Intestinal coccidian: an overview epidemiologic worldwide and Colombia

Neyder Contreras-Puentes¹, Diana Duarte-Amador¹, Dilia Aparicio-Marenco¹, Andrés Bautista-Fuentes¹

Abstract
Intestinal coccidia have been classified as protozoa of the Apicomplexa phylum, with the presence of an intracellular behavior and adaptation to the habit of the intestinal mucosa, related to several parasites that can cause enteric infections in humans, generating especially complications in immunocompetent patients and opportunistic infections in immunosuppressed patients. Alterations such as HIV/AIDS, cancer and immunosuppression. Cryptosporidium spp., Cyclospora cayetanensis and Cystoisospora belli are frequently found in the species. Multiple cases have been reported in which their parasitic organisms are associated with varying degrees of infections in the host, generally characterized by gastrointestinal clinical manifestations that can be observed with diarrhea, vomiting, abdominal cramps, malaise and severe dehydration. Therefore, in this review, a specific study of epidemiology has been conducted in relation to its distribution throughout the world and in Colombia, especially, global and national reports about the association of coccidia informed with HIV/AIDS. Proposed revision considering the needs of a consolidated study in parasitology, establishing clarifications from the transmission mechanisms, global and national epidemiological situation, impact at a clinical level related to immunocompetent and immunocompromised individuals, as well as a focus on public health in institutional government policies and scientific information based on the characterization of coccidia in the tropical region and Colombia.

Keywords: Coccidia, Cryptosporidium spp., Cyclospora cayetanensis, Cystoisospora belli.

Coccidias Intestinales: Panorama epidemiológico mundial y en Colombia

Resumen
Los coccidios intestinales se han clasificado como protozoos del Phylum Apicomplexa, con presencia de un comportamiento intracelular y adaptación al hábitat de la mucosa intestinal, relacionado con varios parásitos que pueden causar infecciones entéricas en los humanos, generando especialmente complicaciones en pacientes inmunocompetentes e infecciones oportunistas en individuos inmunodeprimidos. Alteraciones como el VIH/SIDA, cáncer e inmunosupresión con tratamientos farmacológicos. En las especies que se encuentran frecuentemente se encuentran Cryptosporidium spp., Cyclospora cayetanensis y Cystoisospora belli. Se han reportado múltiples casos en los que sus organismos parásitos se asocian a diversos grados de infecciones en el huésped, generalmente caracterizadas por manifestaciones clínicas gastrointestinales que pueden observarse con diarrea, vómitos, calambres abdominales, malestar general y deshidratación severa. Por lo tanto, en esta revisión se ha realizado un estudio específico de epidemiología con relación a su distribución en todo el mundo y en Colombia, especialmente, reportes a nivel global y nacional a cerca de la asociación de coccidios informados con el VIH/SIDA. Revisión propuesta con el objetivo de considerar las necesidades de un estudio consolidado a nivel del campo de la parasitología, evidenciando literatura actualizada, estableciendo información de los mecanismos de transmisión, situación epidemiológica global y nacional, impacto a nivel clínico relacionadas con individuos inmunocompetentes e inmunocomprometidos, así como un enfoque en salud pública en políticas gubernamentales institucionales y la información científica basada en la caracterización de coccidias en la región tropical y principalmente en Colombia.

Palabras claves: Coccidia, Cryptosporidium spp., Cyclospora cayetanensis, Cystoisospora belli.

Introduction
Intestinal coccidia are intracellular protozoa of the intestinal epithelium classified taxonomically in the Phylum Apicomplexa. It’s have a life cycle that includes asexual and sexual reproductive stages, producing resistant parasitic stages called oocysts that are expelled into the environment and allow the spread of infection¹. Its epidemiological significance is associated with opportunistic infections responsible for a high morbi-mortality in individuals with HIV/AIDS, intestinal coccidia are also involved in acute diarrhea commonly self-limited in immunocompetent².

Cryptosporidium spp., Cyclospora cayetanensis and Cystoisospora belli are the most frequent agents involved in coccidiosis, have a cosmopolitan distribution; however, are reported

¹ University Corporation Rafael Nuñez, Faculty of Sciences of Health, Medicine, GINUMED group, Cartagena, Colombia.
² Autor para correspondencia.
Correo electrónico: neyderc.contreras@curnvirtual.edu.co
Cl. 10 ##10-17, Cartagena, Bolívar, Tel: (+57) 3217117666

Recibido: 29/03/2019; Actualizado: 23/10/2019; Aceptado: 23/10/2019

Cómo citar este artículo: N. Contreras-Puentes, et al. Intestinal coccidian: an overview epidemiologic worldwide and Colombia. Infectio 2020; 24(2):112-125
more frequently in developing countries, especially in tropical and subtropical zones. The species of the genus Cryptosporidium have been reported in reptiles, fish, birds and mammals mainly. Taking into account its zoonotic potential, Cryptosporidium can also be transmitted person to person through feces, consumption of contaminated food, additionally it has been described that water constitutes a vehicle for this coccidian, since it resists the purification techniques. Oocysts are acid-resistant alcohol can be of two types: thick-walled that are released with fecal matter, have infective capacity once expelled, and are resistant to environmental conditions, on the other hand thin-walled that are related to infection endogenous or autoinfection. Cryptosporidium spp. is the etiological agent of cryptosporidiosis emergent associated with acute and chronic diarrhea whose morbidity and severity of symptoms are related to the immune status of the host. The cryptosporidiosis was considered a serious public health problem in 1993 due to an outbreak in Milwaukee Wisconsin caused by contaminated water consumption where more than 400,000 people were affected. Equally, C. cayetanensis is the agent of endemic parasitosis worldwide, whose first case reported in humans was from Papua New Guinea. The resistant acid-alcohol oocysts sporulated in the environment, so a direct person-to-person transmission by fecal matter is rare. They have recovered from water sources, soil and food by infecting through the oral route incompetent and immunosuppressed individuals who produce acute inflammation, shortening and widening of the villi. For another hand, Cystoisospora belli is responsible for human cystoisosporiasis which has a worldwide distribution, is more frequent in tropical regions and its association with HIV patients has been described, transplant patients, with lymphomas, leukemias, considering itself a pathogen opportunistic and generating a serious clinical conditions under immunosuppression. It is also associated with traveler’s diarrhea.

Commonly founded in the Tropical regions as Africa (sub-Saharan Africa), Latin America and the Caribbean and Asia. Have been observed a variability in epidemiological frequency into 1 – 40% prevalence infection by coccidia, and that may be increase in situation related with HIV/AIDS infected patients. Therefore, these types of individuals due to immune commitment are disadvantaged, and it’s evidenced by the progressive increase in prevalence in the population, which are identified in the common and differential clinical manifestations. However, the symptomatic description starts from a series of causes that are initiated from the transmission and incubation of these agents inside the enterocyte where it achieves its differentiation and multiplication, and therefore it is exacerbated in patients with this type of alterations in the health.

It has been shown that these coccidia are frequently reported species in patients suffering from HIV/AIDS, whose clinical conditions at the gastrointestinal level such as excessive bowel movements and poor nutrition are observed, the direct causes due to infection and spread within the system is initially evidencing an apical complex consisting of structures such as rhoptries, micronemes and conoids that allows them to internalize and reproduce in the enterocyte, this internalization of invasive forms induces a proliferative development of sexual and asexual forms that they continue successively its life cycles, mainly due to the contribution of virulence factors that will facilitate interactions with the host cell, developing encysting, anchoring, motility, parasitophorous vacuole formation and the own damage generated at the level of enterocytic cells. Many of these mechanisms are related to the functioning of adhesion molecules (CSL, Gp900 reported in Cryptosporidium spp.) ingestion and survival inside the host cells. It also increases the pathogenic aspects and susceptibility at the intestinal level in patients with HIV/AIDS are reflected in the activation of proteases capable of damaging the epithelium and inside the enterocyte, subsequently triggering an inadequate immunological response, with the expression of mediators and pro-inflammatory cytokines. Alike, at the level of intestinal cells, ruptures of junctions between cells with increased mitotic activity are induced, alterations in the microvilli that condition the emergence of the malabsorption syndrome, as well as cellular involvement with increased permeability and eosinophilic infiltrations. Comparable, as infection in immunocompetent individuals producing self-limited watery diarrhea, with abdominal pain, steatorrhea and peripheral eosinophilia.

