Exploring Collaborative Research Opportunities Between NIAID and Bolivia

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Abbreviations

CENETROP	Centro Nacional de Enfermedades Tropicales
CIGMO	Centro Integral de Genética Molecular
EID	Emerging Infectious Disease
ELISA	Enzyme-Linked Immunosorbent Assay
FIC	Fogarty International Center
GRADS	Global Research Affairs Database Systems
IAMAT	International Association for Medical Assistance to Travelers
IINSAD	Instituto de Investigacion en Salud y Desarrollo
IBMB	Instituto de Biología Molecular y Biotecnología
IITCUP	Instituto de Investigaciones Técnico Científicas de la Universidad Policial
INLASA	Instituto Nacional de Laboratorios de Salúd
IPPA	High Altitude Pulmonary and Pathology Institute
JHSPH	Johns Hopkins School of Public Health
MoHS	Ministry of Health and Sports
MODS	Microscopic Observation Direct Susceptibility
NCI	National Cancer Institute
NEXTCAP	Networking EXTention and CAPacity Building
NIAID	National Institutes of Allergy and Infectious Disease
PAHO	Pan American Health Organization
PCR	Polymerase Chain Reaction
QVR	Query View Report
RT-PCR	Reverse Transcription Polymerase Chain Reaction
SELADIS	Institute of Services for Diagnostic Laboratories and Health Research
UMSA	Universidad Mayor de San Andrés
USAID	United States Agency for International Development

Executive Summary

Named after the Venezuelan military leader, Simon Bolivar, Bolivia is a landlocked country in South America with great topographic variance. The Andes mountains, comprised of two parallel ranges, dominates approximately one-third of the country, while lowlands make up the remainder. The lowlands vary drastically in climate, with the north-central region consisting of tropical rainforest, the center remaining rather dry, and the south-east region experiencing nine months of drought and three months of heavy rain.

Bolivia is now considered a middle-income country, with the top exports being natural gas, zinc, gold, silver, soy and tin, and top imports being industrial supplies, capital goods, transport equipment, fuel, and consumable goods. Evo Morales, who served as President from 2006-2018, established the National Development Plan in 2007, and from this came new policies in the agricultural sector, which involved advancing agricultural development through the expansion of irrigation coverage and assigning rights of water use. This economic advancement led to a decrease in moderate poverty rates, as they fell from 59.0% to 39.0% between 2004 and 2014. The 2016-2020 Economic and Social Development Plan, an extension of the National Development Plan, was then proposed, establishing universal access to both healthcare and education. and ensuring food security and quality. In November 2019, Bolivia's Morales resigned over alleged election rigging and was replaced with an interim until the next election, which was set to take place in May 2020 but has since been delayed as a result of COVID-19.

There are approximately 11.6 million people in Bolivia. The population structure continues to shift as the rate of growth in children under fifteen decreases and life expectancy increases. As of 2018, approximately 34.6% of the country's population lived below the poverty line. Socially vulnerable populations (i.e. those living in rural areas like indigenous people and those living in poverty) are particularly vulnerable to both non-communicable and communicable diseases. Over 2,700 primary care clinics have been established since 2015, which expanded primary healthcare access to 25% of the most vulnerable populations. Present in 307 of 339 municipalities and 25 indigenous communities, the Mi Salud project has helped close the gap in healthcare access for vulnerable populations by enhancing individual- and community-level primary health promotion and disease prevention efforts. In March 2019, the Morales Government established universal healthcare through the United Health System, but healthcare delivery remains a challenge in some indigenous communities as they can be extremely remote, and resources and infrastructure are limited.

Research infrastructure in Bolivia is influenced by the Ministry of Health and Sports as the National Institute of Health Laboratories (INLASA) and National Center for Tropical Diseases (CENETROP) are under the MoHS, as well as Universidad Mayor de San Andrés (USMA) and (Instituto de Investigaciones Técnico Científicas de la Universidad Policial) IITCUP. USAID's PREDICT

project greatly impacted research advancements as it enhanced interdisciplinary partnerships, trained personnel, and enhanced laboratory capacity, specifically diagnostic capabilities. Much of the research infrastructure that stemmed from PREDICT remains available to those who can afford to utilize it.

