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Sick on a South American Sugarcane Plantation

By Kevin M. Bonney

This interrupted case study was designed for use in an undergraduate microbiology course over two to four class periods. The case is also appropriate for high school or undergraduate courses in introductory biology, microbiology, parasitology, and public health. Chagas disease, as described in the case, is one of the greatest public health burdens in Central and South America, yet it remains largely unknown by the general public in the United States. This case familiarizes students with a relatively common disease while illustrating an uncommon route of transmission, as well as the lesser known risk the disease poses to citizens of nonendemic areas such as the United States.

Students are asked to compare protozoans to bacteria and viruses and to apply critical thinking to explain why bacterial and protozoan pathogens must be treated with different types of medication. Epidemiological facts about Chagas disease are presented, and students are asked to develop two different public health campaigns to

target the disease—first in high-risk populations living in endemic areas of Latin America and then in people living in the United States.

Objectives

In working through this case study, students will do the following:

- acquire knowledge of the following terms: American trypanosomiasis, acute and chronic Chagas disease, parasite, protozoan, *Trypanosoma cruzi*, triatomine (reduviid) bug, and vectoral transmission;
- evaluate the presentation of disease symptoms along with demographic, behavioral, and environmental factors for clues to likely causes of an unknown disease;
- conduct research using external scientific and medical resources and apply this knowledge to synthesize a diagnosis and identify possible treatments for Chagas disease;
- compare and contrast the

symptoms and temporal progression of acute and chronic Chagas disease;

- explain the difference between bacteria and protozoans (including differences in cell structure, associated diseases, and treatment);
- use critical thinking skills to create multifaceted solutions to the complex problem of eradicating the public health burden of American trypanosomiasis in different populations;
- create visual aids to inform an audience about scientific and public health information; and
- evaluate the relationship of socioeconomic factors to the epidemiology and other public health issues associated with Chagas disease.

Classroom management

This case study is intended to be taught in an interrupted format over two to four class periods that are 1 to 2 hours in length.

Case study

Part I: At the plantation, symptoms of an unknown illness appear

João Santos and his son Marco both work at a rural sugarcane plantation in the state of Bahia in northern Brazil. João, who is 48 years old, has

worked there for more than 30 years, and Marco, who is 21 years old, has worked there for almost 5 years. During harvest season, the two work up to 12 hours a day in the hot equatorial sun, chopping tall stalks of sugarcane with machetes and load-

ing the stalks into the backs of trucks to be driven to the processing mill down the road. Their job is physically demanding, and they are given little time to rest during the workday.

The highlight of the Santos' day occurs in the early afternoon

when the plantation owner's young, magnanimous daughter brings out cool, freshly squeezed sugarcane juice for the two men to drink. She usually does not offer the sugarcane juice to the other men, only to João and Marco (João teases Marco that it is because she has a crush on him). She often stays to talk with them while drinking a glass of the sweet juice herself before retreating into her father's luxurious modern house before he notices.

The Santoses live with several dozen other workers in a camp on the outskirts of the plantation near the edge of the forest. They share a small thatched-roof hut with two other workers. Each man has a cot to sleep on and a trunk to store his personal belongings in, but not much else. The camp lacks running water and electricity, but the men do have access to clean water pumped from a well and a suitable outhouse, similar to the conditions they have at home in their village. The Santoses' main concern, other than the long working hours, is the constant invasion of their hut by insects and rodents. The plantation owner has promised to pour concrete on the dirt floors in the huts and provide insect netting to cover their cots, but each year that passes is another year he fails to fulfill his promises. Despite the many discomforts, the Santoses must continue working in order to feed their large family who live in a nearby village, so they stay at the plantation and try not to complain too much. João and Marco each earn the equivalent of less than \$1,000 USD per year, but they have not been able to find any other jobs in the area that would pay them higher wages.

For the past 2 weeks, João and Marco have been experiencing high fevers, fatigue, myalgia (muscle

aches), abdominal pain, nausea, loss of appetite, and diarrhea. João has also experienced headache and dyspnea (shortness of breath) on exertion. At first the men thought that they had come down with one of the diarrheal ailments that are common among the workers, presumably contracted through contaminated food or water, which would usually resolve within a few days. Another worker reported having similar symptoms several weeks earlier that had eventually waned and resolved, so they thought that perhaps they had contracted a contagion from him. They had been sick like this before and it had passed, but this time was different; their symptoms were not improving after a few days as anticipated.

Despite feeling ill, the men were compelled to continue working in the fields so they could earn money to feed their family. They finally decided to send a message to Joaquim, one of the elders in their village who is known as the unofficial village doctor, asking for medicine to relieve their fever and muscle aches so they could continue working. Joaquim brought them a homemade medicine derived from the curare vine, which is commonly used to treat fevers and other ailments in the Amazon. However, despite taking the curare medicine for 7 days, the men's symptoms continued to worsen, especially João's.

