Potential Susceptibility to Soil Transmitted Helminths in Georgia

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Introduction

The impact of intestinal worms is seen as a thing of the past in the United States, but recent studies convey that, while the disease burden may not be as high as a century ago, there is persistence of intestinal worms in pockets of impoverished communities in the United States. Soil Transmitted Helminths (STHs) are a family of intestinal worms that include *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm)*, Ancylostoma duodenale* and *Necator americanus* (hookworms), in addition to Strongyloidiasis. While all are transmitted through contact with feces, hookworms and Strongyloidiasis both infect hosts through the penetration of their skin as young larvae (Brooker et al, 2004).

Globally, interventions are hindered by a poor understanding of the precise distributions of these infections, limiting the ability to combat them(Brooker 2006). This is not to say the infections are not widespread. Strongyloidiasis infects more than 100 million people worldwide, but is difficult to diagnose and has a high potential for fatal complications including "chronic persistent infection and with special characteristic features of autoinfection, hyperinfection involving pulmonary and gastrointestinal systems, and disseminated infection involving other organs" (Puthiyakunnon et. al, 2014, Vadlamudi & Krishnaswamy, 2006). For hookworm, the correlation of treatment with positive outcomes, such as improvements in schooling outcomes and long term income has been noted after hookworm eradication programs (McKenna et. al, 2017), hookworm is estimated to infect 740 million people (Brooker, 2004). In the early 1900's, the discovery that health problems affecting southerners could be attributed to hookworm resulted in the donation of a substantial sum of money and the formation of the Rockefeller Sanitation Commission. This eradication program provided free dewormings, and provided education to recognize the symptoms of the disease, so that fewer cases went untreated (Bleakly 2007),

The current prevalence of infection in the United States has limited insight, but recent research into the intestinal parasite burden in Lowndes County, Alabama provides some evidence for a renewed need for awareness about the infection in parts of the U.S.. Due to the dearth of data from the last several decades, little is known about the prevalence of STHs in the region, but the "socioeconomic and environmental conditions may remain conducive to ongoing infection" (Starr & Montgomery 2011). This is supported by a study performed by researchers from Baylor College of Medicine, which looked at the intestinal parasite burden of an at-risk group of residents of Lowndes County Alabama, where the results showed 34.5% tested positive for *N.Americanus* and 7.3% for *Strongyloides stercoralis* (McKenna et. al 2017). This is backed up by a study that found the Strongyloidiasis infection in the Appalachian region "mainly Eastern Kentucky and rural Tennessee with a prevalence of 4% and 2.5–3% respectively"(Vadlamudi & Krishnaswamy 2006). As such it is estimated there are 68,000 to 110,000 Appalachians infected with S. stercoralis (Hotez 2008). The potential presence of hookworm infection, remains largely undocumented. As noted by Starr & Montgomery in 2011, the most recent high quality study for inclusion in their review was published in 1982. Infection means that the eradication efforts were insufficient and that there is some likelihood that STHs could have a low-level prevalence in the endemic regions in the US, data for which is scarce, as there has been limited monitoring for decades. This is compounded with how, in the study done, with *N.Americanus* as the primary infection, the the endemic species is still present. As such, the evaluation of where there may be other renewals of STH infections in impoverished communities, even at low parasite burdens.

Studies of STHs have relied upon the use of microscopy in the analysis of fecal samples, a method that has a diagnostic sensitivity of 30-50% and thus possible underreporting (Starr & Montgomery, 2011). However, advancements in the field of diagnostics has resulted in the development of qPCR, the use of which as a diagnostic tool detects polyparasitism better and has "increased detection rates and significantly increased specificity," in addition to a decreased cost of analysis in comparison to microscopy (Vicuña et. al, 2013). These methods provide an opportunity to perform analysis on whether there is a even a low level parasite burden.

Much of Georgia is reliant on on-site septic disposal due to its limited sewage infrastructure in many counties. Because of this and the potential for public health problems caused by factors relating to wastewater treatment and soil conditions, the WelSTROM database was created, allowing the documentation and geolocation of septic systems and their vulnerability. A data set describing soil susceptibility, where the soil was rated on a scale of low/medium/high susceptibility to groundwater pollution. This scale is based on an index called DRASTIC, which "is an acronym for the hydrogeological factors which influence pollution potential: depth to water (D), net recharge (R), aquifer media (A), soil media (S), topography (T), the impact of the vadose zone media (I), and the hydraulic conductivity of the aquifer (C). Each factor is incorporated into a relative rating scheme … the higher an area scores on the index, the more vulnerable the specific area is to ground water pollution" (Trent, 1991).

