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Pregnant with Parasites

Assessing Parasitic Infections in Pregnant Women of the Kwale District

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Kenya: Health and Community Development

Spring 2013

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Acknowledgements

My time in Kwale has been nothing short of monumental. Every day presented a new challenge in the world of scientific research and new opportunities to overcome. I had a host of amazing people in my corner that made this Independent Study Project possible. I would like to first thank Juma for all of his hard work in organizing my research. From connecting me with the health care providers in the hospital to pulling together the focus group discussion, he allowed my research to run as smoothly as possible. I would also like to thank Matron and Miss Jacqline for all of their help in distributing and translating the questionnaires to the mothers. I would never have been able to communicate with them in that manner. My next term of endearment goes to the lovely Fatuma who brought friendship and guidance during my stay at the Nagasaki House. My first two weeks would have been a lot more difficult to adjust if I did not have your helping hand. Finally I would like to thank Professor Karama for the encouragement he allotted as my advisor. He also provided me with many of his fellow researchers who were extremely helpful in the formulation of my objectives.

Once again, I would like to say thank you to the aforementioned people and to all others who participated in making my stay memorable. My work would have never been complete without the support of each and every one of you. As I travel back to the United States and continue with my research in the future, I will remember all of the advice that I have received and continue to put it into practice.

Abstract

Parasitic infections such as malaria and intestinal worms plague many tropical and sub-tropical regions. The Kwale district of Kenya is among one of these regions and provides many circumstances that make these parasites endemic to the area. Pregnant women are part of the major groups affected by parasites. Although clinical professionals are making great attempts at reducing the chances for parasitic infections in these women, there are still some factors that are out of their control. Most women do not receive their drinking water from a secure water source and a majority of the women did not have the financial ability to maintain a balanced diet during their pregnancy. This allots for an increase in malnutrition leaving many of the women more vulnerable to infection. From a study of 107 women, 27 have been infected with worms and 15 have gotten malaria during the course of pregnancy. Co-morbidity between intestinal worms and malaria were rare in this community. Roundworms and tapeworms proved to be the most prevalent in these areas and most women infected showed signs of maternal anemia. More research is necessary to determine the direct correlation between anemia and these infections.

Background

Parasites are organisms that use another for survival. This other organism, referred to as a host, unknowingly provides the parasite with beneficial nutrients at its own expense.

Intestinal helminthes and protozoan parasites are the root cause of parasitic infections in humans. The differences between the two occur in their cell structure. Protozoan parasites are single-celled while helminthes are multicellular worms. While both are prevalent throughout developing nations, the protozoan parasites commonly plague the developed countries (1).

Intestinal helminthic parasites—also known as geohelminths because of their direct life cycle involving no intermediate hosts or vectors—affect 3.8 billion people globally (2,3). The four types of geohelminths include *Ascaris lumbricoides* (roundworm), *Trichiuris trichiuria* (whipworm), *Ancylostoma duodenale*, and *Necator americanicus* (hookworms) (2, 4). These infections are endemic to many tropical and subtropical regions. The parasites are mainly transmitted through the soil of impoverished nations where sanitation and average water supply are not optimal. They live in the intestine of the infected persons and are transmitted through their feces. When a person's defecation ends up on soil, the worms are absorbed and mature. Different groups reenter the human in its own form. The eggs of the roundworm and the whipworm must be ingested into the human system leading into more aspects of cleanliness. If a person eats with soiled hands or fails to thoroughly cleanse food such as fruits and vegetables before preparation, they can easily become infected. Hookworm eggs hatch in the soil and their larvae begin to mature enough to penetrate the human skin (5). The risk of the latter corresponds directly with age; adults being the majority. They are also the most common during pregnancy.

Schistosomiasis, often called bilharzias, is caused by larval trematode flatworms, *Schistosoma*, released from freshwater snails. These flatworms then enter the skin of people who come in contact with the water. Within the body the larvae begin to develop into mature worms. There are two main types of Schistosomiasis. One, Urinary, causes damage to the kidneys, ureters, and bladder. The other—intestinal—causes the liver and spleen to become progressively enlarged. The latter also causes hypertension and intestinal damage. This disease statistically affects 200 million people with 80 percent of those infections being in Sub-Saharan Africa. It is estimated that 40 million women of childbearing age are infected ([17](#)).

Differing from geohelminths, malaria parasites require a vector to be passed between humans. When one of these parasites occupies a human, they begin growing and multiplying in the liver cells and then transfer to the red-blood cells. Once there, the parasites continue multiplying and destroying these cells. When a female mosquito bites a human in this condition and gains their blood, the parasites are brought along and continue to grow within the mosquito and after a period of close to two weeks the malaria parasites will be on the salivary glands of the mosquito ready for injection into another human.