"Your illness must be too strong for your bodies to fight, even with help from the curare. I do not know if any of my remedies can cure you. You must go into the big city for treatment. There is a large hospital in Feira de Santana with modern equipment and well-trained doctors who will surely be able to help you," instructed Joaquim.

Because the cost of missing work and traveling into the city would be

a great burden on them and their families, João and Marco decided that Marco would stay behind at the plantation and try to work as many hours as he was able while João traveled to the hospital in Feira de Santana, about 4 hours away. For the price of two day's pay Marco persuaded one of the mill workers to drive his father to the hospital in his pick-up truck.

Questions

1. Research and list some common pathogens present in South America that could be responsible for the symptoms exhibited by João and Marco.
2. What questions are doctors at the hospital likely to ask the men in order to determine clues related to the cause of their symptoms?
3. In small groups, discuss and determine what pathogen and related disease is most likely plaguing these men. What are the risk factors for contracting this disease? How did João and Marco most likely become infected?
4. What tests are doctors likely to conduct to confirm the most likely suspected diagnosis?

Part II: At the hospital, diagnosis

When João arrived at the hospital, he was first interviewed by a nurse who asked him questions about what he had recently done and eaten and about every place he had travelled to in the last few months. Neither João nor Marco had left the plantation or recently engaged in any new or unusual activities. João reported only drinking water taken from a deep well and told the nurse that he always thoroughly cooked any meat he ate over a fire. Nothing in the family medical history that he gave to the nurse provided any clues to the cause of his symptoms.

A physician at the hospital performed a physical examination, which revealed that João had a fever of 38.5 °C (101.3 °F). After palpating his abdomen, the doctor noted an enlargement of his liver, spleen, and several lymph nodes, as well as abdominal tenderness. The doctor also noted a slight heart murmur, but no additional remarkable findings other than the malaise, myalgia, fatigue, loss of appetite, and diarrhea that João reported. The doctor also asked many questions about Marco after João told him that his son was still at the plantation experiencing similar symptoms.

After considering all of this information, including the location and conditions where João spent most of his time, the doctor presumed that he had been infected with *Trypanosoma cruzi* and was exhibiting symptoms of acute Chagas disease. To confirm this diagnosis, blood samples were collected and examined with a microscope for the presence of protozoan parasites. Some of the blood was analyzed for the presence of antibodies specific for *T. cruzi* antigens. The blood tests confirmed that João was infected with *T. cruzi*. As a precaution, the doctor ordered an electrocardiogram to check for problems with the electrical activity of João's heart, as well as an echocardiogram to examine the structure of the heart and how blood was flowing through it. Fortunately, the tests did not indicate signs of serious permanent damage. The cause of João's heart murmur appeared unrelated to his infection and unlikely to pose a serious health threat.

After informing João of his diagnosis, the doctor explained, "*Trypanosoma cruzi* is a protozoan parasite that is endemic to rural areas of Central and South America. It is most commonly transmitted by the triatomine

bug that often inhabits thatched huts like the one you live in at the plantation. I initially assumed you were infected when a triatomine bug bit you in your sleep to feed on your blood. After taking a blood meal from a host, triatomine bugs often defecate, releasing parasites that can enter the body through the bite wound or by being rubbed into the eye or mouth. However, when I saw the name of the plantation where you work on the questionnaire you filled out when you arrived, I developed a different theory to account for your infection."

"I am familiar with this bug that infects people with a parasite. We call it the kissing bug," João replied to the doctor. "But we haven't noticed any marks on our skin or swelling around our eyes to indicate we might have been bitten, so how could we have been infected? And I thought this disease took decades to make someone sick. My son is young and has only been living in the hut on the plantation for 5 years, and he seems to have the same affliction I have. I know of old men who died of heart failure caused by this disease, but I don't know of anyone with this disease who was as young as Marco, or even me."

"Well, that gets to my theory," added the doctor. "You see, 2 weeks ago the daughter of the plantation owner arrived at the hospital complaining of similar symptoms. We performed the same tests on her as we did on you and determined that she was experiencing acute Chagas disease. The symptoms that the three of you have are a classic presentation of this form of the disease, which does often affect younger people. The old men you described dying of heart failure had chronic Chagas heart disease, which is much more common than the acute form of the disease, which explains why that is what you are familiar with."

"How did we all get acute Chagas disease? The plantation owner's daughter is never exposed to the bugs out in the huts or the fields. She spends all of her time in her nice big house, except for the few minutes each day when she brings us sugarcane juice," said João.