This project is concerned with the potential prevalence and distribution of soil transmitted helminths (STHs) in the state of Georgia, taking into account environmental and socioeconomic factors to create a site suitability model. This will be used to convey the potential areas where conditions are amenable to the persistence of the STH life cycle and transmission to human hosts.

Methods

Data selection

The 2017 iteration of the American Community Survey (ACS) 5-year survey provided the data on poverty (Poverty status in the last 12 months), plumbing (whether or not the household had complete plumbing facilities) and education status. From this I was able to obtain for each census tract the percent poverty rate, the percent incomplete plumbing and the percent with at least a highschool diploma or equivalent.

From WelSTROM, the DRASTIC Layer, describing the soil susceptibility to pollution was acquired.

Data Processing

After narrowing down to the data sets available and usable for this analysis, each data file was processed to include only the relevant fields. The ACS data was then ranked and composite indexes were made before the data was intersected with the ranked soil data.

In processing the data, I removed the features from the DRASTIC layer where the soil class was “WATER” to appropriately count the areas as null. In the ACS data, I deleted tracts with no people in them, along with one tract with 2 people, as the relevant values listed were mostly null. For the variables listed below, I replaced the null values with the average of that field.

The ACS data were then each joined to a layer of the census tracts, spatially referencing the data. I then performed an intersect of the soil and ACS data. This permitted the creation of a composite index from the rankings developed.

Ranking

The poverty data was partitioned along the lines of percent poverty in a census tract, with thresholds listed below. The highest weighted ranges were those where the areas could be designated as a “Poverty area” where more than 20% of the population were below the poverty line, or “High poverty area” where more than 40% were below the poverty line (U.S. Census Bureau). Due to the significance of pervasive poverty in an area, I added another threshold at 60%, to have a greater weight for the areas where such a majority of households were in poverty.

Poverty	Range (%)	Rank(1-10)
	min(0.5)-10	1
	10-20.0	2
	20-40	4
	40-60	8
	60-max(88.6)	10

For the education ranking, I gave greatest weight where less than 50% had graduated from highschool.

Education	Range(%)	Rank(1-5)
	min(22)-50	5
	51-60	4
	61-70	3
	71-80	2
	81-93(max)	1

Incomplete plumbing ranking:

Plumbing (Inadec	Range(%)	Rank(1-10)
	0-5	1
	5-10.0	2
	10-15.0	6
	15-20	8
	20-30.4(max)	10

WelSTROM DRASTIC soil susceptibility ranking:

Soil	Range	Rank(1-10)
	LOW	1
	AVERAGE	5
	HIGH	10

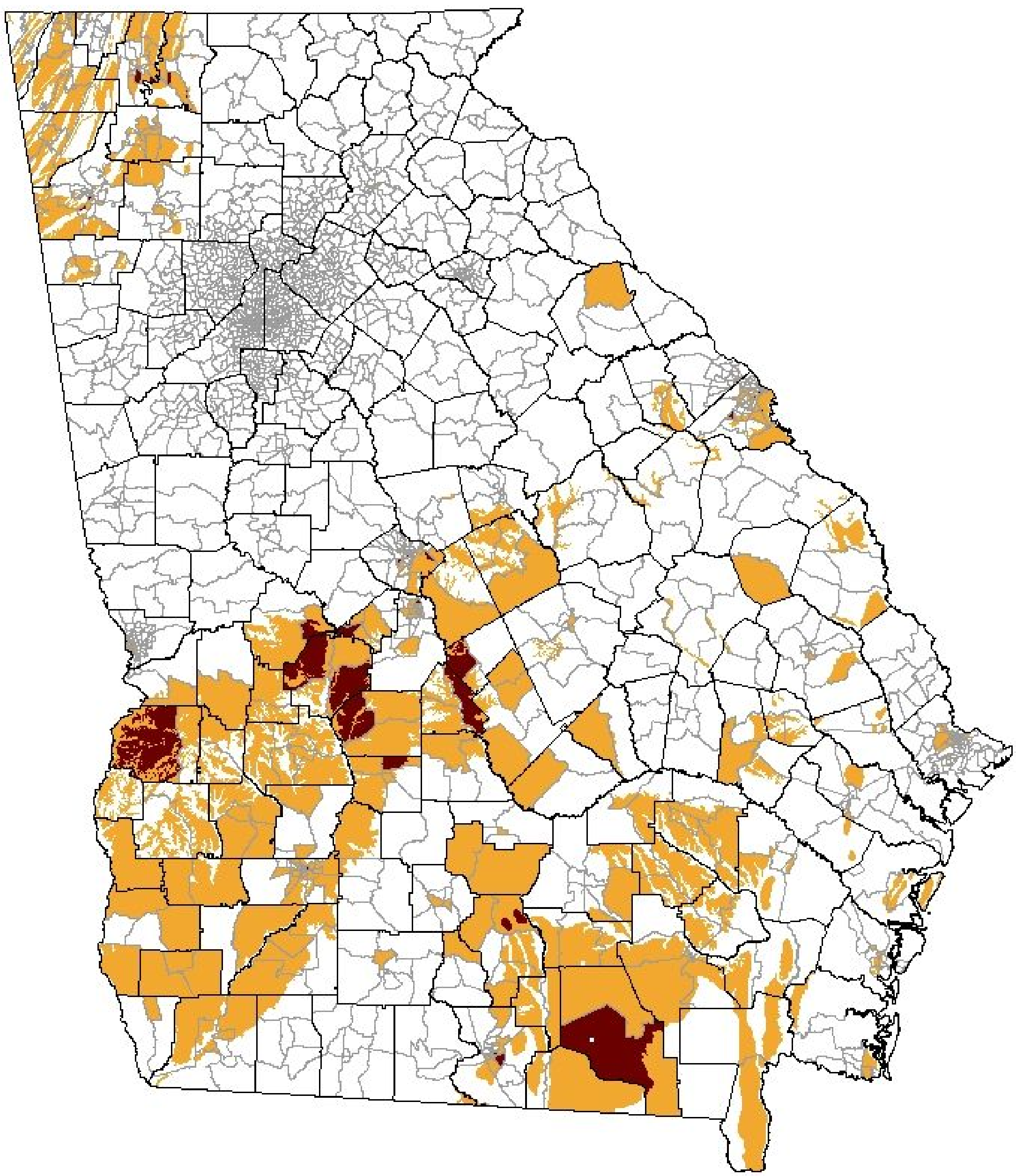
Composite Index

The index values I chose gave equal significance (maximum of 10) to the soil, plumbing and poverty ranking, while education had a lesser influence, having half the weight (maximum of 5) of one of the other three. To aid in the representation, this was then translated to percent by dividing by the maximum total composite index value.

Results

This map depicts for reference the counties and census tracts in Georgia. The areas highlighted are those which have an index of 17.5 or above (50% of maximum index score), with the darker areas representing an index of 24.5 or above, corresponding to 70% of the maximum index score possible. The areas not highlighted represent null values (eg. water) or where the associated value is less than 50% of the maximum index score.

This shows that the southwestern regions fulfill the criteria chosen to a greater extent, with some areas in the northwest corner of the state and isolated pockets in other counties. The area in proximity to metropolitan Atlanta ranks low.



Discussion

The impact of deep poverty, where people live at below 50% of the poverty line was not able to be taken into account in this analysis, as it was not included in the ACS data, whether due to the scale or the scope of using the ACS 5-year estimate by census tract. This could be a telling tool to see how this data fits in with other factors in understanding the susceptibility of a region to these infections.

In the future, evaluations of the flooding risks could be a secondary indicator to better define where might be at the most risk due to environmental factors. For the flooding and risks posed by heavy rainfall, a floodplain model will be created using elevation and past or predicted hydrological data to see where there is rainfall above a threshold that would overwhelm their sewage disposal methods and/or cause outright flooding in the dwellings.

The variations in the climate may be good to take into account if this analysis was to extend beyond the deep south, the temperature in the regions and its variability could be incorporated into the model with allowances made for variation outside the range. The preferential habitat of hookworm larvae was found to be 20-30 °C, but "required a much smaller (8 week) window of thermal suitability for transmission and so were able to persist even when the period available for development was of the order of ten weeks"(Brooker et. al 2006).

The scope of the study does not include possibility and factors facilitating infection by zoonotic STHs, for while they may have an impact on some of the populations and regions in question, their methods of and limits on transmission are not the same as the human-specific parasites. While there is the exposure to farm waste in impoverished rural areas, there is exposure to other waste in poor urban areas. This could confound the analyses of parasite distribution due to habitat, as the hookworm species which are entirely non-zoonotic and depend on poor access to adequate sanitation, which is a greater problem in the rural areas due to limited infrastructure. Another limitation to this and future studies is that there is minimal tracking of septic system usage or connection into municipal waste treatment in most areas. This, due to the efforts in Georgia to document septic systems and other factors that pose environmental threats, may be feasible in this state.

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