In Kenya, Malaria parasites are the leading cause of morbidity and mortality. With 25 million out of 34 million people at risk for this infection—the most vulnerable group being pregnant women and children—it is highly adequate that the country has put a major commitment into the eradication of this disease ([7](#)). In malaria endemic areas of Kenya there

are approximately 1.1 million pregnancies a year with 6,000 of these women being diagnosed with malaria- associated anemia and malnutrition of mother and child. Intestinal helminthes are not widely perceived as extremely dangerous infections because they have rarely been directly related to mortality. However, adult parasites can survive in the body for as many as 15 years, all the while contributing to chronic infections (3). They are part of the worlds Neglected Tropical Diseases because even though they can be easily managed, they still contain a widespread at-risk population (5). These parasites have also been correlated with expecting mothers' adverse nutritional status, poor health, iron deficiency as well as a low birth weight for their infants.

Many previous medical professionals have termed the immune system during pregnancy as "suppressed". Even more call progesterone the "natural immune suppressor". More recent studies on reproductive immunology, however, have suggested that this term is not the correct word for the situation. A woman's immune system has a sense of complexity at the time of pregnancy. Placental immune responses are determined on a case by case basis. These cases depend on the amount of microphages, regulatory T-cells, and natural killer cells being produced. When these responses to specific diseases are low it creates a high risk of many mothers becoming infected (6). Being aware of the separation of cases instead of grouping them together as a common cause is imperative in rightfully diagnosing and treating these infections.

Literature Review

With increasing interest in the world's Neglected Tropical Diseases, many researchers have studied the correlation between parasitic infections and overall health in pregnancy. Many aspects that can stimulate the transmission of infections such as nutrition, economic status and sanitation have also been reviewed. Common issues such as maternal mortality as well as anemia and co-morbidity of infections during pregnancy have not been left unnoticed. The critical evidence presented below recognizes this relationship and areas of weak knowledge in need of further study.

Hookworms and Nutrition

Geophagy is the continuous and purposeful consumption of soil. Many pregnant women in sub-Saharan Africa participate in this habit. A longitudinal study conducted in the Nyanza Province in western Kenya looked into the reinfection rate of women with intestinal parasites who eat on different earth mounds. Results showed that 19.6% of the women were reinfected with at least one of the geohelminth parasites. 11.2% of those infections were hookworms (8). In Tanzania, HIV positive expecting mothers whom consumed soil regularly were also tested for helminthic infections. The findings of this study showed an association between geophagy and roundworms infection (9).

Geohelminths and Anemia

One effect of hookworm infection is the increased risk of maternal anemia. Anemia occurs when one does not have enough healthy red blood cells to carry oxygen to body tissues. Because hookworms feed on the human blood it lowers the amount that is able to spread throughout the body. Many studies based in endemic areas have measured hemoglobin (Hb), serum ferritin and erythrocyte protoporphyrin (EP) levels in pregnant women alongside parasitic infection ([10](#)). In Uganda researchers found a 10% increase in Anemia for women infected with parasites—an 8% increase specific to hookworms ([11](#)). In Nepal, 336 women were tested for anemia, malaria, hookworms and vitamin A deficiency. The results showed 74.2% infected with hookworms and 72.6% with anemia being the strongest correlation ([12](#)).

Maternal Anemia

A study done at the Soroka University Medical Center over a period of 14 years analyzed the birth outcomes of women with anemia. These women showed an increased rate of preterm deliveries (<37 weeks) and low birth weight from the women without anemia ([13](#)). Another study based in southeastern China focused on maternal- neonatal iron-deficiency status. They concluded that iron-deficiency in pregnancy does not guarantee that in neonates. In this study most infants born to women with anemia were iron-sufficient except when the

mother's iron was extremely low (14). A clear correlation between anemia in pregnancy and maternal mortality has yet to be identified. This warrants further study on the subject.

Parasitic Co-morbidity

Studies conducted on the co-morbidity between parasites have yielded few concrete results. Some such as the cross-sectional studies in Western Kenya showed an increase in malaria prevalence with that of whipworms and a negative correlation between roundworms and malaria (15). Another study in Colombia agreed with the latter, but instead found the hookworm to be a risk factor for malaria. The study also noticed the possibility of common determinants for soil-transmitted helminthic infections and malaria posing the necessity of future research (16).

Study site

Kwale is the capital of the Kwale district in the Coastal Province of Kenya. This area of the developing nation has a population of around 650,000 with 75% being poverty-stricken (18). Most people in this district are employed in the informal economy because governmental careers in this area are scarce. Many homes do not have access to safe drinking water or water treatment. At times there is no water in the city due to water shortages or main leaks, yet people must still prepare meals for their families even if there is no proper way of cleansing the food. The same is true for the Mwaluphamba area of the Kwale district. It is more of a rural

village without a true town center like that of Kwale. All of these circumstances along with the district's tropical climate make it endemic to many of the world's tropical and sub-tropical diseases.