However, due to few epidemiological reports of coccidia in worldwide and Tropical regions as Colombia is necessary realize a detailed review with respect to presence of these microorganisms and areas with poor reports, offers a new dates, criterion and perspectives of scenery of presence of these species in national territory and its implications in the health of the population.

Material and Methods

We searched PubMed, Scielo, ScienceDirect and Google Scholar databases for studies reporting Cryptosporidium, Cyclospora cayetanensis and Cystoisospora belli infection in normal patients and HIV-infected populations from May and October 2018. The databases were searched using the term “Cryptosporidium”, “cryptosporidiosis”, “Cyclospora cayetanensis”, “cryptosporiasis”, “Cystoisospora belli” and “cystoisosporiasis” combined by cross-referenced employed term as “HIV”, “immunodeficiency”, “immunocompromised”, “immunocompetent”, “AIDS”, without language restriction.

Selection dates criteria

The included studies in this review were based in reports populations, epidemiological behavior and presence of coccidian in normal and HIV-infected communities, were needed obtain raw data to calculate the prevalence of Cryptosporidium, C. cayetanensis, and C. belli infection. We excluded studies as reviews or repeated studies; likewise, were not selected studies that present sample size was less than 20; or if the diagnostic methods of parasite infection were establishing. The reviewers examined titles, abstracts and keywords.
of the search, thus considered the full text considered great relevant. For condensation and data analysis the reviewers extracted the information related with the first author, reported year of selection sample of the publication, country of the study, calculated prevalences associated to HIV-infected and uninfected populations and its relationship with reported coccidia, type of sample and diagnostic techniques.

**Results**

In this review research were identified 2,365 publications related with ours studied thematic. After primary screening and excluded of duplicates, were evaluated 326 articles of selective form. Likewise, of these, 119 articles were excluded for present insufficient data that were required according to the criteria of this review, 76 were unavailable for full text and 67 present duplicate samples. Following, 64 articles were selected for review full-text of content and have been distributed in reports of prevalence’s of worldwide and Colombia, including 55 and 12 articles, respectively (Figure 1).

**Epidemiological reports of coccidia in worldwide**

According to 55 studies included, have been related 46 references with reports of Cryptosporidium infection in HIV-infected and uninfected people. Equally, for C. cayetanensis were founded 28 studies with reports of prevalences in populations of the World and C. bellii have been related around 32 studies which have determine populations infected with coccidian. These studies were done with reports of Cryptosporidium in 29 countries, C. cayetanensis in 25 countries and C. bellii around 19 countries (Fig. 2), including a distribution patron in countries of Europe, North America, sub-Saharan Africa, Latin America and the Caribbean and Asia. Evidencing a generalization de this type of microorganism typically in Tropical regions which may be related with its development and few sanitary conditions. However, the increase of these species is continuous, with high values of cases reports of infections, that have conditioned with major force clinical manifestation and management of new diagnostic techniques, have generated most investigations with respect the frequency of coccidia at level worldwide, where have been observed reports of infection in population that may be important your countries as in urban and rural areas. However, the infection by coccidian are widely distributed in the world, observe rates of prevalence with much variations that may be associated to immunocompromised and immunocompetent patients able of increased prevalence’s rates.

In this review, are showed a variability in the reports of prevalence’s of Cryptosporidium infection that may be established in range between 0.09 - 44% associated with patients HIV/AIDS, coincident with registered in areas as Africa and sub-Saharan Africa (2.2 - 44%); Asia (1.5 – 37.9%); Europe (0.09 -5.7%) and in Latin America and the Caribbean with North America (3.3 – 40.6%). In the case of C. cayetanensis is observed a general prevalence between 0.7 – 36.9% with high relationship in patients with HIV/AIDS. Alike, in populations of Africa and sub-Saharan Africa is frequently found high prevalence’s (0.7 – 28.9%); Asia (0.7 – 24%); Europe (0.7 – 5.7%) and elevated prevalences data in Latin America and the Caribbean similar to evidence in Africa (1.8 – 36.9%). Also, C. bellii shown values of prevalences into 0.4 – 31% observed at HIV-infected patients, which is evidenced similarly in communities of Africa and sub-Saharan Africa (0.7 – 13.3%); Asia (0.4 – 31.0%); Europe (1.0%) and in Latin America and the Caribbean with North America (3.2 – 9.9%).

**Figure 1.**

![Flowchart](image-url)
In general, epidemiologic studies have been registered prevalence’s of Cryptosporidium spp., Cyclospora cayetanensis and Cystoisospora belli in European countries as UK (15.2%), France (0.2-23.0%), Italy (0.6-33.3%), Poland (5.4%), Portugal (7.7%), Turkey (0.5-6%)\(^{38-44}\). In Africa have established countries such as Cameroon (2.1-44.0%), DR Congo (2.9-31.0%), Ethiopia (1.3-34.0%), Kenya (8.8-25.9%), Ghana (28.6%), Nigeria (1.0-79.0%), Senegal (13.9-16.0%), South Africa (7.7-75.6%), Uganda (0.1-74%), Zambia (2.2-7.7%) and Zimbabwe (0-10%)\(^{65-68}\). Equally, in Asiatic continent exist a high prevalence in countries as China (12.0%), India (1.1-31.3%), Iran (0.6-9.6%), Saudi Arabia (4.2-19.2%), Libya (0.9-13.0%), Malaysia (3.0-23.0%), Nepal (0.2%-11.2%), South Korea (7.5-10.4%), Thailand (1.1-25.3%)\(^{65,70,71}\). In Latin-American, have been found prevalence’s with similar frequency, including Cuba (1.5-12%), Colombia (2.6-29%), Guatemala (0.9-13.7%), Honduras (2.0-6.8%), Mexico (9.8-28.4%), Argentina (1.3%), Peru (0.7-52%), USA (0.8-33%) and Venezuela (0.2-41.6%)\(^{72}\). (Figure 2).

In wide evidences have established the association and coexistence of opportunistic intestinal parasites and increase the worldwide prevalence in HIV infected patients, being Cryptosporidium, C. cayetanensis and C. belli, the main intestinal organisms detected with high relevance in HIV-infected patients; have been considered prevalences usually high in areas as sub-Saharan Africa, Asia and Latin American and Caribbean which have observed the intensification of numerous clinical signs in patients with diarrhea as principal manifestation in this type of patients. Possibly, the behavior in immunocompromised and immunocompetent lead to a substantial development of coccidia and largeness clinical indications, given the ineffectiveness of the immune response and poor results with pharmacological treatments, alike, these comportments are favored by the existence of conditions environmental in these populations, poor access to sanitary care and educational factors, that directly influence the exacerbation of the clinical alterations presented. For other hand, in ours review the studies included were predominated in Africa and sub-Saharan African (n=18), Asia (n=14) and Latin American and the Caribbean (n=10) and with few studies development in Europe (n=4), emphasizing the need for more robust investigation of Cryptosporidium spp., C. cayetanensis and C. belli infection in HIV-infected individuals in these areas. Likewise, many studies were identified through literature search, but not all results were available, additionally, the major part of studies registered were based traditional microscopic techniques that present a minor detection response compared with PCR, ELISA and fluorescent techniques, inducing to minor quantitation of coccidian or no corrected estimation of prevalences.

**Epidemiological reports of coccidia in Colombia**

In Colombia, some epidemiological data have been shown regarding the identification of intestinal coccidia and associated with multiple clinical manifestations. Likewise, different routes of exposure related to the invasion in different hosts. Some of these routes have been described from the conditions of health, food, consumption of contaminated water, soil and air with spores or oocysts, seasonal distribution, agricultural and livestock practices. Thus, in the limited reports established for the diagnosis of these parasites, some genera of intestinal coccidia have been detected such as Cryptosporidium spp, Cyclosporas spp., Cystoisospora spp. and Microsporidium spp. The few studies reported with respect to presence of coccidian in Colombia are listed in the Table 2.

