidities in Ghana has shown that coinfection with helminths and malaria was “associated with low birth weight, preterm delivery, and small birth weight for gestational age” (Blackwell, 2016). Another study in Nigeria also supported these results, suggesting that co-infection of helminths and malaria contributed more to lower birth weight than malaria infection alone did (Blackwell, 2016). These studies suggest that comorbidities exacerbate the effect of STH infections if additional infections are circulating in the body. Thus, an infected individual with multiple diseases and pre-existing health factors may experience more negative health outcomes compared to an infected individual infected with only one particular disease. In both cases, pregnant women experience different health outcomes and symptoms than non-pregnant people do.

Studies have shown that STH infections may bring immunological changes that might alter the immune system of the pregnant woman and affect fecundity, the ability to produce more healthy offspring. In a study exploring the connection between helminth infections and fecundity, the findings reported that certain STH species, like *A. lumbricoides* and hookworm, are associated with immunological changes. Continuing the discussion on the impact of STH infections on immune systems, T-cells are a type of white blood cells that help the immune response. In the case for STH, *A. lumbricoides* is only associated with type 2 T-cell responses, while the hookworm is associated with both type 1 and type 2 T-cell responses (Blackwell et al., 2015). It has been theorized that type-2 inducing helminth infections may positively influence pregnancy in infected mothers, leading to successful pregnancy and immune tolerance (Chetty et al., 2020). This finding was supported by another study that found *A. lumbricoides* may be beneficial for pregnancy outcomes and promote conception rather than suppress fecundity. This contrasts with the widely-held theory that diseases and parasites decrease reproduction (Blackwell et al., 2015).

Beyond the effects of STH directly on pregnant women, maternal to fetal transmission of STH infections may occur. Studies show that helminth antigens are transferred to infants *in utero*, and infants show alterations in immunity. Infants may experience increases in type 2 T-cell responses due to helminth antigens, crucial for humoral immune responses, and decreases in type 1 T-cell responses, which identify and eradicate viruses and bacteria, to non-helminth antigens (Blackwell, 2016).

In summary, pregnant women are particularly susceptible to STH infections; these co-comorbidities and different health risk factors may bring even worse symptoms and responses to STH-infected mothers (Blackwell, 2016; Mpairwe et al., 2014).

Geophagy:

There are different aspects—from fetal development, nutritional intake, malaria, nutritional stress, and anemia—that influence the susceptibility to STH during pregnancy. However, one hypothesized explanation for this increased vulnerability involves a form of pica, called geophagy. The term 'pica' originates from the Latin word for 'magpie,' a bird known for its indiscriminate eating habits. The condition was formally named in the sixth century A.D. (Kiple & Tarver, n.d.). Pica is not characterized by a mere desire to consume non-foods, but it is an

uncontrollable and strong craving for non-food materials like clay, ice, chalk, starch, and sand. It is often associated with mental health disorders, nutritional deficiencies, and pregnancy.

On the other hand, some believe that geophagy develops to palliate pregnancy-related symptoms such as nausea, providing therapeutic benefits; they believe that practicing geophagy protects against toxins and harmful pathogens, aids digestion, provides micronutrients, acts as an antacid, and prevents diarrhea (Pica, 2024; Bonglaisin et al., 2022). Cultural, spiritual, and traditional beliefs also affect the practice of geophagy. For example, in Western Kenya, geophagy is an outlet to express gender identities and a way for women to belong within the household (Geissler, 2000). It is seen as a continuity of the lineage and family ancestry since earth materials symbolize the graves of ancestors and are seen as elements that bring people together with life-giving forces (Geissler, 2000; Jefferds et al., 2010). These different aspects associated with the cultural practice of geophagy may influence a pregnant woman's decision to engage in such practices.

Geophagy is most commonly practiced by pregnant populations in areas around Sub-Saharan Africa. It has been reported that the prevalence of geophagy among pregnant women ranged from 65% in Kenya, 46% in Ghana, 42% in Namibia, to 28% in Tanzania (Kawai et al., 2009). In Southwest Ethiopia, there was a statistically significant association between STH infections and geophagia: pregnant and lactating women reported to consume earth during gestation (Getachew et al., 2021).