Most women in the surrounding locations attend the Kwale Sub-District Hospital for antenatal care. My research originally took place at this hospital and the Kenya Medical Research Institute base in Kwale, hereafter referred to as KEMRI. This base attracts scientific researchers from all over Kenya and other nations. KEMRI along with the Nagasaki University Institute of Tropical Medicine provided me many researchers with whom to discuss my topic and assist me in analyzing data. The hospital saw between 5 and 15 pregnant women for antenatal care each day and contained joint laboratory services for ultrasounds and testing. Because I was not receiving enough women at the local clinic, I made the decision to distribute the questionnaire to women at the Mwaluphamba health clinic as well. From this decision, I was able to see the difference in a rural village area and a small town center.

Methodology

The bulk of this study was in the form of a questionnaire. 107 pregnant women who were either attending Kwale sub-district medical center or mwaluphamba health center were interviewed with questions indicating the signs and symptoms of intestinal worms and Schistosomiasis infections as well as those of anemia and malaria. We described the parasitic

symptoms as follows: extreme fatigue, rapid heartbeats, having blood in urine, excessive abdominal pain, nausea, vomiting, and diarrhea. For anemia, questions were asked on habitual behaviors such as eating rocks or clay and also biting ones nails. Nutritional status was also in question by looking at the weight gained over the course of pregnancy as well as the birth weights of previous children to those whom it applied.

Looking into sanitation as a possible factor for the infection of worms and Schistosoma was accomplished by seeing if these women received their water from a secure location. Rivers, lakes, rainwater, and tap water were considered insecure locations for this study. The uses of a borehole or treatments on any of the aforementioned sources were considered secure drinking water. Education level was also investigated as having a possible correlation to pregnancy outcomes and rate of infections.

Knowing that the hospital provides routine prevention methods for malaria and worms, the only way to gather true data on the prevalence of these infections was to test the women who were attending the Kwale and Mwaluphamba clinics for the first time. They provided a stool and urine sample for analysis and blood to test their hemoglobin. These routine tests were conducted by clinical specialists at the district laboratory. Copies of the results were returned to the Maternal and Child Health Clinic for retrieval so that the women could receive proper treatment.

During the first week of research, we conducted a focus group discussion at the Mwaluphamba Health Center. The only criterion to participate in the discussion was that you must be a currently pregnant woman. After we reached out to the health administrator at the site, she was able to invite women from the Mwaluphamba area to cooperatively participate. The target number for this portion was between 10 and 13, but because 17 women arrived at the site, we allowed them all to participate. The main objectives were to see the level of their understanding of parasitic infections and in turn leave them with an even greater knowledge on how to not only combat, but also decrease the spread of these infections.

Lastly, I interviewed several health care providers and laboratory technicians at the Kwale District Hospital. My objective was to gain insight into the way the many health centers in Kwale are working to treat and eradicate these infections. It was also of importance to see the priority that these providers place parasitic infections in the local villages and how they are able to get this information passed along to the members of the community.

Attire and Ethical consideration

Provided that my ISP takes place in a conservative, predominately Muslim area, I remained aware of my physical appearance at all times—especially in the field—in order to make sure that I did not offend anyone. My attire frequently consisted of dera and other loose-

fitting clothing. All of the women who were willing to fill out the questionnaire were previously briefed on the study and assured that their answers would be strictly for academia usage. Any woman who showed positive signs and/or symptoms of infections was reported to the maternal and child health clinic for follow up. All of the women who consented to have their stool samples analyzed were briefed on the findings and those who were in fact infected with geohelminths were again sent to the clinic. I was assigned Dr. Guykurya, the Matron of the clinic, to assist me in translation during the course of my questionnaire distribution. Because she was taking time out of her schedule to assist me, I made sure that she obtained a reasonable compensation. Likewise, the women who agreed to participate in the focused group discussion received a stipend for their travel and lunch.

Results

After conducting the questionnaires and laboratory work, my study yielded conclusive results. From the 107 participants there were 37 (34.58%) who presented with at least four of the symptoms of parasitological infections. There were 27 (25.23%) who had been infected with some type of worms. This percentage was broken down as follows: 1.87% threadworms, 3.74% pinworms, 5.61% tapeworms, 8.41% roundworms, and 5.6% uncertainty. There was also one case of a double diagnosis of roundworms and pinworms and one *Schistosoma* infection. The treatment of choice in these areas proved to be Albendazole. Most of the women have been receiving this medication during their clinical visits. Even though 90.65% of the mothers received malaria prevention drugs over the course of their pregnancy, 15 of the women

(14.02%) were infected with malaria during this time. There was a 5.6% rate of co-morbidity of malaria and worm infection of pinworms and roundworms. Anemia prevalence also proved to be high with 30 women (28.03%) having the diagnosis and even more experiencing the symptoms of nail biting and rock eating. The correlation of worms and anemia was 9.35% and malaria and anemia was 5.16%.