![Figure 2](image-url)
| Countries                      | Year report | Population affected                                                                 | Prevalence            | Sample and diagnostic                                                                 | References |
|-------------------------------|-------------|-------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|------------|
| **Africa and Sub-Saharan Africa** |             |                                                                                     |                       |                                                                                       |            |
| Burkina Faso                  | 2015        | 291 patients                                                                         | 26.5% (77/291)*       | Faecal samples - Modified Ziehl-Neelsen method                                         | 12         |
|                               |             | 207 samples from HIV-positive patients                                                | 12.6% (26/207)*       | Direct microscopy, formalin-ether concentration, Ziehl Neelsen modified and Kato-Katz methods. | 2          |
| Cameroon                      | 2016        | 52 pre-ART and 248 on-ART HIV patients                                              | 44.0% (132/300)*      | Stools sample - Modified field staining, and modified Ziehl-Neelsen staining           | 13         |
| Cameroon                      | 2013        | 396 samples of HIV                                                                   | 2.5% (10/396)*        |                                                                        | 14         |
| Cameroon                      | 2014        | 207 samples from HIV-positive patients                                               | 12.6% (26/207)*       | Ziehl–Neelsen staining (modified Henricksen-Pohlenz); Real-Time PCR; nested PCR and PCR-RFLP | 15         |
| Cameroon                      | 2013        | 242 patients with HIV/AIDS                                                            | 5.4% (13/242)*        | Stools samples - Sodium acetate-acetic acid-formalin-fixed stool                       | 16         |
| Congo                         | 2012        | 102 patients                                                                         | 0.97% (1/102)***      | Stools samples - Modified acid-fast (Kinyoun) staining protocol as                     | 20         |
| Côte d’Ivoire                 | 2010        | 268 (HIV infected)                                                                  | 34.3% (92/268)*       | Stool samples - formalin-ether and modified Ziehl-Neelsen stain                       | 17         |
| Ethiopia                      | 2014        | 378 HIV-positive persons (with ART and without ART)                                   | 8.4% (32/378)*        | Stools samples – Formal-ether and modified acid-fast staining techniques               | 18         |
| Ethiopia                      | 2013        | 248 subject (188 HIV-positive and 60 HIV-negative)                                     | 33.1% (82/248)*       | Stool samples - Formal-ether sedimentation concentration and modified Ziehl-Neelsen staining | 19         |
| Ethiopia                      | 2011        | 371 patients (112 ART-naive group and 259 on ART)                                     | 2.2% (8/371)*         | Stool samples - Modified Ziehl-Neelsen method (for                                    | 20         |
| Ethiopia                      | 2013        | 200 children (symptomatic and asymptomatic)                                          | 17.0% (17/100)*       | Stools samples - Examination with saline and iodine smear, Sheather’s sugar floatation technique and staining modified Ziehl–Neelsen. | 21         |
| Ghana                         | 2012        | 413 patients (HIV and non-HIV)                                                        | 8.2% (34/413)*        | Stools samples - Modified Ziehl-Neelsen staining technique                             | 22         |
| Nigeria                       | 2010        | 90 patients                                                                          | 41.1% (37/90)*        | Stools samples - Modified Ziehl-Neelsen staining technique                             | 23         |
| Nigeria                       | 2009        | 268 samples from HIV-positive and 20 samples from HIV-negative patients               | 3.1% (9/288)***       | Stools samples - modified Ziehl-Neelsen staining technique                             | 24         |
| Nigeria                       | 2010        | 2500 patients (2000 HIV-positive and 500 HIV-negative)                                 | 22.2% (80/360)*       | Stools samples - modified Ziehl-Neelsen staining technique                             | 25         |
| Nigeria                       | 2008        | 900 patients (700 HIV-seropositive and 200 HIV-seronegative)                          | 30.2% (64/197)*       | Stools samples - Modified Ziehl Neelson (ZN) staining method                          | 26         |
| Nigeria                       | 2011        | 2000 samples of patients (1966 HIV-infected)                                         | 22.2%*                | Stools samples - modified Ziehl-Neelsen stain                                        | 27         |
| South Africa                  | 2009        | 823 samples (528 patients from Hospitals and 295 children schools)                   | 17.9% (148/823)*      | Stools samples - Modified Ziehl Neelson staining                                     | 28         |
| Country       | Year | Study Details                                                                 | Prevalence Details       | Methods of Detection                                      | References |
|---------------|------|--------------------------------------------------------------------------------|--------------------------|------------------------------------------------------------|------------|
| Mozambique    | 2018 | 108 patients (83 individuals with HIV+)                                         | 8.3% (9/108)* 25.0% (27/108)*** | Stools samples - modified Ziehl–Neelsen and PCR             | 29         |
| Egypt         | 2019 | 120 HD patients 100 healthy individuals                                         | 32.5% (39/120) and 11% (11/100)* 1.7% (2/120)** 1.7% (2/120)*** | Stool samples - modified Ziehl–Neelsen technique            | 30         |
| Asia          |      |                                                                                 |                          |                                                            |            |
| China         | 2011 | 11554 patients                                                                   | 0.70% (81/11554)***     | Stools specimens - modified acid-fast staining technique   | 31         |
| India         | 2009 | 137 HIV-infected with diarrhea                                                   | 12.1% (16/137)* 0.73% (1/137)** 8.0% (11/137)*** | Stools samples -Modified acid fast staining                 | 32         |
| India         | 2002 | 120 HIV-seropositive patients                                                    | 10.8% (13/120)* 3.3% (4/120)** 2.5% (3/120)*** | Fecal samples – Modified Ziehl–Neelsen technique            | 33         |
| India         | 2013 | 75 HIV-infected patients                                                         | 37.9% (11/75)* 31.0% (9/75)*** | Modified AFB procedure and                               | 34         |
| India         | 2012 | 50 HIV-positive individuals                                                       | 24.0% (12/50)**        | Stools specimens - Modified acid fast staining (Kinyoun’s method) and the Safranin staining methods | 35         |
| India         | 2013 | 100 individuals with HIV seropositive                                            | 2.0% (2/100)* 18.0% (18/100)*** | Stools samples - Modified acid fast staining              | 36         |
| India         | 2011 | 64 samples of patients                                                           | 12.5% (8/64)* 7.8% (5/64)*** | ELISA for detection of Cryptosporidium antigen; Hot modified acid fast stain; Kinyoun carbol fuchsin stain; Safranin-methylene blue stain. | 37         |
| India         | 2013 | 100 patients (HIV-positive)                                                      | 4.0% (4/100)* 10.0% (10/100)*** | Stool samples -Modified acid fast staining                | 38         |
| Iran          | 2013 | 356 patients HIV-infected (children and adults)                                  | 9.5% (34/356)* 0.56% (1/356)** 0.28% (1/356)*** 0.56% (2/356)*** | Fecal samples – detection employing PCR techniques         | 39         |
| Iran          | 2016 | 350 immunocompromised patients                                                   | 0.9% (3/350)* 1.1% (4/350)*** | Formol-ether concentration and Ziehl–Neelsen technique      | 40         |
| Iraq          | 2015 | 245 samples                                                                      | 14.3% (35/245)* 11.0% (27/245)*** 0.40% (1/245)*** | Lugols iodine stain and flotation technique (zinc sulphate solution) | 41         |
| Nepal         | 2017 | 588 patients                                                                      | 2.02% (12/588)***      | Stool samples - Parasites were observed using saline, iodine and potassium dichromate | 42         |
| Nepal         | 2017 | 262 children and adults                                                          | 1.5% (4/262)*** 3.8% (10/262)*** | Stools specimens - Formal-ether sedimentation method combined with modified acid fast staining method       | 43         |
| Yemen         | 2017 | 282 children                                                                      | 11.3% (32/282)* 4.6% (13/282)*** | Modified Kinyoun’s acid-fast staining technique (Kinyoun’s cold method) | 44         |
| Iran          | 2018 | 250 patients                                                                      | 10.8% (27/250)***      | Nested PCR-RFLP technique                                  | 45         |
| Iran          | 2019 | 87 patients                                                                       | 5.7% (5/87)*** 3.5% (3/87)*** | Stool sample stained by modified Ziehl–Neelsen               | 46         |
| Iran          | 2019 | 102 patients HIV/AIDS                                                             | 0.98% (1/102)***       | Acid-fast staining and PCR                                   | 47         |
| Country                      | Year | Sample Size | Prevalence | Methods                                                                 |
|------------------------------|------|-------------|------------|-------------------------------------------------------------------------|
| Denmark                      | 2011 | 96 HIV-infected patients | 1.0% (1/96)*<br>1.0% (1/96)**<br>1.0% (1/96)*** | Faecal specimens – PCR analysis                                       |
| Germany                      | 1997 | 795 patients (diarrhea, fever, white) | 1.6% (13/795)*<br>0.7% (5/795)**<br>1.6% (13/795)**<br>0.7% (5/795)** | Stools specimens – Microscopy (iron-haematoxylin stain, SAF concentration, modified acid fast stain) and ELISA |
| Turkey                       | 2015 | 2281 patients with digestive complaints | 5.7% (129/2281)**<br>5.7% (129/2281)**<br>5.7% (129/2281)**<br>5.7% (129/2281)** | Stool samples – Treatment with Entellan™ and acid-fast staining |
| Turkey                       | 2010 | 27664 patients | 0.09% (1/1114)*<br>0.09% (1/1114)*<br>0.09% (1/1114)*<br>0.09% (1/1114)* | Stools samples - Lugol and formalin-ethyl acetate concentration technique |
| Poland                       | 2018 | 283 patients | 1.4% (4/283)*<br>0.7% (2/283)**<br>1.4% (4/283)*<br>0.7% (2/283)** | Ziehl-Neelsen and PCR analysis |
| Sur American, Latin American, Caribbean and North American | | | | |
| Brazil                       | 1993 | 131 patients | 19.1% (25/131)*<br>9.9% (13/131)**<br>9.9% (13/131)**<br>9.9% (13/131)** | Faecal samples – Modified formol-ether concentration, carbol (phenol) auramine staining, and a modified Kinyoun acid-fast method |
| Brazil                       | 2013 | 120 patients (59 HIV-infected) | 10.1% (6/59)*<br>6.7% (4/59)**<br>10.1% (6/59)*<br>6.7% (4/59)** | Stool samples – modified Ziehl-Neelsen technique and PCR |
| Peru                         | 2016 | 325 Children | 3.7% (12/325)*<br>1.8% (6/325)**<br>3.7% (12/325)*<br>1.8% (6/325)** | Stool samples – modified acid-fast staining procedure and the Cryptosporidium ELISA method (kit r-Biopharm) |
| Venezuela                    | 2010 | 130 samples of < 5 years old with diarrhea | 7.7% (10/130)*<br>4.6% (6/130)**<br>7.7% (10/130)*<br>4.6% (6/130)** | Direct determination, formaldehyde-ether and Kinyoun staining |
| Venezuela                    | 2010 | 100 Children (3 months and 5 years old) | 4% (4/100)*<br>4% (4/100)*<br>4% (4/100)*<br>4% (4/100)* | Faecal samples – SSF (0.85%) and iodine, Kinyoun stain |
| Venezuela                    | 2018 | 186 individuals | 26.6% (50/188)*<br>32.9% (62/188)**<br>26.6% (50/188)*<br>32.9% (62/188)**<br>3.19% (6/188)**<br>3.19% (6/188)** | Lugol solution for direct determination; Kinyoun (modified Ziehl-Neelsen) |
| Venezuela                    | 2014 | 187 individuals | 40.6% (76/187)*<br>36.4% (68/187)**<br>6.95% (13/187)**<br>6.95% (13/187)** | Lugol solution for direct determination; Kinyoun solution (Modified Ziehl-Neelsen) |
| Venezuela                    | 2015 | 336 individuals reported | 3.3% (11/336)*<br>0.89% (3/336)**<br>3.3% (11/336)*<br>0.89% (3/336)** | Retrospective review of data bases. |
| Venezuela                    | 2003 | 212 subjects | 6.1% (13/212)**<br>6.1% (13/212)**<br>6.1% (13/212)**<br>6.1% (13/212)** | Fecal samples – modified Ziehl-Neelsen carbol-fuchsin staining of formalin-ether concentrates |
| Brazil                       | 2018 | 90 patients (HIV/AIDS) | 1.1% (1/90)**<br>1.1% (1/90)**<br>1.1% (1/90)**<br>1.1% (1/90)** | Ziehl-Neelsen and Kinyoun’s methods and the safranin technique |
| USA                          | 2018 | 401 patients (cholecystectomy specimens) of immunocompetent patients | 9.7% (39/401)**<br>9.7% (39/401)**<br>9.7% (39/401)**<br>9.7% (39/401)** | Oocyst in stools – microscopic examination. |
| Peru                         | 2019 | 102 | 11.2% (11/102)*<br>8.9% (9/102)**<br>11.2% (11/102)*<br>8.9% (9/102)**<br>15.6% (16/102)***<br>15.6% (16/102)*** | Medical history and coprological test. |