Although this is a universal trend in Sub-Saharan Africa, the type of soil preferred by pregnant women varies. In Northern Uganda, for example, soils are collected and consumed from riverbanks, burnt bricks, wells, markets, termite mounds, and swamps. In areas of Kenya, pregnant women prefer clay solids because of its fine texture and tendency to dissolve easily in the mouth (P. Geissler et al., 1998). Either way, those who practice geophagy seek particular types of soil and consume them based on availability and region; soils that contain high amounts of clay, air-dried, baked, and smoked are eaten depending on the region (Huebl et al., 2016).

The prevalence of geophagy increases as pregnant women face the second and third trimesters, essential for the developmental and physiological changes of both the mother and the fetus. As the fetus matures, more nutritional demands, food cravings, and greater demand compel women to practice geophagy to combat hormonal fluctuations and nutritional deficiencies (Getachew et al., 2021; Allport, n.d.). For instance, pregnancy hormones can heighten their sense of smell and turn on olfactory triggers, provoking pregnant women to engage in this practice (Cameron, 2014; Kortei et al., 2019). Furthermore, as the pregnancy stage progresses to the second and third trimesters, the demand for iron increases as the body tries to support both the fetus and the mother (Luke, 1991).

While pregnant women practice geophagy for many different reasons, the precise information on the actual impact on pregnancy and the fetuses is still limited, and available information likely underreports prevalence from these populations. One reason that could contribute to underreported or inaccurate data is that the practice of geophagy differs significantly from the hygiene practices linked to Western medicine. Thus, pregnant women may perceive the practice as too normalized or feel ashamed to disclose their participation (Bonglaisin et al., 2022; Huebl et al., 2016).

What Is The Connection Between Geophagy And STH?

STH infections are commonly transmitted through the ingestion of food, skin penetration, water, or soil contaminated with human feces. When pregnant women practice geophagy, especially during the second and third trimesters, they engage in a practice that puts them at risk for infections like *Ascaris lumbricoides* (roundworm) and *Trichuris trichiura* (whipworm). This is backed by studies indicating that soil consumption can expose pregnant women to accidental ingestion of STH, lead poisoning, and heavy metals (Blum et al., 2019; Odongo et al., 2015). Direct consumption of soil increases the risk of ingesting STH eggs, which, in turn, heightens the likelihood of pregnant women becoming infected by STH infections. As a result, they may be more likely to face side effects of infection including low birth rate and preterm delivery.

The effect of geophagia and its link with STH infections still varies and is being debated by healthcare professionals. While some studies report a strong association between geophagia in pregnant women and STH infections like *Ascaris lumbricoides* and *Trichuris trichiura*, other studies report a weaker association (Getachew et al., 2021; Young et al., 2007). These inconsistencies could stem from various factors including the environment of the conducted research, the prevalence of STHs based on each region, the lack of accepted techniques or methodologies, and inadequate research on pregnant women in these regions around Sub-Saharan Africa.

Preventing STH In Pregnant Populations:

It is essential to keep pregnant women safe from infection and informed during a particularly vulnerable period using water, sanitation, and hygiene (WASH) practices. WASH are practices labeled as crucial to the well-being of human health and well-being (Hutton & Chase, 2017). These practices are particularly important to uphold public health and protect the lives of those living in underprivileged and low-income areas with limited access to clean water, proper sanitation, and available hygiene practices. Clean water, hand washing, personal cleanliness, reliable sanitation, and proper hygienic practices aim to improve individual well-being and stop the spread of infectious diseases (Hutton & Chase, 2017; Shrestha et al., 2022; Zerbo et al., 2021). Regardless of the form, these practices are essential to prevent the spread of infectious diseases, germs, and illnesses.

WASH Practices:

Currently, national deworming campaigns and health education campaigns are in place to combat STH infections (Adriko et al., 2018). Wearing shoes, engaging in hand washing practices before eating and after defecating, and using soap are WASH intervention methods proven to reduce STH infections (Strunz et al., 2014). Yet, millions of people around the world still lack these basic services and fail to engage in clean practices crucial for health and protection. In Africa alone, 411 million people lack access to basic water services, 779 million people lack access to basic sanitation, and 839 million lack basic hygiene as of 2022 (Mustapha et al., 2024). This lack of access to important services drives both the general population and pregnant women around this area to practice open defecation, drink unsafe water, and bathe and wash clothes in contaminated water, thereby heightening exposure to these different infections (Prüss-Ustün et al., 2019; Tseole et al., 2022).