Currently, there are five ongoing NIAID-funded grants in Bolivia, most pertaining to Chagas disease. However other infectious diseases, including dengue, leptospirosis, tuberculosis and hantavirus impact the health of the country and are being addressed by researchers with minimal resources. Many ongoing efforts, both NIAID-funded and not, involve creating interdisciplinary partnerships and training interdisciplinary teams, both professional and community-based, in addition to developing therapeutics. Furthering successful projects that stemmed from PREDICT, either through the NIH-USAID interagency agreement or by engaging intramural scientists or extramural program officers at NIAID could further enhance scientific research in Bolivia. R03 and R21 grants as well as programs through Fogarty International Center (FIC), such as the Ecology and Evolution of Infectious Diseases Initiative (EEID) and the Global Infectious Disease Research Training (GID) program, have the potential to benefit researchers with little resources and initiate research opportunities in Bolivia.

1. Introduction

General Information on Bolivia

History

The Andes region of South America was originally inhabited by Indian civilizations (Incas) long before the Europeans arrived. One of the more prominent Andean civilizations was the Tiwanaku, which extended into present-day Peru and Chile and dominated this region until the Aymara emerged as the most powerful civilization.[1] In the 1400s, the Incas incorporated northern Bolivia into their empire, which led to the organization of political power, military, and agriculture and mining practices. Despite great efforts, the Incas were unable to invade and control the lowlands where the nomadic tribes resided.

The Spaniards first reached the present-day Peruvian coast in 1532 and defeated the Inca Empire in 1538, allowing expansion into the central and southern Bolivia.[1,2] Although Indian resistance remained, the Spanish expansion continued, establishing La Paz in 1549 and Santa Cruz de la Sierra in 1561.[2] In the 1570s, the viceroy in Potosí initiated an exploitative statute called the *mita*, which forced Indian males to work in the mines, and as a result, the mining industry flourished and continued its growth throughout the seventeenth century, until disease caused a rapid decline in the Indian population.[2] During this time Indian labor was also used in the expanding agriculture industry, making Cochabamba a mass producer of corn, wheat, and coca.[1]

Throughout the eighteenth century, Spanish control in South America continued to weaken, and in 1825 Bolivia officially broke away from Spanish rule after the Battle of Ayacucho (the Peruvian War of Independence).[3] The Venezuelan military leader, Simon Bolivar, served as Bolivia's President for only five months. Although independent, Bolivia faced many challenges in the nineteenth century including political instability, authoritarian leadership economic stagnation and geographic isolation.[2] Subsequent history involved wars, continued political instability, military rule and series of coups and countercoups until Democratic civilian rule was established in 1982.[3] Bolivia has since moved towards Socialist government after electing Evo Morales in 2005, the country's first indigenous President.

Geography

Bolivia is a landlocked country in west-central South America. Topographically, Bolivia is split into three regions, Andean, sub-Andean and the plains. With the Andes mountains dominating roughly one-third of the country, topographic features vary drastically. The highest peak is Mount Sajama in Nevado Sajama, sitting at 6,542m (21,463 ft), while the lowest point is located in Rio Paraguay at 90m (295 ft).[1] In Bolivia, the Andes mountains are comprised of parallel ranges, the Cordillera Occidental, a chain of active volcanos sitting along the western border, and Cordillera Oriental, which extends through La Paz, the country's capital. The Altiplano is the plateau that lies between these two ranges. The Altiplano's most noted feature is Lake Titicaca, which is the world's largest navigable body of water with a surface area of 9,064 km^2.[4] East of the Andes resides the

lowlands, which accounts for roughly two-thirds of the country. This part of the country varies drastically in climate, with the north-central region consisting of tropical rainforest, the center remaining rather dry, and the south-east region experiencing nine months of drought and three months of heavy rain.[4] While sparsely populated, the lowlands still play a central role in economic growth.