"That's it!" exclaimed the doctor. "It was the sugarcane juice. All three of you must have consumed juice contaminated with the parasites! Triatomine bugs carrying *Trypanosoma cruzi* often live in sugarcane and can be inadvertently ground up during the juice-making process, releasing live protozoan parasites into the juice. Although vectoral transmission involving an insect bite is a more common means of *Trypanosoma cruzi* transmission, many cases of oral transmission have been documented in which people became infected by drinking contaminated sugarcane or açai berry juice" (Bastos et al., 2010; Nobrega et al., 2009; Pereira et al., 2009).

"Oh no!" cried João. "Does this mean we are going to be infected with the parasite for the rest of our lives until we die of heart failure?"

"There is still no cure for Chagas disease, but we do have medicines to treat the parasite and hopefully prevent further complications. Only about one third of infected people will develop chronic Chagas disease, even without treatment, so there is a high likelihood you will never develop heart failure," stated the doctor (Andrade, 1999; World Health Organization, 2002, 2012).

"Oh," said João, sounding relieved. "So acute Chagas disease is not a serious disease like chronic Chagas disease?"

"Actually," the doctor responded, "acute Chagas disease can be serious and even fatal. However, only about

5% of acute Chagas cases result in death (World Health Organization, 2002). Now that we are treating you and your heart does not show signs of serious damage, I am confident you will recover and go on to live a long life. You must send your son here so he can be examined and treated if necessary. Since the antiparasitic medications we use to treat Chagas disease are not without risks and side effects, we must confirm whether he is also infected and in need of treatment before starting him on medication” (Centers for Disease Control and Prevention, 2013; World Health Organization, 2012).

Questions

1. If you had known that the plantation owner’s daughter was hospitalized with the same symptoms as João and Marco, would that have changed the prediction that you made in Part I? Why or why not?
2. Describe how acute and chronic Chagas disease differ in terms of symptoms and the time of onset.
3. Research and list potential treatments for Chagas disease. Are the treatments that are commercially available considered to be “good” and not in need of improvement? Why or why not?
4. It is likely that many of the diseases discussed in Part I, Question 1, are caused by bacteria or viruses, but Chagas disease is caused by a protozoan. Draw a *T. cruzi* cell and label the major cellular structures. Also draw and label a bacterial cell and a virus. How are the three similar? How are they different?
5. Briefly describe the mechanism by which antiprotozoan medications inhibit protozoan infections. Why are antibiotics,

such as penicillin, that are used to treat bacterial infections not effective at treating protozoan infections?

Part III: Back in the field, public health campaign

The World Health Organization has recently reported that approximately 10 million people in Latin America are currently infected with *T. cruzi* (Centers for Disease Control and Prevention, 2013; World Health Organization, 2012). This is over seven times the number of HIV/AIDS cases in the same region (Joint United Nations Programme on HIV/AIDS, 2011). Although the rate of *T. cruzi* infection has been declining in recent years because of the effects of ongoing public health programs, approximately 75 to 90 million people are potentially at risk of infection (World Health Organization, 2002). The fact that people living in poor, rural, and often remote areas are most at risk poses significant challenges in the fight against Chagas disease (World Health Organization, 2002).

Chagas disease is not only a concern for people living in Central and South America. In fact, it is estimated that more than 300,000 people who are infected with *T. cruzi* currently reside in the United States (Centers for Disease Control and Prevention, 2013). The majority of these people were infected while living or traveling in endemic countries; however, the triatomine bugs that transmit the parasite live as far north as the central United States. A number of people have been infected from triatomine bug bites in California, Texas, Tennessee, and Louisiana (Bern, Kjos, Yabsley, & Montgomery, 2011). The risk to those in the United States is not necessarily limited to vectoral

transmission. There are a number of other ways that people can become infected besides those mentioned in this case study (Centers for Disease Control and Prevention, 2013; Pereira et al., 2009; World Health Organization, 2002, 2012).

Questions

1. In addition to bites from infected triatomine bugs or ingestion of foods contaminated with *T. cruzi*, what are the other modes of transmission of this pathogen?
2. Chagas disease is sometimes referred to as “a disease of poverty.” Explain what is meant by the statement and whether you agree or disagree.
3. What can local governments and public health organizations in South America do in order to prevent the transmission of *T. cruzi*?
4. Create a poster or flyer that could be distributed to people in endemic areas who are at high risk for becoming infected by *T. cruzi* through oral or vectoral transmission that warns them of the risks of infection and informs them on how to protect themselves.
5. List ways that people in the United States are at risk for Chagas disease. Prepare a service announcement in the form of a short speech or slide show to inform Americans about the risk Chagas disease poses to them and what they need to know to protect themselves.

Note: Detailed teaching notes and the answer key may be found at the National Center for Case Study Teaching in Science at <http://sciencecases.lib.buffalo.edu/cs/collection>.

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