*C. Cryptosporidium spp. **Cyclospora cayetanensis. ***Cystoisospora belli. qPCR: Quantitative Polymerase Chain Reaction. ELISA: Enzyme-Linked ImmunoSorbent Assay. RFLP: Restriction Fragment Length Polymorphism.
In the context Colombian, some the reports established by the Ministry of Health between the periods of 2012 to 2014, the diagnosis of the presence of intestinal coccidia in low proportion was demonstrated, values established on average between 0.5%, and individual records in some regions such as the Caribbean ocean territories in values close to 3.9%, and at the Pericaribeño, Norandina, Chocó-Magdalena and Amazonia Belt levels close to the value established at the national level; on the other hand, some historical studies of cryptosporidiosis in Colombia have shown prevalences between 2.5 and 4.0% in people with characteristic clinical manifestations such as diarrhea; However, this report can be higher in immunosuppressed individuals, among which 32 and 42% prevalence can be reached. Likewise, other researchers establish the same scenario regarding the predominance of Cryptosporidium spp. with totally coincident values between 1 and 45.3% of case reports. Aspect that is not fully detailed for other types of coccidia such as Cyclospora cayetanensis including C. belli which have shown some reports, but without a total distribution of prevalence. Figure 3

However, the prevalence of the disease associated with Cryptosporidium from animal species is not fully clarified and the zoonotic association in Colombia is still lacking information. The few reports have shown the presence of Cryptosporidium around 16.4% of positive samples, where it was observed more frequently in children under one year of age, diarrhea (OR = 2.99; p = 0.01) and the antecedent of a low vaccination effect. related to the probability of infection, which suggests that it can be an indicator or predictor of infection. In this way, some similar reports have been established in the coffee region and specifically in the municipality of Caldas where fecal samples of cattle were analyzed by PCR-RFLP techniques, in which the confirmation of around 13.5% was demonstrated of presence of these parasites, being C. parvum the species completely identified in all the samples. The authors have indicated that the presence of C. parvum in bovines represents a risk for individuals who perform tasks associated with these animals, possibly through direct routes such as contact with fecal matter in crop or grazing areas, or indirectly through the routes of contamination of drinking water by the presence of oocysts generated from the practice of grazing. Table 2

Likewise, in cross-sectional studies descriptive type, the department of Atlántico allowed the identification of the presence of oocysts of Cryptosporidium spp. by microscopic and macroscopic analysis in fecal samples. Evidence of similar prevalence values at the national level, these prevalence values of 1.9%, further demonstrated the association between the presence of the parasitic agent and symptoms such as fever, the presence of blood in the samples and the incidence

Table 2. Prevalence of Cryptosporidium spp., Cyclospora cayetanensis and Cystoisospora belli in communities from Colombia.