Economy

As a result of a 4.9% increase in economic growth between 2004 and 2014, Bolivia is now considered a middle-income country.[10] Between 2013 and 2018, Bolivia's economy grew at an annual rate of 5.1%, and in 2018, there was a 9.5% increase in Bolivian exports, reaching $8.9 billion dollars, with the top exports being natural gas, zinc, gold, silver, soy, and tin.[11] Bolivia's top export market countries are Brazil, Argentina, South Korea, India, Japan and the United States. Bolivian imports increased by 7.9% to $10 billion between 2017 and 2018, with the top imports being industrial supplies, capital goods, transport equipment, fuel, and consumable goods.[11] As a result of economic growth, rates of poverty have substantially decreased. Between 2004 and 2014, moderate poverty fell from 59.0% to 39.0%, and has since continued a slower decrease, dropping to 35.0% by 2018.[10]

Much of this advancement stemmed from the economic reform that occurred throughout the 1990s. Although the period between 2003 and 2005 brought about more political instability, when the government proposed exporting newly discovered gas reserves, it also led to economic growth when the government instead passed hydrocarbon laws that drastically increased royalties and required predetermined service fees to foreign firms. In 2006, Evo Morales became the first indigenous president and his government quickly established the National Development Plan, which was the idea of a "dignified, sovereign, productive and democratic Bolivia", incorporating the indigenous concept "Vivir Bien" (good living) as a fundamental principle.[12] The central piece of that paradigm pertains to water access as a "human right, legitimate and fundamental of all living beings".[12]rom this came new policies in the agricultural sector, which involved advancing agricultural development through the expansion of irrigation coverage and assigning rights of water use. As a result of the economic growth that stemmed from the industrialization of such natural resources, the 2016-2020 Economic and Social Development Plan was proposed, which is an extension of the National Development Plan. Objectives for this plan include eradicating extreme poverty, extending access of basic services (i.e. water, sewage, electricity, road transportation), establishing universal access to both healthcare and education, and ensuring food security and quality. In 2015, Morales also expanded efforts to increase energy production capacity via a hydroelectric dam, which has created great controversy, especially from indigenous peoples whose land will become inundated by the surrounding rivers.

Government

Bolivia has nine administrative divisions, which are Beni, Chuquisaca, Cochabamba, La Paz, Oruro, Pando, Potosí, Santa Cruz, and Tarija. Similar to the United States, Bolivia is a presidential republic with three branches of government; executive, legislative and judicial. Currently, Bolivia has an interim president, Jeanine Anez Chavez and is without a vice president. In November 2019, Bolivia's former President, Evo Morales, resigned over alleged election rigging. The next election was set to take place in May 2020 but has since been delayed as a result of COVID-19.

Population demographics

Bolivia's population continues to rise as it was 10.9 million in 2016, 11.3 million in 2018, and estimated to be 11.6 million in 2020.[5,7] The number of inhabitants in urban areas as also increased, from ~66% in 2016 to ~69% in 2018.[6,7] Three of the nine departments (La Paz, Santa Cruz, Cochobamba) hold approximately 71% of the country's population.[8] Population structure continues to shift as the rate of growth in children under 15 decreases and life expectancy increases. As of 2016, ~33% of the population was under 15 years of age, 58.5% between the ages of 15 and 59, and ~9% was over the age of 60.[7] As of 2018, approximately 35% of the country's population lived below the poverty line.[9]

The three most commonly practiced religions are Roman Catholic (~77%), Evangelical/ Pentecostal (~8%) and Protestant (~8%).[6] Ethnically, Bolivia is diverse and not dominated by any ethnic groups, however, the most prominent ones include mestizo (mixed), indigenous (i.e. Quechuan, Aymaran), and European/White.