In accordance with nutrition and sanitation I questioned where the women received their drinking water. 77% of the population acquires their water from an insecure source. 14% receive their water from boreholes and only 9% are able to use treatments to insure sanitary water. There was no direct correlation between water source and parasite infection. However, a majority of women who were infected with parasites showed a minute change in weight over the course of their pregnancy. Some even lost a significant amount of weight between antenatal visits. Many women were not able to remember the birth weights of their previous children, but those who did presented weights of 2.5 kilograms or higher indicating well nourished children at birth.

Other Findings

In both the Kwale and Mwaluphamba clinics, the majority of the women were between 20 and 30 years of age. Most of these women are married and even looked offended when asked about their marital status. Of the 13 women who were single all were between 16 and 22

years of age. In the Mwaluphamba area, the average education level was less than Standard 5. In the town of Kwale the average level increased three years with most women completing Standard 8 and some even continuing on for post secondary education. This is uncommon in the rural areas because many families are unable to support their children's education due to lack of finances. Along with this I noticed general observations such as a few of the women not wearing shoes at all times in the Mwaluphamba area which can be noted as a cause of their infection rate.

Focus Group Discussion

The focus group discussion in Mwaluphamba presented interesting results. At the beginning, the women were not interested in answering the questions being asked so the process was extremely slow, but when it came to presenting them with facts and information on how these parasites are transmitted and ways they can be avoided, the women became highly interested in giving their input. The nutritional habits of the women were almost identical. An average meal for most of them is ugali, vegetables, and sometimes fish or another meat. Living in the rural villages, they cannot afford much of a variation in meals which can lead to many mothers missing vital nutrients they desperately need during pregnancy for the growth and development of the child. The villages also provide fewer opportunities for a secure water source. Many women cannot afford water treatment and boreholes are few and far between so most of the women drink directly from the tap. They were all in agreement that since the water was in the tap it must be safe to drink. Therefore they did not see this as having much

importance until we reminded them that the impurities presented in rain and river water were still available in the tap water. We urged all of them to use a borehole or boiling when possible for their drinking water to lessen the possibility of infection during pregnancy.

The women showed a basic understanding of these parasites—mostly what is expressed in antenatal care. Most of the women stated that if they began having the signs of these infections or other illnesses they immediately come to the clinic. Others inferred that they wait a day to see if the symptoms will continue before they attend. One topic that they all seemed passionate about was that of traditional birth attendants. They stated that in the past many women would have numerous complications during birth because the attendants would have them go into labor before they were physically ready. So they would have the women pushing when their baby was not in the proper position or status for delivery. This caused a lot of stillbirths and post partum bleeding leading to maternal mortality. For these reasons and others the women will only visit traditional birth attendants prior to delivery while leaving the actual birth to the clinical professionals.

Conclusions and Further Study

The health providers in the Kwale district allot many services to ensure the health of expecting mothers. Antenatal visits consist of regular testing of hemoglobin levels as well as stool and urine sampling. They also present the mothers with malaria prevention and

antibiotics to reduce the chances of intestinal worm infection as well as conducting monthly field visits to accomplish de-worming in the community. However, they cannot control the living situations of their patients. Many of these women who are not receiving proper nutrition during pregnancy can have an immune system that is more susceptible to infections. Roundworms presented to be the most prevalent intestinal parasites in Kwale while tapeworms—not one of the geohelminths—plague the Mwaluphamba area. From this I conclude that the issue in both areas has the most to do with food preparation. A person is infected with tapeworms from undercooked meat and roundworms are commonly ingested while eating unclean fruits or vegetables. Since many women stated vegetables and meat in their daily food intake, I infer that education on proper food cleansing prior to its preparation would be beneficial to the mothers during antenatal visits. Many women in these areas are secure in attending their local clinic if symptoms do arise, yet are not cognizant of the situational causes that are ongoing at home.

