PhD defence Gerardo Zavala Gómez

Intestinal parasites, inflammation and nutritional status in Mexican children

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Dit is de omschrijving

Supervisors

- Prof. dr. ir. Jaap Seidell (VU Amsterdam),
- Prof. dr. Katja Polman (VU Amsterdam/ITM),
- Dr. Maiza Campos Ponce (VU),
- Dr. C.M. Doak (VU),
- Prof. dr. Olga Patricia García Obregón (Universidad Autoónoma de Querétaro, Mexico)

Summary

Intestinal parasitic infections and malnutrition are very common in children of low and middle income countries. Intestinal parasitic infection, obesity and micronutrient deficiencies account for more than 10% of the global disability-adjusted-life-years (DALYs). More than half of the children in Mexico are estimated to be infected with at least one species of intestinal parasites. In addition, micronutrient deficiencies such as iron (34-39%) and zinc (19-24%) are highly prevalent while the combined prevalence of overweight and obesity in children is more than 30%. These co-existing conditions place a heavy burden on the health care system in Mexico. In this thesis, we studied the associations between intestinal parasitic infections and nutritional outcomes in a pediatric population with high rates of overweight and obesity.

For this purpose we conducted a cross-sectional and an ecological study. For the cross-sectional study we recruited a total of 296 school-aged children (5-10 years) from a rural area in Querétaro, Mexico. We measured body fat (DXA and anthropometry); dietary intake using both, a food frequency questionnaire and three 24-h recalls; concentrations of zinc, iron, ferritin, vitamins A, E, C, D, and B12 in a fasting blood sample; the plasma concentrations of CRP, leptin, TNF-a, IL-6 and IL-10 as systemic inflammation markers and the count of stool leukocytes as marker of intestinal inflammation. Additionally, a stool sample was collected from each child and analyzed for intestinal parasites. For the ecological study, we used publicly available data from the Health and nutrition survey 2012 (ENSANUT) with information on the body mass index for age z-score (BMIz) in 2012 as a measure of nutritional status. In addition we used state-level data on incidence of infection with intestinal helminths (*Ascaris lumbricoides*) and intestinal protozoa (*Entamoeba coli, Balantidium coli, Endolimax nana, Cryptosporidium*) in 2000, 2006 and 2012 as a proxy for the probability of intestinal parasitic infection.

In the cross-sectional study, approximately 11% of the children were obese and 19% were overweight. The overall prevalence of infection was 61%. *Ascaris lumbricoides* was the most prevalent soil transmitted helminth (16%) followed by hookworm. *Entamoeba coli* was the predominant protozoa (20%) followed by *Endolimax nana* (16%), *Balantidium coli* (13%), *Entamoeba histolytica/dispar* (5%), *Giardia lamblia* (3%) and *Iodamoeba Bütschlii* (1%).

Children with moderate or heavy infection of *Entamoeba coli* had a higher waist circumference, waist to height ratio, body and abdominal fat than children not infected or with light intensity infection (**chapter 2**). These findings raise the possibility that *Entamoeba coli* infection may contribute to fat deposition and thereby have long term consequences on human health.

In order to test the association between intestinal parasites and obesity the country level, in **chapter 3** we performed an ecological study. We found that

in 2012, the combined prevalence of overweight and obesity in Mexico was 10% for children aged 1-5y, 35% for children aged 6-10y and 36% for the age group of 11-19y. In total, 47% percent of the population lived in poverty. The health coverage was 62% and the rate of households without sanitation facilities was 12%. A higher probability of infection with *Ascaris lumbricoides* and protozoan infections in 2000 and 2006 was associated with a higher BMIz in 2012. Furthermore, a higher probability of intestinal protozoan infection in 2012 was associated with a higher BMIz in 2012, while a higher probability of *Ascaris lumbricoides* infection in 2012 was associated with a lower BMIz in 2012. These results suggest that a higher probability of infection with *Ascaris lumbricoides* or intestinal protozoa was associated with a higher BMIz later in life. The association between current intestinal parasite infection and BMIz is opposite for *Ascaris lumbricoides* and protozoa. These findings may have important implications for Mexico, given the context of a high prevalence of parasitic infection and an emerging obesity epidemic.

In **chapter 4** we investigated if food intake plays a role in the association between intestinal parasitic infection and body fat. Children infected with *Entamoeba coli* had a higher intake of energy and fat and higher consumption of dairy, legumes, meat and cereals than non-infected children. In contrast, children infected with *Ascaris lumbricoides* had significantly lower intake of energy, carbohydrates and fiber, and lower consumption of dairy and meat compared with non-infected children. For the other intestinal parasite infections, no significant differences in energy or food intake were found. Our results show that *Ascaris lumbricoides* infection was associated with a lower reported food intake, while *E. coli* was associated with a higher reported food intake. This finding suggests that alterations in food intake may represent an important link in the chain connecting intestinal parasitic infections and nutritional status outcomes.

In **chapter 5** we explored the association between specific intestinal parasitic infections and the concentration of micronutrients and how this association is affected by individual´s body fat. We found that children infected with *Ascaris lumbricoides* had significantly lower concentrations of zinc and vitamin C than parasite-free children. Children infected with any intestinal protozoa, *Endolimax nana* or *Entamoeba coli*, had significantly higher concentrations of iron and vitamin B12 than parasite-free children. Among the children with high body fat, those infected with soil transmitted helminths had lower zinc concentrations than parasite-free children, and those infected with intestinal protozoa had lower vitamin A concentrations than parasite-free children. Our results suggest that soil transmitted helminths and intestinal protozoa have different associations with micronutrient concentrations, and these associations may differ according to the body fat content of the individuals.

Intestinal parasites have been associated with the same inflammatory markers related to obesity and chronic diseases; however there is a lack of studies evaluating the association between intestinal parasites and inflammatory markers in countries with high rates of obesity such as Mexico. In **chapter 6** we evaluated the associations between intestinal parasitic infections with intestinal and systemic inflammatory markers in school-aged children from Mexico. We found that none of the studied intestinal parasites were associated with CRP, IL-6, IL-10 or TNF-a. Children infected with *Ascaris lumbricoides* and *Entamoeba coli* were more likely to have higher stool leucocytes than parasite-free children and children with multiple-infections were more likely to have higher leptin concentrations than parasite-free children.

Mexico is the country with the highest combined rates of overweight and obesity in children worldwide. From this thesis, we confirm that malnutrition is a major public health problem in Mexican children, and demonstrate that intestinal parasitic infections are still highly endemic. We found a high prevalence of intestinal parasitic infection (60%) and malnutrition; high body fat (53.8%) and micronutrient deficiencies (37.2%).

E. coli infection was associated with a higher body fat %, BMIz, food intake and micronutrient concentrations, whereas *A. lumbricoides* infection was associated with lower BMIz, food intake and micronutrient concentrations. None of the studied parasite infections was associated with inflammatory markers (CRP, Il-6, Il-10 and TNF-α) while all of them were associated with higher intestinal inflammation. *E. coli* was the intestinal parasite infection with the highest association with intestinal inflammation.

Considering the high rates of malnutrition and intestinal parasitic infections in Mexico and the fact that malnutrition and intestinal parasitic infections are linked through several mechanisms (chapters 2-6), improvement on food environment (i.e. accessibility and availability of “healthy food”), education and living conditions (i.e. sanitation) are needed for any strategy reducing the burden of intestinal parasitic infection and malnutrition to be effective.