Health Care Infrastructure

Health Status

Socially vulnerable populations (i.e. those living in rural areas such as indigenous people and those living in poverty) continue to experience avoidable health problems like malnutrition, maternal and child mortality, communicable diseases, and noncommunicable diseases (i.e. cardiovascular conditions and diabetes).[13,14] Communicable diseases (i.e. neonatal disorders and lower respiratory infections) cause the most premature death.[14] Major infectious diseases that impact those residing in Bolivia include food and waterborne diseases like bacterial diarrhea and hepatitis A, and vectorborne diseases like Chagas, dengue and malaria.[1]

Despite the burden of disease, life expectancy continues to rise, currently being 73 for women and 68 for men.[14] As a result of the Government's investment in clean water access stemming from the National Development Plan, 96.7% of the urban population and 75.6% of the rural population have "improved" water quality.[1] Irrigation systems have also improved , not only to better combat drought, but to also ensure food security.[14]

Health Care Services

Nationally, the supply of physicians in the public sector is estimated at 8 per 10,000 population.[7] Prior to 2014, 77% of physicians were in urban areas and 23% were in rural areas; however, that imbalance has lessened as 65% are now in urban areas and 35% are in rural areas.[15] To promote disease prevention and early disease diagnosis, over 2,700 primary care clinics have been established since 2015, which expanded primary healthcare access to 25% of the most vulnerable populations.[7] The Mi Salud project, established by the Ministry of Health, has also been integral in closing the gap in healthcare access for vulnerable populations. The project has a presence in 307 of 339 municipalities and 25 indigenous communities and aims to enhance individual- and community-level primary health promotion and disease prevention efforts.[7]

In March 2019, the United Health System was introduced by the Morales Government as a means of providing free healthcare to the country's poorest citizens. Prior to this, roughly 5.8 million people were uninsured,[14] and three main systems to obtain healthcare coverage existed; 1) Social Security for those over 60, 2) Seguro Universal Materno y Infancil for women who were pregnant and children under five years of age, and 3) Private Insurance.[16]

Challenges in Healthcare Delivery and Addressing Infectious Diseases

Some indigenous communities have a designated medical center; however, they can be extremely limited. For instance, in San Jose de Uchupiamonas, a Tacana indigenous territory, a medical doctor visits only twice each year. When the Center de Salud is occupied by a medical doctor, community members have access to limited array of pharmaceutical drugs, mental health screenings, and contraceptives. The center lacks necessities like hospital beds, access to routine laboratory tests, and refrigerators to properly store vaccines.

Some indigenous communities are extremely remote and without a designated medical center. The Rio Beni Health Foundation, based out of Rurrenabaque, is one example of a mobile health clinic which seeks to address this absence of healthcare access in such remote communities. The small team of doctors and nurses travel along the Beni and Quiquibey rivers, providing basic health care, laboratory services, dental services and access to clean water (via bio-sand water filters) at no cost.

Other barriers include communication challenges between healthcare professionals and community members, as there are dialects specific to each indigenous community, and low education and health literacy, contributing to low levels of medical adherence.[16]

Prominent Infectious Diseases

Arboviruses

Dengue

Dengue is the most prevalent arbrovirus in the Americas with a significant burden both physically and economically.[22] Dengue is a mosquito-borne flavivirus, primarily transmitted by the *Aedes aegypti* mosquito. In 2019, there were 16,193 cases of dengue in Bolivia, 7,420 of which were laboratory-confirmed.[20] In January 2020, Santa Cruz declared a departmental emergency, when 9,142 cases were reported in the first four weeks of the year.[18,20] Dengue often goes without symptoms; however, it can be diagnosed with a blood test. In some more severe cases, dengue can develop into a fatal dengue hemorrhagic fever.[19] While there is a new vaccine for dengue (Dengvaxia), it poses health risks to those who have no history of the infection. Prevention and control efforts consists of minimizing skin exposure and using repellents and insecticides on breading sites.