The signs and symptoms proved to be too vague of a way to detect these parasitic infections in pregnant women because many of them correlate directly with the pregnancy itself. As shown in previous studies, there were also many women infected without showing any symptoms. Results also showed that more women with intestinal worm infections will also have anemia than those with malaria infections. Anemia is a concern in this community and geophagy is extremely common. Consumption of soil to gain a sufficient amount of iron is another way these mothers can become infected with many parasites. Iron supplements are not readily available to these women and should be taken into further discussion with the Ministry of Health for these areas. One difference from previous expectations was the lack of

hookworm infection in this population. Although these are the most common in adults globally, they did not show prevalence in this community. Because I only witnessed a few mothers without shoes, I can understand the possible reasoning. Hookworms must grow in the soil and penetrate the skin once they mature. When the easiest contact to the soil—feet—are protected it decreases the spread of this infection.

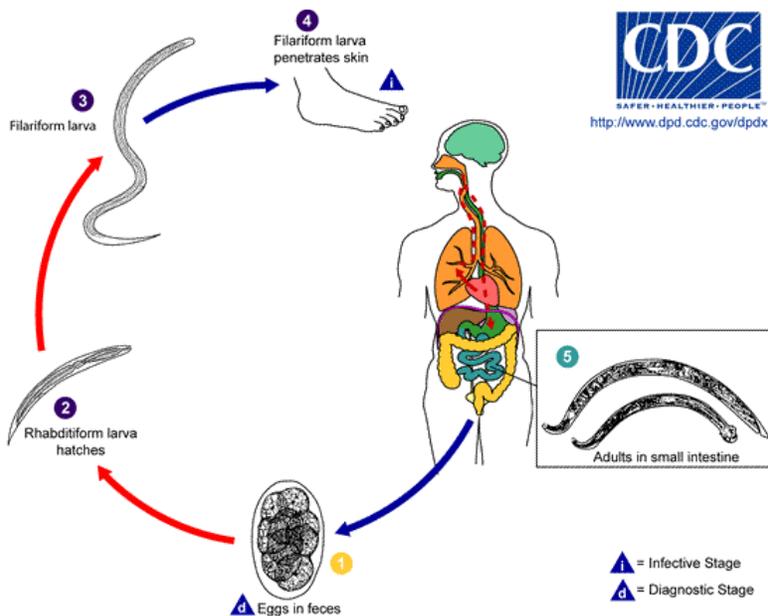
The women in this community are married early—some as young as 16 years. They begin child bearing just as early and usually continue well into their thirties. Therefore, many of the mothers will have around 7 to 10 children during their lifetime. Having all of these births puts an extreme toll on the body and unless they are properly able to take care of themselves, they are continually being put at risk for malnutrition and immune deficiency. During the focus group discussion I understood that the women put having many children as normality. They feel as though it is their job to have as many as possible. One possible reason for this could be the lack of formal education for these women. Family planning is a part of clinical visits, but when condom usage is thought of as a taboo, it makes family planning extremely difficult.

After finishing this study, I want to continue looking into the life cycle of parasites and the specific effects they have on the human body. I encourage anyone interested in this subject to focus on these varying topics: malnutrition in the Kwale district as a possible indicator of these parasites or the women's susceptibility to them, parasitic infections as a possible cause of anemia, co-morbidity of infections, and the effects of Mebendazole and Albendazole

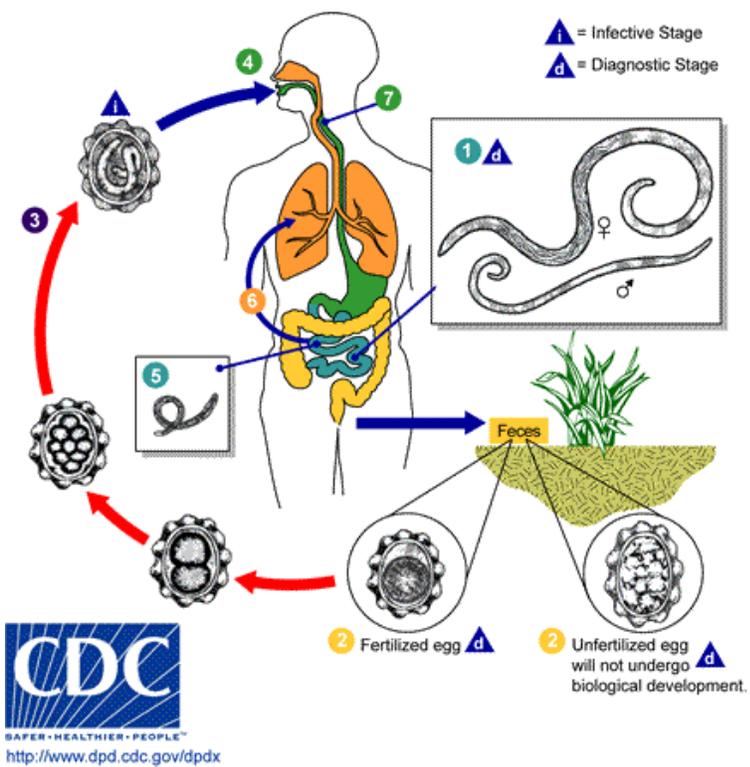
treatments on the body. Most of these topics need a large scale population to acquire concrete results which requires more time than the month provided. However, it is possible to plan ahead and begin the study as early as possible to gain the best data.