In particular, people living in poor rural areas have less access and lower coverage of WASH practices compared to those in urban areas. To illustrate, in Ethiopia, 75% of the urban population has access to on-premises water, while only 5% of its rural population has water piped in their homes. In the Democratic Republic of the Congo, 1% of its rural populations have

access to on-premises water. Only 2% of rural populations in Chad have water running in their homes (Water Scarcity in Sub-Saharan Africa, 2022). Generally, 40% of urban populations in Sub-Saharan Africa used better sanitation, while only 23% of rural populations did (“Barriers to Water, Sanitation, and Hygiene,” n.d.; Lynn et al., 2021). Sanitation services and formal water supply have always favored urban and wealthier populations than rural areas (“Water Scarcity in Sub-Saharan Africa,” 2022). Consequently, pregnant women living in rural areas experience this disparity and suffer from inadequate access to WASH practices and resources than pregnant women residing in urban and wealthier areas.

Mass Drug Administration:

Mass drug administration (MDA) is a possible intervention to control tropical diseases like STH infections. It involves providing treatment to all populations in an area, regardless of the circumstances and disease status. MDA is frequently labeled as a campaign-style strategy to administer drugs to high-risk populations and vulnerable areas (Chong et al., 2021). These drugs are very effective and minimize the severe effects of STH infections. In particular, the World Health Organization (WHO) recommends MDA be given in the form of two anthelmintic medications: mebendazole or albendazole (Ng’etich et al., 2023). Mebendazole and albendazole are inexpensive, produce minor side effects, and are effective.

Delving deeper into these two anthelmintic medications, mebendazole works by preventing worms from absorbing glucose, an essential component for the survival of STH (Chai et al., 2021). Albendazole is another effective treatment option for STH infections. Similar to the mebendazole, albendazole kills the worm by preventing it from absorbing sugar or glucose (Chai et al., 2021). For pregnant populations, a single 500 mg mebendazole dose or a single albendazole 400 mg dose is recommended after the first trimester, usually after a diagnosis (“Principles and Practice of Pediatric Infectious Diseases,” n.d.).

While these effective preventive medication options are available, they are less available to females compared to males; children, too, may not be reached by the deworming programs in certain areas around Sub-Saharan Africa due to the lack of equitable educational status, family size, and household media exposure. Consequently, this inequity hinders pregnant populations from receiving preventive medication options (Wong et al., 2023).

Policy And Governmental Interventions:

The control of these diseases and infections has been labeled as a priority among many donors, government, and agencies providing funding and aid for STH control (Tchuenté, 2011). In areas around Ethiopia, international partners support deworming programs financially, and the government continues to strengthen its partnership with international, national, and regional partners for a safer and healthier environment (Negussu et al., 2017). With the support from these partners, government ministries have even launched strategies focusing on deworming among school-based health activities.

Indeed, significant progress and measures has been made, but the level of interventions in Sub-Saharan Africa is still lacking, and communities and pregnant populations living on the continent continue to suffer from STH infections.

Social And Behavior Change Communication:

Social and Behavior Change Communication (SBCC) is a framework used to promote health changes in a community through communication strategies and educational materials.

Some behavior change interventions include improving health literacy, enhancing partnerships with policymakers to create stronger guidelines, and building sustainable models for the future (Chauhan et al., 2017). In regions of Sub-Saharan Africa, implementation of this framework is particularly weak, possibly due to differences in language barriers, dialects, inadequate WASH infrastructures, mass drug administration (MDA), and distribution points throughout the region (Hoeffle-Bénard & Salloch, 2024). In Southern Ethiopia for instance, MDA coverage struggles to reach all populations due to the lack of awareness about STH infections and inaccessibility to reach drug distribution points. Depending on the location of these distribution points, the availability of effective anthelmintic drugs differs significantly. Some pregnant populations living closer to distribution points may have better access to prevention drugs than others who have to travel longer to access them (Asfaw et al., 2021).