Chikungunya

Chikungunya is a mosquito-transmitted alphavirus belonging to the *Togaviridae* family. In the 2018 mid-year Epidemiological Situation analysis, the Ministry of Health noted 1,961 suspected cases and 75 confirmed cases across six of the nine departments in Bolivia.[22] *Aedes aegypti*, commonly bred in sites among human habitation, and *Aedes albopictus*, primarily found in the tropics and subtropics, are two mosquito species implicated with larger outbreaks of chikungunya.[17] Currently, there is no vaccine or medicine to treat chikungunya. Prevention and control efforts consist of minimizing skin exposure and using repellents and insecticides on breading sites.

Zika

According to the International Association for Medical Assistance to Travelers (IAMAT), there is no evidence indicating a current Zika outbreak in Bolivia.[23] Zika presence in Bolivia has significantly decreased since its first laboratory-confirmed case in 2016, as there were 583 confirmed cases in 2017, 475 confirmed cases in 2018, and 19 confirmed cases in the first half of 2019.[20,24] There is no vaccine or treatment for Zika, rather, when someone becomes infected, the aim is to reduce physical symptoms.

Other Vectorborne Diseases

Chagas

The burden of Chagas disease primarily resides in Latin America where the disease is considered endemic.[25] Bolivia has one of the highest prevalence's of Chagas disease in the world, with three endemic zones comprised of six of the nine departments (Santa Cruz, Beni,

Cochabamba, La Paz, Sucre and Tarija).[25] There are approximately 3 million people infected with Chagas in Bolivia, and in 2016, the Ministry of Health recorded 17,892 new cases.[31] In Bolivia, 21 types of vinchucas (triatoma infestans) have been identified, *Triatoma Infestans* being most commonly associated with cases in the country.[30] Chagas disease is especially prevalent in low-socioeconomic areas, thus greatly impacting indigenous communities where medical care is deficient and living spaces commonly host vectors of disease (i.e. mosquitos, rodents).

Other vectorborne diseases in Bolivia include *cutaneous leishmaniasis*, which is considered a neglected tropical disease and endemic in the country,[31] leptospirosis, Bolivian Hemorrhagic Fever, hantavirus, which is considered endemic in the Santa Cruz and Tarija departments,[35] malaria and yellow fever. Tuberculosis (TB) also remains endemic and an ongoing public health issue, reporting 7,538 cases in 2017 from all nine departments in the country.[33] To address this, the National Tuberculosis Control Program in Bolivia 2016-2020 is in effect and the Ministry of Health has provided all nine departments with laboratory equipment to diagnose TB.[32]

2. Methods

Internal Databases

Global Research Affairs Database Systems (GRADS), an internal NIAID-specific grants database, was utilized to view both ongoing and past NIAID-funded projects in Bolivia. To better understand laboratory capacity, I directly emailed the Principal Investigators (PIs)s on all active grants. Query View Report (QVR), an internal NIH grants database, was also utilized to view both ongoing and past projects funded through other NIH institutes and centers (i.e. Fogarty International Center, National Cancer Institute). From this, I gained insight into the prominent U.S. and Bolivian infectious researchers in Bolivia, infectious diseases that researchers consider pertinent to address, methods of research and laboratory capacities in Bolivian hospitals, universities, and institutes. I used this information for the public database search that proceeded.

Public Databases (PubMed)

After acquiring relevant grant information, I searched the principle investigators identified NIH-funded grants in PubMed to see whether they were actively publishing and what they were publishing on. I also searched the U.S. and Bolivian PIs that Erika Robles has collaborated with in the past to see whether they've remained active in their research around zoonotic diseases. Lastly, I utilized PubMed to search for researchers prominent in the field specific to both Bolivia and Latin America. I performed a general search in the database pertaining to zoonotic diseases in Bolivia. In addition to Robles, I chose to mention those who are most active in their research, both US and Bolivian, in this paper.