| Department/City | Year report | Population affected | Prevalence | Sample and diagnostic | References |
|----------------|-------------|---------------------|------------|-----------------------|------------|
| Cundinamarca   | 2003        | 115 patients with HIV | 10.4% (12/112)* | Ziehl-Neelsen modified | 73         |
| Cartagena de Indias | 2003      | 38 patients with HIV     | 23.7% (9/38)* | Ziehl-Neelsen modified | 74         |
| Medellin       | 2006        | 56 samples of patients  | 55.0% (30/56)* | Ziehl-Neelsen modified | 75         |
| Cali           | 2006        | 72 children HIV/AIDS between 0 and 15 years | 51.4% (37/72)* | Ziehl-Neelsen modified | 76         |
| Tunja          | 2009        | 137 samples of dogs     | 16.4% (22/132)* | Ziehl-Neelsen modified | 77         |
| Cali           | 2011        | 131 children with HIV/AIDS | 29.0% (38/131)* | Ziehl-Neelsen modified | 78         |
| Atlántico      | 2012        | 423 patients            | 1.9% (8/423)* | Ziehl-Neelsen modified | 79         |
| Caldas         | 2012        | 80 samples from         | 13.8% (11/80)* | PCR-RFLP analysis     | 80         |
| Caqueta        | 2015        | 193 Children (0-5 years old) | 7.3% (14/193)* | Kinyoun modified      | 3          |
| Tolima         | 2015        | 208 children            | 23.6% (Rural)* | Ziehl-Neelsen staining | 81         |
| Amazonas       | 2017        | 284 Children and adolescents between 1-15 years | 1.9% (5/261)* | qPCR                  | 82         |
| Cauca          | 2019        | 258 children            | 9.8% (25/258)* | qPCR                  | 83         |

*Cryptosporidium spp. **Cyclospora cayetanensis. ***Cystoisospora belli. qPCR: Quantitative Polymerase Chain Reaction.
of zoonotic elements (domestic animals). In order to provide detailed information regarding the clinical manifestations due to this type of coccidian. Additionally, this similar behavior is evidenced in other increasingly rural populations such as Amazonas (Puerto Nariño, San Juan del Socó, Villa Andrea and Nuevo Paraíso), where the presence of intestinal coccidia such as Cryptosporidium sp. was established in these communities. Which were diagnosed in faecal samples in minors by using microscopy techniques, showed prevalences greater than 1.8%, managing to identify 3 species of Cryptosporidium including C. viatorum, C. hominis and C. parvum, establishing that these species are linked in the transmission in humans and keeping a close relationship with the living conditions of these populations.

On the other hand, it is very common to find a high association and presence of this type of coccidiosis in immunocompetent and immunosuppressed individuals, as is the case of patients with HIV, in which they have been associated with Cryptosporidium and other coccidia as opportunistic parasites. In studies developed by Flórez et al, the prevalence of Microsporidium and other opportunistic intestinal parasites in HIV-infected patients with gastrointestinal symptoms was studied, for which 115 patients were studied during 2001, in different health institutions and in which the Sample of fecal matter of each individual. In this way, it was established that the prevalence of opportunists was 10.4% for Cryptosporidium spp. Regarding Microsporidium spp, a figure of around 29% was found through modified screening. Likewise, Botero et al, determined the presence of intestinal parasites such as Cryptosporidium spp., Microsporidium spp, C. cayetanensis and C. belli, in which prevalences of 3.6% and 1.8% were indicated for Cryptosporidium spp., Microsporidium spp., respectively. For another hand, Siuffi et al. have identified the presence of coccidia in feces of infants with AIDS through colormetric tests and detection of viral load accompanied by an increase in TCD4 lymphocyte values. The prevalence was close to 51.4%, with the population mostly affected between the ages of 5-10 years and related to the most advanced cases of AIDS. Similarly, some reports have established the prevalence in 29% of children in the department of Valle del Cauca, in addition to the detection of a high percentage of presence, some manifestations and aspects were related as abdominal pain, the presence of animals and a considerable viral load. Likewise, a behavior of higher incidence of infection by Cryptosporidium was observed in terms of its geographical distribution at the level of rural areas or with clinical recidivism.

However, for Cyclospora cayetanensis and Cystoisospora belli no evidence of parasite oocysts was found. However, there have been evidenced minor reports of prevalence of Cyclospora cayetanensis as study development by Botero-Garcés et al., in number of cases of diarrhoea appeared in 2002, obtained of 56 samples of stool from patient found as etiological agent to Cyclospora cayetanensis with positive response. Which, 55.4% of the patients evaluated proved positive for C. cayetanensis. Equally, in a study realized by Lucero-Garzón et al in Caquetá, Colombia, which fecal samples were collected from 193 children and coccidia were identified using the Kinyoun technique with modifications, demonstrating that the prevalence of coccidia was 19%; with prevalence’s individually for Cryptosporidium spp. (7%), Cystoisospora spp. (8%) and Cyclospora spp. (4%).

**Discussion**

During years the epidemiological studies of coccidia in the world increases progressively due to sanitary conditions and factors that encourage the transmission and propagation from one vector to another. The large cases reported worldwide, especially in countries in Africa, Asia and America, have been associated with a high alteration in health care conditions, inadequate implementation of public policies and cultural patterns, in which have been evidenced high rates prevalence and particularly in cases of immunosuppression related to patients with HIV/AIDS.

Likewise, the propagation of these agents in these regions has been schematized in different routes, but definitely maintain common patterns of infection independent of the region. Thus, in the transmission and invasion of the host, the oocysts of Cryptosporidium spp., C. belli and C. cayetanensis can remain in the stool and eventually be transmitted to humans; multiple routes of infection can be established dependig of geographic reference, including areas of medium to high prevalence, such as in rural zone associated with wide agricultural activities, with low sanitary access and inadequate life habits, in which the passage of feces of infected animals through direct manipulation by the individuals of farm leads to an increase in the likelihood of invasion by the oocysts and finally could contaminate plants and fruits as possible route of contact with the organisms, or indirectly
by runoff waters or wastewater that may be serve as vehi-
cles of parasitic forms, leading to contamination of plants94–96; likewise with contamination of water deposits that can be
used as water sources of supply for human consumption or
animal husbandry94–96. However, atypical infections of non-
endemic individuals may be affected due to the consumption
of contaminated food or water ingested by the mechanisms
established above97. Figure 4.

Correspondingly, multiple methods of diagnosis of coccidia
were established in the global and national prevalence re-
ports, in which traditional and modern methods for the iden-
tification of these agents have been established. The use
of each of these methods depends the objectives, sensitivity,
precision and accuracy in the characterization of each spe-
cies, as well as the dependence on the operational cost of
equipment and materials to diagnosis. Likewise, in traditional
microscopy methods for the correct detection of intestinal
coccidia, it is advisable to process a coprological examina-
tion using a stool concentration technique and thus increa-
sing the chances of finding oocysts, it’s also required to apply
the modified Ziehl Neelsen staining, for their visualization,
taking into account that coccidia are acid resistant alcohol. At
present, in less developed countries such as Colombia, these
methodologies are still tools of wide application due to sev-
eral advantages such as rapid screening, low cost, and to
which research institutions and clinics have access98,99. How-
ever, these techniques have some disadvantages in terms of
handling, the development of poorly validated and non-re-
producible techniques that lead to the inaccurate detection
of some species of coccidia100.

Also, other methods applicable in the identification of intesti-
nal coccidia, specified the ability of self-fluorescence that has
the genus *Cyclospora*, fluorescence microscopy is a very sen-
sitive and specific method of support for its diagnosis within
which the auramine O101, and other diagnostic methodolo-
gies such as Enzyme immune-assays (EIAs) or immuno-
chromatographic lateral flow (ICLF) and automated capillary
electrophoresis (CE)-based DNA fragment analysis tool102–104.
Additionally, the use of DNA extracted from coccidia oocysts
for PCR amplification is very useful for an accurate diagnosis.
At present, PCR techniques can represent advantages around
the time of analysis, improvement of sensitivity and reduc-
tion of cross contamination, resulting in a greater response
capacity and accuracy105. However, some methodological li-
mitations appear to be related to the stool samples of the
organisms analyzed, in which agents capable of inhibiting
polymerase activity, necessary for the DNA amplification
process of these agents may be present106,107. On the other
hand, in Colombia due to the barely growing research deve-
lopment, and taking into account the high economic costs
for the implementation of these techniques, few institutions
have carried out this type of strategies in order to establish
an accurate opinion and complete validation of the complete
epidemiological panorama of the country.