Neglected Tropical Disease Control Programs:

In Sub-Saharan Africa, the implementation of WHO's NTD control programs, which aim to eliminate and control neglected tropical diseases like STH infections with regional collaborations, are difficult to maintain due to programmatic, political, and social differences (Akinsolu et al., 2023; Belay et al., 2022). For instance, the educational backgrounds of pregnant women differ significantly; women with higher educational backgrounds are more likely to take their child to receive deworming medication compared to women with no such education (Belay et al., 2022). Depending on these differences, the effectiveness of NTD control programs may differ and are harder to maintain for less educated pregnant populations unaware of control programs (Mustapha et al., 2024b).

Discussion:

This project aims to bring more awareness around the different ways in which STH infections (STH) and the cultural practice of geophagy impact pregnancy and pregnancy outcomes in Sub-Saharan Africa. Its goal is to bring more recognition toward the health risks of STH infections and advocate for better prevention methods and interventions in Sub-Saharan Africa. The data collected from a thorough literature review suggests that pregnant women are at higher risk of STH infections due to the cultural practice of geophagy.

Clash Between WASH And STH:

Prevention of STH infections is particularly difficult to address due to the cultural component of geophagy both from an infectious view and WASH intervention standpoint. Currently, WASH practices clash with the cultural practice of geophagy. WASH practices emphasize basic hygiene and sanitation practices, but geophagy directly contradicts this practice as it involves the direct consumption of potentially harmful earth materials. Consequently, western interventions, like WASH initiatives, can overlook the importance of the cultural practice of geophagy among different regions around Sub-Saharan Africa. Research indicates that pregnant individuals may feel ashamed and avoid seeking treatment options.

While WASH practices must continue to be emphasized in vulnerable areas around Sub-Saharan Africa and other regions around the world, it is also crucial to recognize and find ways to disseminate culturally sensitive health information. As a public health community, there must be more effective ways to address and communicate about cultural practices that could be harmful to health. WASH practices must serve as an intervention system that addresses differences and encompasses the needs of populations around the world. Implementing

ineffective or uninformed interventions does not positively promote change in the region; rather, it hinders and disrespects the culture and identity of those living in the area.

Indeed, implementing efficient intervention methods that account for these diverse cultures and approaches to pregnancy will be challenging. However, with careful tailoring to individual countries and tribal differences, the public health community can make gradual but meaningful progress to find more suitable treatment options for pregnant populations in each area.

More Targeted Action:

In addition to more culturally-sensitive interventions, stronger implementation of SBCC interventions, NTD control programs, MDA, preventive medications, and deworming programs are needed. While these interventions are present in Sub-Saharan Africa and have made significant progress, they are inadequate to fully address the unique needs of pregnant populations. The inequalities influencing this—wealth status, distribution points, misconceptions of drug safety, lack of sanitation campaigns, and shortage of health education messages—need to improve for the betterment of these populations as a whole.

Most importantly, better funding and aid programs must be implemented in Sub-Saharan Africa to control STH infections in the longer term. Currently, funding and aid programs through U.S. global health assistance are temporary and not sustainable (Ingram et al., 2013). These funding mechanisms often fail to support a stable infrastructure that can support itself even after the grant period (Ingram et al., 2013).

In conclusion, there are many programs and organizations providing funding and aid to countries across Sub-Saharan Africa, but more permanent intervention is necessary to ensure control of STH infections in pregnant populations around Sub-Saharan Africa.

Limitations:

This is a literature review based on secondary research. The biggest limitation of this project was the inability to observe first-hand the impacts of STH infections and geophagy on pregnant populations. While there have been studies looking at STH infections, geophagy, and pregnant populations, conclusions varied based on the control group, environment, research methodology, and findings. Furthermore, pregnant women are a protected group due to their vulnerabilities and health needs. This factor alone limits the amount of necessary research available to fully address STH infections and health concerns in this population. Considering these limitations, this paper reflects the available data in the best way possible.

Conclusion:

STH infections are one of many neglected tropical diseases and pose major risks to populations worldwide. While STH infections and the cultural practice of geophagy negatively affect pregnancy populations in Sub-Saharan Africa, there must be further research done to fully address and understand the link between STH infections, geophagy, and pregnancy risks. A greater and more targeted focus on eliminating the risks of STH is needed to raise awareness of intervention practices and address the loopholes in implementation within each region across Sub-Saharan Africa. While doing so, it is crucial to recognize the existing practices in the region and remain respectful when educating communities on the potential health risks involved in their respective practices.

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