Informational Interviews

In 2019, I studied abroad in Bolivia where I met a variety of public health professionals from both Bolivia and the United States whose backgrounds included biodiversity conservation, EIDs and zoonotic disease prevention, healthcare access, and agroecology. Reconnecting with some of them would be relevant to this report and provide unique insight into the challenges around preventing transmission of emerging and reemerging infectious diseases, particularly in low-income rural and indigenous communities. I also connected with U.S. PIs from active NIAID grants and infectious disease researchers from public database searches.

Robert Gilman, MD, DMTH

Dr. Gilman is a professor of international health and director of the Institutes of Tropical Medicine at the JHSPH. His main areas of research relevant to infectious disease include *Helicobacter pylori*, diseases of high altitude, sexual behavior and sexually transmitted diseases, cysticercosis, Chagas disease, and tuberculosis. His most recent infectious disease research specific to Peru and Bolivia pertains to Chagas disease, specifically cardiomyopathy, congenital transmission, and insecticide resistance in *Triatoma infestans*.[30,34]

Questions proposed:

1. How did you become involved in research in Bolivia?
2. What is the significance of your D43 grant?
3. What interferes with furthering or utilizing already existing research infrastructure in Bolivia?
4. Do you feel that your research priorities align with the priorities of Bolivian researchers/peoples, and in what way?

Carlos Zambrana-Torrelio, PhD

Dr. Zambrana-Torrelio is the associate vice president for conservation and health at EcoHealth Alliance who is originally from Bolivia. Much of his research pertains to zoonotic diseases, specifically the interrelatedness of biodiversity and anthropogenic gradients (i.e. human-induced environmental changes).[35,37,38]

Questions proposed:

1. What are you currently involved in in Bolivia?
2. Do you have any insight into lab capacity, especially at UMSA or IITCUP?
3. What kinds of challenges does Bolivia face when addressing EIDs? (i.e. What is lacking? What barriers exist as a researcher?)

Erika Robles MSc, DVM

Erika is wildlife veterinarian who specializes in transmission of zoonotic diseases is rural areas of Bolivia. While traveling with her, she shared her experiences working on various projects pertaining to zoonotic disease prevention in indigenous communities. I learned that she was the country coordinator for the PREDICT project when it was active, and that much of her research involves the detection of pathogens with zoonotic potential in wildlife, such as yellow fever in primates and hemorrhagic fever in rodents. Because of this experience, we reconnected through social media as a means of gaining additional insight into her involvement in zoonotic disease research, laboratory capacity in the country, connections with other infectious disease researchers, implications around disruptions in the natural environment from economical infrastructure and EIDs.

Questions proposed:

1. What are you currently involved in in Bolivia?
2. What are the implications of ending a project like PREDICT?
3. Do you have any insight into lab capacity in the country?
4. What challenges have you faced in preventing infectious diseases in indigenous communities?

Ruth Alipaz

Ruth is from the northeastern lowlands of Bolivia, a community called San José de Uchupiamonas. She is the national defense coordinator of Indigenous Territories, Native Peasants and Protected Areas of Bolivia and an environmental activist who has devoted her efforts to protecting indigenous rights. Most recently, opposing the mega-dam project that the Bolivian government has supported, which would not only impact San José de Uchupiamonas, a community of ~750 Indigenous Tacana–Quechua people, but would ultimately displace more than 5,000 Indigenous people. Although she is more of an environmental activist and indigenous leader, she possesses considerable insight into the implications of displacing so many people, other governmental influences on the natural environment, which ultimately influence the emergence of diseases. Additionally, she has connections with public health professionals, one of them being Erika Robles.

Questions proposed:

1. What are the implications of the government's current status (having an interim President) and how has that impacted the megadam construction?
2. What other government-funded economic infrastructure is impacting indigenous communities and disrupting the natural environment?
3. Do you have any connections with public health professionals in infectious diseases?