On the other hand, the relationship of the presence of di-
seases with a growing background such as HIV/AIDS, which
affects disadvantaged populations and even countries with
high economic incomes, has been established. The global
reports established by the WHO register that more than 30
million individuals are related to HIV/AIDS108, supporting a
death rate of more than 900,000 people109. Also, in consid-
eration of the increases in the prevalence, the parasitic agents
such as coccidia show a sustained increase at the level of
the whole world, in which show a substantial relationship in
immunocompetent and immunocompromised individuals110.
According to the epidemiological reports it has been esti-
"...
prevalence levels of coccidia. In this way, populations that reach reports of infection between 3.1 - 44% in the African continent have been characterized\cite{14,171}, likewise, in Asia with values between 0.98 - 37.9%\cite{12,172} and similar estimates are established in the American continent, with records between 1.1 - 40%\cite{18}. In addition, in Colombia the presence of coccidia has a behavior similar to that established by the world reports, despite establishing the registry of few studies at the national level. These general data indicate a behavior trend that can affect approximately half of the individuals detected with HIV/AIDS, due to the opportunism of these microorganisms, which spread rapidly and lodge at the intestinal level, during the infection by coccidias multiples mechanism are active inducing internalization into enterocyte, modifying cellular structure by exportation and activation of cytokines pro-inflammatory that increase phagocytic capacity\cite{19}. Therefore, these activated cells release mediators such as prostaglandins, neurotransmitters, leukotriene’s that influence the secretion of chloride and water ions, as well as the negative regulation of intestinal absorption\cite{20}, and finally have a direct impact on the deterioration of the cell epithelium, established by an apoptotic effect induced by the parasite due to its growth and generation of new infectious agents, as well as damage of microvilli and cryptic hyperplasia\cite{21}. Alike, in the patients a series of clinical complications occur, where about 90% of the patients diagnosed manifest each of these physiological alterations\cite{22}. Moreover, the clinical symptomatology related between HIV/AIDS and the presence of coccidia in patients is denoted by the development of diarrheal stools as an indicator of increased complications of the alteration in patients\cite{23,108}, with repercussions on their nutritional status and body homeostasis. Similarly, scientific literature has associated the development of acute or chronic diarrheal syndromes that reflect a marked loss of body mass, electrolyte imbalance, abdominal pain and alterations in the absorption of nutrients\cite{24,25} often established in immunocompromised patients. On the other hand, chronic diarrheal can lead to increased morbidity and mortality in these patients. In this way, the presence of these enteroparasitosis increases the mortality probability of immunocompromised patients or could cause refractory infections\cite{26}.

Conversely, intestinal coccidia are infectious agents of great importance in public health, due to the impact generated and the increasing detection cases in the world population and national level. The presence of coccidia induces direct effects in the countries of low and medium development, with consequences especially in the health and well-being, due to the lack or ineffectiveness of the health systems, low development of the sanitary conditions and a notable decrease to the access to education\cite{19}. Additionally, based at the aspects of public health, few studies as the Parasitism Survey 2012-2014 has been notified, considered as a repository that collects the behavior of different parasitic agents including coccidia, which have established conceptual aspects regarding its characteristics, a globalized distribution and prevalence at national level, in which 0.5% of Cryptosporidium sp. were detected throughout the national territory, and almost distributed to other agents\cite{109}. However, can be variable due to the health conditions of the patients, in which it has been observed in immunosuppressed individuals, who manage a tendency to increase these prevalence rates\cite{5}. Considerations that have been reflected in the cases studies about of the presence of coccidia at the national level, which demonstrates a high rate of affection and a notable intensification of clinical manifestations (Table 2).

Thus, in order to maintain a basis of balance, prevention of cases and optimal living conditions, the implementation of public policies has been generated as considerable tool for the reduction of the effect generated. In the national territory there are limited declarations of public policies associated with the control of these agents. However, according to the guidelines established by the WHO, PAHO, the Ministry of Health and Social Protection of Colombia have been contemplated in the Health Plan 2012-2021, the interventions for the search for the reduction of inequality in health, establishes policies and programs based on 8 dimensions, as indicated in the dimension of healthy living and communicable diseases, which incorporate a set of regulations and actions that allow the right to live free of communicable diseases to be realized through strategies, where the emergent, reemerging and neglected diseases\cite{27}, which is related to infectious processes caused by intestinal coccidia.

Similarly, in public health the environmental factor plays an important role for the maintenance of the well-being of the population and its environment, So, some comprehensive regulations have been included in the regulation of microbiological quality and, including the detection of these agents in consumer elements such as the one developed in the Conpes 113 of 2008 regulation\cite{28}, which have been related to the presence of coccidia such as Cryptosporidium spp., which have a negative impact due to their ability to contaminate water sources and as a consequence generate intestinal diseases\cite{29,30}. Likewise, the Ministry of Social Protection through Decree 1575 of 2007, establishes the implementation of prevention and control measures for drinking water sources for the purpose of monitoring microbiological risks\cite{31}, due to the impact of intestinal coccidia in the generation of diseases transported by these routes, and in addition to this, the development of operational strategies through the use of information systems that allow estimates and monitoring of affected populations. In addition, other regulations, such as resolution 2115 of 2007, have established the identification of invasive forms as Cryptosporidium oocysts, aspects that have been validated by the National Health Institute with the aim of implementing analysis methodologies\cite{32}.

Finally, these regulations should be implemented with greater operational direction in the prevention and promotion of the health conditions of the populations, and inclusive from the perspective of study of all the coccidia triggering intestinal parasitosis. This behavior will allow for greater consolida-
tion of public health programs, the development of updated databases and the dynamism in the execution of action plans to reduce epidemiological indices.

**Future perspectives and upcoming directions**

This paper reviews the evidences of generalities and the importance of a knowledge of the epidemiology of human pathologies associated to coccidian, focusing in developing populations and specially in Colombia. In this way, not exist complete studies in relation to the reports of the presence of intestinal pathogenic coccidia in each of the regions of the country, and knowing the succession of associated factors such as sanitation, adequate knowledge of crops and methods optimized breeding of livestock, sustainable social development and education, it seems to indicate that currently it is necessary to perform a new knowledge and verification of records due to the continuous increase in clinical cases that could be associated with this problem. Thus, is necessary the compression of punctual dates that are essential understanding the surveillance and risk factors for the infection, in order to supports risk management, control and prevention of cases and evasion of elements of transmission.

**Ethical disclosures**

**Acknowledgments.** The authors thank all members of University Corporation Rafael Núñez for support

**Funding.** None

**Conflict of Interest.** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Abbreviations.** AIDS: Acquired Immune Deficiency Syndrome; DNA: Deoxyribonucleic acid; EIA: Enzyme immune-assays; ELISA: Enzyme-Linked ImmunoSorbent Assay; FDA: Food and Drug Administration; HIV: Human Immunodeficiency Virus; ICLF: Immunochromatographic Lateral Flow; PAHO: Pan American Health Organization; PCR: Polymerase Chain Reaction; RFLP: Restriction Fragment Length Polymorphism; UV: Ultraviolet; WHO: World Health Organization