Parasite Life Cycles

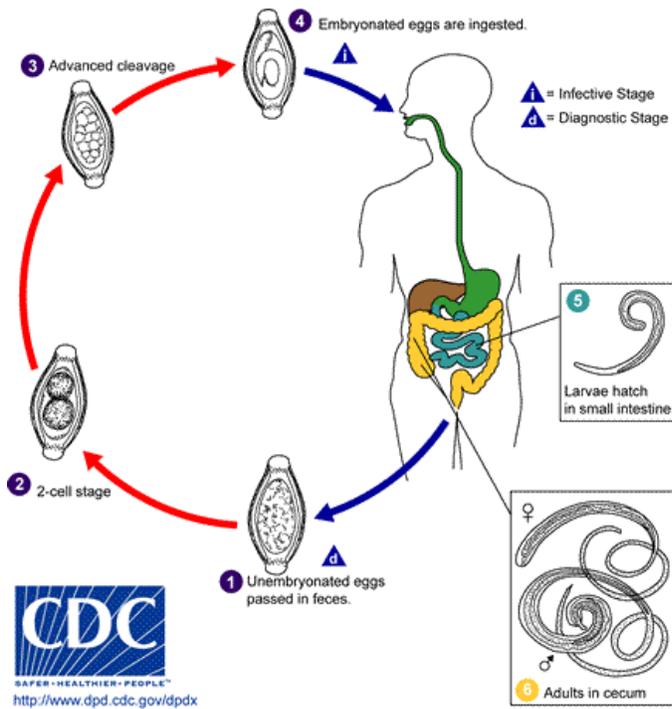
Ancylostoma and Necator



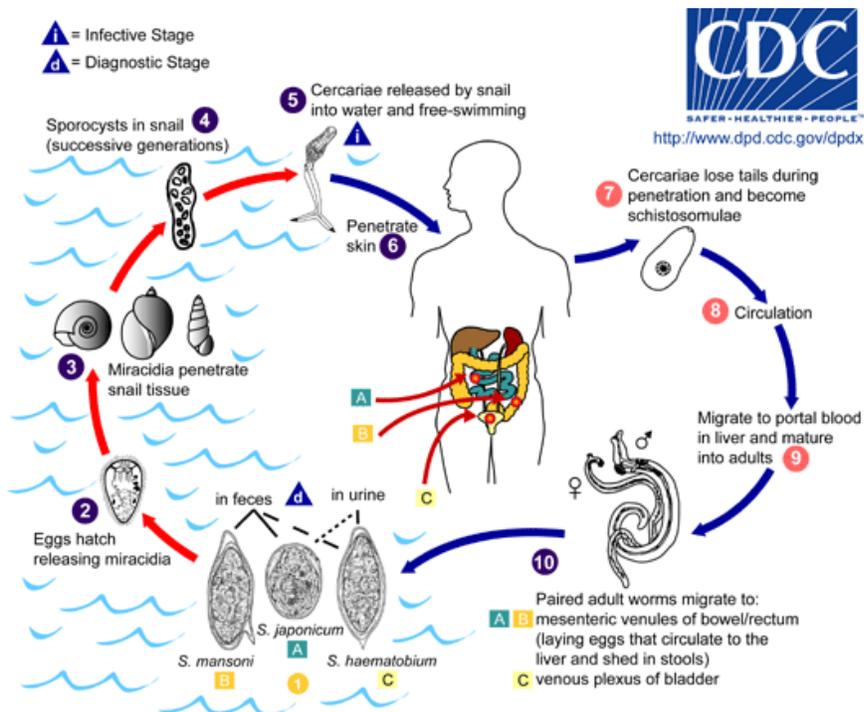
Ascaris



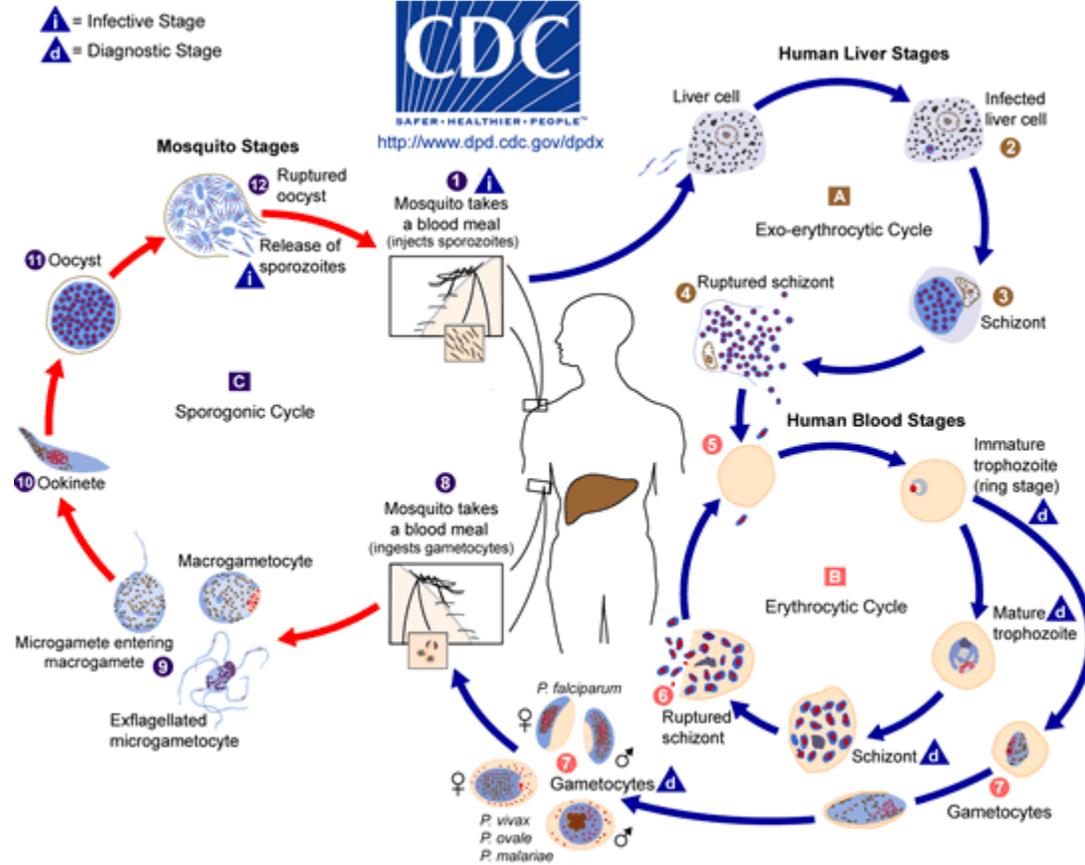
Trichiuris



Schistosoma



Malaria



Questionnaire #1 (Pregnant Mothers)

Please note that questionnaires are optional and used for health research only. Should you feel uncomfortable answering any questions provided, feel free to leave it blank. If you do choose to participate in the survey please answer these questions with relevance to your current pregnancy.

Age

Marital Status.....

Education level.....

Number of children.....

Location.....

- What is the duration of pregnancy (No of weeks)?
- How many times have you attended clinic so far?
- Weight at previous visit_____ Current weight_____
- Other than this clinic do you seek health services elsewhere?
 - Other clinics_____ Traditional Birth Attendants_____
- Do you experience any of the following
 - Tiredness____ Rapid Heart Beat_____ Blood in urine____ Abdominal Pain_____
- Do you eat rocks (udongo), how often?
- Do you bite your nails?
- Have you been told that you have anemia?
- Have you been given malaria prevention drugs during the course of your pregnancy?
 - Once_____ Twice_____
- Have you had malaria during the course of your pregnancy?
- Have you been infected with worms? If yes, which one?
- Do you have home remedies for worms?
- Have you been treated for worms?
- If so, what treatment was used?
- Do you experience any of the following
 - Nausea_____ Vomiting_____ Diarrhea_____
 - How often?
- What was the birth weight of your previous children?
- Have you ever had a miscarriage? How many?
- Where do you get your drinking water?

Borehole____ River____ Lake____ Rainwater____ Tap

Lab Request Form - ANC Profile

- Blood
 - HB _____
 - Malaria _____
 - Grouping _____
 - Rhesus _____
 - VDRL _____
- Stool
 - o/c _____
- Urine
 - Urinalysis _____

Questionnaire #2 (Focus Group Discussion)

- How often do you attend antenatal care?
- What do you know about intestinal worms?
- If you get them, what do you do?
- How much do you know about malaria?
- What do you know about anemia?
- Are you or your children typically treated for parasites?
- How do you get these parasites?
- Are you usually able to use treated water?
- Do you perceive this as a big problem?
- What do you think can be done at home to prevent the spread of these parasites?
- Would you consider yourself in good health during this pregnancy?
- What do your usual dinners consist of?
- Do you seek a doctor for Nausea, vomiting, or diarrhea?

Works Cited

1. Haque, Rashidul. "Human Intestinal Parasites." *Journal of Health, Population and Nutrition* 25.4 (2007): 387-91. Web. 19 Apr. 2013.
2. "The Geohelminths: Ascaris, Trichuris, and Hookworm." *World Class Parasites*. Ed. Cecial V. Holland and Malcolm W. Kennedy. Vol. 2. Dordrecht: Kluwer, 2001. 335. Print.
3. Cooper, P. J., M. L. Barreto, and L. C. Rodrigues. "Human Allergy and Geohelminth Infections: A Review of the Literature and a Proposed Conceptual Model to Guide the Investigation of Possible Causal Associations." *British Medical Bulletin* 79-80.1 (2006): 203-18. Print.
4. "Intestinal Worms." *World Health Organization*. N.p., n.d. Web. Apr.-May 2013.
5. "Parasites - Soil Transmitted Helminths." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 10 Jan. 2013. Web. 21 Apr. 2013.
6. Mor, Gil, and Ingrid Cardenas. "The Immune System in Pregnancy: A Unique Complexity." *American Journal of Reproductive Immunology* 63.6 (2010): 425-33. Print.
7. "Kenya Malaria Fact Sheet." *Kenya Malaria Fact Sheet*. N.p., n.d. Web. 21 Apr. 2013.
8. Luoba, Alfred I., P. Wenzel Geissler, Benson Estambale, John H. Ouma, Dorcas Alusala, Rosemary Ayah, David Mwaniki, Pascal Magnussen, and Henrik Friis. "Earth-eating and Reinfection with Intestinal Helminths among Pregnant and Lactating Women in Western Kenya." *Tropical Medicine and International Health* 10.3 (2005): 220-27. Print.
9. Kawai, Kosuke, Elmar Saathoff, Gretchen Antelman, Gernard Msamanga, and Wafaie W. Fawzi. "Geophagy (Soil-eating) in Relation to Anemia and Helminth Infection among HIV-Infected Pregnant Women in Tanzania." *The American Journal of Tropical Medicine and Hygiene* 80.1 (2009): 36-43. Print.
10. "Anemia in Pregnancy: Causes, Symptoms, and Treatment." *WebMD*. WebMD, 03 Jan. 0000. Web. 22 Apr. 2013.
11. Ndyomugenyi, Richard, Narcis Kabatereine, Annette Olsen, and Pascal Magussen. "Malaria and Hookworm Infections in Relation to Haemoglobin and Serum Ferritin Levels in Pregnancy in Masindi District, Western Uganda." *Oxford Journals* 102.2 (2007): 130-36. Web. 22 Apr. 2013.
12. Dreyfuss, Michele. "Hookworms, Malaria and Vitamin A Deficiency Contribute to Anemia and Iron Deficiency among Pregnant Women in the Plains of Nepal." *The Journal of Nutrition* 130.10 (2000): 2527-536. Print.
13. Levy, A., D. Fraser, M. Katz, M. Mazor, and E. Sheiner. "Maternal Anemia during Pregnancy Is an Independent Risk Factor for Low Birthweight and Preterm Delivery." *European Journal of Obstetrics & Gynecology and Reproductive Biology* 122.2 (2005): 182-86. Print.
14. Zhao, Zheng-Yan, Jie Shao, Jingan Lou, Raghavendra Rao, Michael K. Georgieff, Niko Kaciroti, Barbara T. Felt, and Betsy Lozoff. "Maternal Serum Ferritin Concentration Is Positively Associated with Newborn Iron Stores in Women with Low Ferritin Status in Late Pregnancy." *The Journal of Nutrition* 142.11 (2012): 2004-009. Print.
15. Van Eijk, Anna M., Kim A. Lindblade, Frank Odhiambo, Elizabeth Peterson, Daniel H. Rosen, Diana Karanja, John G. Ayisi, Ya Ping Shi, Kubaje Adazu, and Laurence Slutsker. "Geohelminth Infections among Pregnant Women in Rural Western Kenya; a Cross-Sectional Study." Ed. Jeffrey M. Bethony. *PLoS Neglected Tropical Diseases* 3.1 (2009): E370. Print.
16. Fernandez-Nino, Julia'n A. "Paradoxical Associations between Soil-transmitted Helminths and Plasmodium Falciparum Infection." *Oxford Journals* 106.11 (2012): 701-08. Web. 22 Apr. 2013.
17. "Schistosomiasis." *WHO*. N.p., n.d. Web. 28 Apr. 2013.
18. "Kwale County - Kenya Decides 2012 | Kenya Decides." *Kwale County - Kenya Decides 2012 | Kenya Decides*. N.p., n.d. Web. 21 Apr. 2013.