**References**

1. Cama VA, Mathison BA. Infections by Intestinal Coccidia and Giardia duodenalis. Clin Lab Med [Internet]. 2015;35(2):423–444.
2. Voukou MZ, Enoka P, Tamo1 CV, Tadenfok CN. Prevalence of intestinal parasites among HIV patients in the Yaounde Central Hospital, Cameroon. Pan Afr Med J. 2014;18:136.
3. Lucero-Garzón TA, Álvarez-Motta LA, Chúc-Jerez LF, López-Zapata A, Mendoza-Laygo CA. Parasitosis intestinal y factores de riesgo en niños de los asentamientos subnormales, Florencia- Caquetá, Colombia. Rev Fac Nac Salud Pública. 2015;33(2):171–80.
4. Sánchez-Gómez R, Valladares-Carranza B, Talavera-Rojas M, Velázquez-Ordóñez V. Cryptosporidiosis. Importancia en salud pública. REVET Rev Electrónica Vet. 2014;15(3).
5. García-Sánchez E, Valladares-Carranza B, Talavera-Rojas M, Velázquez-Ordóñez V. Cryptosporidiosis. Importancia en salud pública. REVET Rev Electrónica Vet. 2014;15(3).
6. Archelli S, Kozubsky LE. Cyclospora cayetanensis: Un coccidio emergente. Acta Bioquímica Clínica Latinoam. 2012;46(4):683–8.
7. Neira O, P. Barthele M, Wilson LG, Munoz SN. Infección por Isospora belli en pacientes con infección por VIH. Presentación de dos casos y revisión de la literatura. Rev Chil Infectol. 2010;27(3):219–27.
8. Bones AJ, Josse L, More C, Miller CN, Michaelis M, Tsao-Aud AD. Past and future trends of Cryptosporidium in vitro research. Exp Parasitol [Internet]. 2019;196(November 2018):28–37.
9. Bouzid M, Hunter PR, Chambers RM, Tyler KM. Cryptosporidium pathogenicity and virulence. Clin Microbiol Rev. 2013;26(1):115–34.
10. Ludington JG, Ward HD. Systemic and Mucosal Immune Responses to Cryptosporidium—Vaccine Development. Curr Trop Med Rep. 2015;2(3):171–80.
11. Silva-Diaz H, Fernández-Valverde D, Hernández-Córdova G, Failing-Jarros VE. Infección por Cryptosporidium bellini en pacientes con VIH: análisis de casos con diferente evolución clínica. Rev Chil Infectolgia [Internet]. 2017;34(4):347–51.
12. Sangare I, Bamba S, Cissé M, Zida A, Barroge M, Sirima C, et al. Prevalence of intestinal opportunistic parasites infections in the University hospital of Bobo-Dioulasso, Burkina Faso. Infect Dis Poverty [Internet]. 2015;4(1):1–6.
13. Naqsha DS, Njua AL, Jules N, Assis C, Ayira CW, Tanue EA, et al. Intestinal parasitic infections in relation to CD4 + T cell counts and diarrhea in HIV / AIDS patients with or without antiretroviral therapy in Cameroon. BMC Infect Dis [Internet]. 2016;16(9):1–10.
14. Nikiforov CN, Nana CT, Payne VK. Intestinal Parasitic Infections in HIV Infected and Non-Infected Patients in a Low HIV Prevalence Region West-Cameroon. PLoS One. 2013(8);e27914.
15. Wumbale R, Lungo-mbenga B, Kendo L, Epidemiology, clinical, and molecular profiles of microsporidiosis and cryptosporidiosis among HIV/AIDS patients. Int J Gen Med. 2012;5:603–11.
16. Utzinger J, Botero-Kleiven S, Castelli F, Chioldi PL, Edwards H, Köhler N, et al. Microscopic diagnosis of sodium acetate-acetic acid-formalin-fixed stool samples for helminths and intestinal protozoa : a comparison among European reference laboratories. Clin Microbiol Infect. 2010;16(3):267–73.
17. Girna M, Teshome W, Betos B, Endeshaw T. Cryptosporidiosis and Isosporosis among HIV-positive individuals in south Ethiopia : a cross- sectional study. BMC Infect Dis [Internet]. 2014;14(1):1–6.
18. Adamu H, Wegayehu T, Petros B. High Prevalence of Diarrhoegenic Intestinal Parasite Infections among Non-ART HIV Patients in Fitche Hospital, Ethiopia. PLoS One. 2013(8);e72634.
19. Almeu A, Shifferaw Y, Getinet G, Yalaw E, Addis Z. Opportunistic and other intestinal parasites among HIV/AIDS patients attending Gambi higher clinic in Bahir Dar city, North West Ethiopia. Asian Pac J Trop Med [Internet]. 2011;4(8):61–6.
20. Teklemariam Z, Abate D, Mitiku H, Dessye Y. Prevalence of Intestinal Parasitic Infection among HIV Positive Persons Who Are Naive and on Antiretroviral Treatment in Hivfon Fana Specialized University Hospital , Eastern Ethiopia. ISRN AIDS. 2013;2013:1–7.
21. Massoud NM, Said DE, El-Salamouny AR. Prevalence of Cyclospora cayetanensis among asymptomatic and asymptomatic immune-competent children less than five years of age in Alexandria, Egypt. Alexandria J Med [Internet]. 2012;48(3):251–9.
22. Acquah F, Tay SCK, Frimpong EH. Prevalence of Cryptosporidium and Isospora belli in HIV/AIDS Patients at KomfoAnokye Teaching Hospital, Kumasi-Ghana. Int J Pure Appl Sci Technol. 2012;8(2):26–33.
23. Babatunde SK, Salami AK, Fabiyi JP, Agbede OO, Desalu O. Prevalence of intestinal parasitic infestation in HIV seropositive and seronegative patients in Ilorin , Nigeria. Afr J Med Med Sci. 2010;39(3):123–8.
24. Olusesegun AF, Okake CE, Dantas Machado RL. Isosporosis in HIV/AIDS Patients in Edo State, Nigeria. Malaysian J Med Sci. 2009;16(3):41–4.
25. Akinbo FO, Okaka CE, Omoregie R, Akinbo FO, Okaka CE, Omorogie R. Prevalence of intestinal parasitic infections among HIV patients in Benin City, Nigeria. Libyan J Med. 2010;5(5506).
26. Udeh EO, Gosele ON, D-Dopava DD, Abelau M, Popov TV, Jean N, et al. The prevalence of intestinal protozoans in the University Corporation Rafael Núñez for support

**Intestinal coccidian: an overview epidemiologic worldwide and Colombia**
Prevalence and genetic characterization of Cryptosporidium spp. and Cyclospora bellii in HIV-infected patients. Rev Inst Med Trop Sao Paulo. 2013;55(3):149–54.

Silva-Díaz H, Campos-Flores H, Llagas-Linares JP, Llatas-Cancino D. Coccioidiosis intestinal en niños admitidos en un hospital de pediatría en México. Emerg Infect Dis. 2009;15(10):1874–80.

De Vera R, Blanco Y, Amarya I, Requena I, Rodríguez Y. Artículo original. Coccioidosis intestinal en niños menores de 5 años con diarrea. Emergencia pediátrica, Hospital “Ruíz y Pérez.” Rev la Soc Venez Microbiol. 2010;30:140–4.

Bracho Á, Rivero-Rodríguez Z, Salazar S, Jaimes P, Sepúlveda M, Monsalve-Castro F, et al. Cryptosporidium sp. y otros parasitos intestinales en niños menores de 5 años con diarrea y su relación con las pruebas coproacumulativas Cryptosporidium spp. y Other Intestinal Parasites in Children to Cephalosporin Qualitative Tests. Kasmiera. 2010;36(2):128–37.

Cazorla Perfetti D, Acosta Quintero M, Eugenia M, Morales Moreno P. Aspectos epidemiológicos de coccidiiosis intestinales en comunidad rural de la península de Paraguaná, estado Falcón, Venezuela. Rev la Univ Ind Santander. 2018;50(1):67–78.

Cazorla Perfetti D, Leal Rojas G, Escalona Nelo A, Hernández Nava J, Acosta Quintero M, Morales Moreno P. Aspectos clínicos y epidemiológicos de la infección por coccidios intestinales en falcon state, Venezuela. Boletin Maniología y Salud Ambiental. 2014;19(2):159–73.

Nastasi Miranda JA. Prevalencia de parasitos intestinales en unidades educativas de Ciudad Bolivar, Venezuela. Rev Cuid. 2015;6(2):1077–84.

Chacin-bonilla I, Mejía de Young M, Estevez J. Prevalence and pathogenic role of Cyclospora cayetanensis in a Venezuelan community. Am J Trop Med Hyg. 2008;63(3):304–6.

Barcelos NB, et al. Silva L, Dias RGF, de Menezes Filho HR, Rodrigues RM. Opportunistic and non-opportunistic intestinal parasites in HIV/AIDS patients in relation to their clinical and epidemiological status in a specialized medical service in Goiás, Brazil. Rev Inst Med Trop Sao Paulo. 2018;60:e13.

Noor M, Katzmann PJ, Huber AR, Findelis-hoeye JT, Whitney-miller C, Gonzalez RS, et al. Unexpectedly High Prevalence of Cyclospora bellii Infection in Acalculous Gallbladders of Immunocompetent Patients. Am J Gastroenterol. 2018;1–8.

Hosseinyrad M. Enteric Opportunistic Infection and the Impact of Cryptosporidium parvum and Cyclospora cayetanensis Infection among International Travellers. Jundishapur J Travel Med. 2006;13(6):334–7.

LahozJM. Cyclosporiasis: A Point Source Outbreak Acquired in Guatemala. Microbiol Rev. 2013;75(1):15–24.

Srivastava CR, Nijhawan P, Badharpuri J, Embgeb J, Friss-raller M, Nielsen NS, et al. Prevalence and clinical significance of intestinal parasites in HIV-infected patients in Denmark. Scand J Infect Dis. 2011;43:129–35.

Jelinek T, Lotze M, Eichenlaub S, Lüscher N, Nordstrum HD. Prevalence of infection with Cryptosporidium parvum and Cyclospora cayetanensis among international travellers. Gut. 1997;41:801–4.

Karaman U, Daldal N, Ozer A, Enginyurt O, Erturk O. Epidemiology of Cyclospora cayetanensis among International Travellers. Jundishapur J Travel Med. 2006;13(6):334–7.

Barcelos NB, et al. Silva L, Dias RGF, de Menezes Filho HR, Rodrigues RM. Opportunistic and non-opportunistic intestinal parasites in HIV/AIDS patients in relation to their clinical and epidemiological status in a specialized medical service in Goiás, Brazil. Rev Inst Med Trop Sao Paulo. 2018;60:e13.
Intestinal coccidiosis: an overview epidemiologic worldwide and Colombia

98. Silva-Díaz H, Falconor A, Linnea Solano HI, Romero Vivas CM. Manifestaciones clínicas y factores de riesgo asociados a la infección por Cryptosporidium en pacientes de Barranquilla y tres municipios del Atlántico (Colombia). Rev Científica Salud Uninorte. 2012;23(1):18–31.

90. Berto Moreano CG, Cahuana Aparco J, Cárdenas Gallegos JK, Botiquín Ortiz NR, Balbín Navarro CA, Tejada Llacsa PJ, et al. Nivel de pobreza y otros parásitos intestinales en pacientes con infección por VIH, Bogotá, Colombia. Comunicación presentada en la Reunión Anual de la Sociedad Colombiana de Medicina Preventiva y Salud Pública. Bogotá, 2007;14(1):16–12.

99. Joseph A, Popoola G. Comparison of various staining techniques in the diagnosis of coccidian parasitosis in HIV infection. Med J Zambia. 2017;44(1):1–8.

100. Tahildar-Biderouni F, Salehi N. Detection of Cryptosporidium infection by modified ziehl-neelsen and PCR methods in children with diarrhea in pediatric hospitals in Tehran. Gastroenterol Hepatol from Bed to Bench. 2014;7(2):125–30.

101. Hanscheid T, Cristino JM, Salgado MJ. Screening of Cryptosporidium. Int J Infect Dis. 2008;12(1):47–50.

102. Guo L, Xu L, Song S, Liu L, Kuang H. Development of an immunochromatographic strip for the rapid detection of maduraminic in chicken and egg samples. Food Agric Immunol. 2018;29(1):458–69.

103. Chowdhury R. Evaluation of Lateral Flow Test for Detection of Cryptosporidium species in human fecal specimens. East West University; 2015.

104. Ramo A, Montaegudo L V. Multifocus fragment analysis detection of Cryptosporidium parvum from pre-weaned calves in Colombia. Acta Trop [Internet]. 2019;191:151–7. Available from: https://doi.org/10.1016/j.actatropica.2019.02.005

105. Lee H-A, Hong S, Chung Y, Kim O. Sensitive and specific identification by polymerase chain reaction of Eimeria tenella and Eimeria maxima, important protozoan pathogens in laboratory avian facilities. Lab Anim Res. 2011;21(3):255.

106. Schroder C, Schielke A, Eillerbroek, Johnne R. PCR inhibitors - occurrence, properties and removal. J Appl Microbiol. 2012;113(5):1014–26.

107. Carvalho FS, Wenceslau AA, Teixeira M, Matos Carneiro JA, Melo AD. Cryptosporidium in human fecal specimens.Acta Med Costarric [Internet]. 2012;25(3):139–45.

108. WHO. HIV/AIDS [Internet]. WHO Immunization, Vaccines and Biologicals. 2017. p. 1. Available from: http://www.who.int/immunization/topics/hiv/en/index2.html

109. Díaz S. Coccidiosis Intestinal En El Perú: Actualización De Su Intestinal Coccidiosis in Peru: Update of Its Frequency, Transmission and Laboratory Diagnosis. Rev Exp Med. 2017;3(2):74–8.

110. Squire SA, Ryan U. Cryptosporidium and Giardia in Africa: current and future challenges. Parasites and Vectors. 2017;10(1):1–32.

111. Pape JW, Verdier R-I, Boncy M, Boncy J, Johnson WD. Cyclospora infection and other gastrointestinal infections in immunocompromised patients with and without gastrointestinal manifestations. Rev Inst Med trop S Paulo. 2003;35(4):197–200.

112. Berto Moreano CG, Cahuana Aparco J, Cárdenas Gallegos JK, Botiquín Ortiz NR, Balbín Navarro CA, Tejada Llacsa PJ, et al. Nivel de pobreza y otros parásitos intestinales a asociados a parasitosis intestinal en estudiantes, Huánuco, Perú. 2010. An la Fac Med. 2017;74(4):301.

113. Giangaspero A, Marangi M, Koehler A V, Papini P, Normanno G, Lacasella V, et al. Molecular detection of Cyclospora in water, soil, vegetables and humans in southern Italy signals a need for improved monitoring by health authorities. Int J Food Microbiol (Internet). 2015;211:95–100.

114. Mahmood A, Lian-Lim YA, Amir A. Coccidia. In: Springer International. 2010. p. 53–70.

115. Scott R, Fate and behaviour of parasites in wastewater treatment systems [Internet]. Handbook of Water and Wastewater Microbiology. Elsevier; 2013. 491–521 p.

116. Hatam-Nahavandi K, Mahvi AH, Mohabadi M, Keshavarz H, Mobedi I, Rezaeean M. Detection of parasitic particles in domestic and urban wastewaters and assessment of removal efficiency of treatment plants in Tehran, Iran. J Environ Heal Sci Eng. 2015;13(1).

117. Girard YA, Johnson CK, Fritz HM, Shapiro K, Packham AE, Melli AC, et al. Detection and characterization of diverse coccidian protozoa shed by California sea lions. Int J Parasitol Wild [Internet]. 2015;3(1):5–16.

118. Giangaspero A, Gasser RB. Human cyclosporiasis. Lancet Infect Dis [Internet]. 2019;19(7):e236–36.

119. Sánchez C, López MC, Galeano LA, Quarnstrom Y, Houghton K, Ramirez JD. Molecular detection and genotyping of pathogenic coccidian parasites in raw and treated water samples from southwest Colombia. Parasites and Vectors. 2018;11(563):1–11.

120. Ministry of Salud and Protección Social de Colombia. Plan Decenal de Salud Pública. PDSP. 2012 – 2021 [Internet]. Vol. 1. p. 3. Available from: http://www.saludcapital.gov.co/DPS/Documentos/Plan_Decenal_de_Salud_Publica.pdf

121. CONPES 3514. Política Nacional Fitosanitaria y de Inocuidad para las Cadenas de Frutas y de otros Vegetales. Vol. 3514. Documento Conpes. 2008. p. 1–45.

122. Ministry of the Protection Social. Decreto 1575 de 2007 [Internet]. 2007 p. 1–14. Available from: http://www.minambiente.gov.co/Documentos/GestionIntegral/RecursosHidricos/pdf/Disponibilida-del-recurs-o-hidrico/Decreto-1575-de-2007.pdf

123. Ministry of the Protection Social. Resolution numero 2115 de 2007 [Internet]. 2007 p. 23. Available from: http://www.minambiente.gov.co/Documentos/GestionIntegral/RecursosHidricos/pdf/normativa/Res_2115_de_2007.pdf