3. Findings

Infectious Disease Research in Bolivia

Noted Infectious Disease Researchers – Interviews

1. Dr. Robert Gilman's research involvement in Bolivia is quite extensive and began in 1992, when he collaborated with Prosalud, a Bolivian NGO, on high altitude pneumonia studies at IPPA. In 2002, he and two other Bloomberg School of Public Health professors established the Iquitos Satellite Laboratory in Iquitos, Peru. Much of his higher-level biosafety laboratory analyses in Latin America takes place there. As a means of leveraging the human capacity and research infrastructure that JHSPH has built in Peru over the last two decades, the South-South training approach is now in place as a means of expanding such research capabilities to Bolivia. An ongoing five-year Fogarty grant (TW010074) supports the South-South training program, which involves training students at the Cayetano Heredia University (Universidad Peruana Cayetano Heredia) in Peru as well as Bolivian students in the Tropical Medicine and Public Health Summer Institute at the Bloomberg School of Public Health. This also involves enhancing research infrastructure, which includes the reverse transcription polymerase chain reaction (RT-PCR) laboratory for congenital Chagas that was recently built at Maternidad Hospital in Santa Cruz, the largest maternity hospital in Bolivia. Prior to this, all laboratory tests had been shipped to Peru for analysis, since research infrastructure in Peru is more advanced.

Dr. Gilman's ongoing projects involve an array of universities and hospitals in Santa Cruz, including Hospital Boliviano Japonesa, Hospital San Juan de Dios, Universidad Major de San Andres, the Children's Hospital, and Catholica University, where he helped established a microscopic observation direct susceptibility (MODS) for tuberculosis. Most recently, Dr. Gilman has started collaboration with Universidad Privada Cumbre, what he describes as a well-funded economics university in La Paz that provides excellent surveillance in dengue. Dr. Gilman has been the U.S. PI on three NIAID-funded grant projects, two of which are currently active (AI107028 and AI136722). All of these grants pertain to *Trypanosoma cruzi* (Chagas). It is worth noting that for over 25 years, JHSPH, the Universidad Peruana Cayetano Heredia in Peru, and the Peruvian NGO, PRISMA, have been in collaboration as a means of enhancing research infrastructure and research capabilities in Peru, and now also Bolivia.

Dr. Gilman also provided insight into the challenges around infectious disease research in Bolivia, much of which pertains to a lack of capacity and funding. The government's lack of infectious disease support and continued transience has greatly impacted the amount of research that can take place. The recent resignation of Evo Morales in 2019 caused much unrest and made Bolivia an undesirable place to continue research because of safety concerns. Prior to that, the Morales government ceased integral funding for infectious diseases (i.e. USAID). The absence of USAID has drastically impacted the amount of infectious disease research funding available for training, surveillance, and infrastructure, limiting hospitals, university, and research capacities. In fact, the only biosafety level (BSL) 3 in the country resides at CENETROP, which was established by

the French Embassy to handle samples of arenaviruses, specifically Machupo, Chapre, hantavirus, and yellow fever. At this time, he is one of few researchers currently utilizing it, and only part-time for TB research as it needs proper ventilation and air conditioning maintenance. He mentioned thatthis laboratory is the only in the country that is equipped for handling SARS-CoV-2.

A final challenge Dr. Gilman mentioned was the lack of academic relationships with the United States, as Johns Hopkins University has the largest academic presence in Bolivia. Additionally, there is little longevity in some bilateral relationships with other countries. This is one of the reasons why laboratory capacity is weak in Bolivia. For example, Bolivia obtained CENETROP's BSL3 and the High Altitude Pulmonary and Pathology Institute (IPPA) from the French embassy; however, necessary routine lab maintenance for these structures to remain fully functional is commonly lacking. Dr. Gilman mentioned his fear that because Bolivia is so ill-equipped compared to other South American countries that it could very well allow for an epidemic, or even pandemic, to emerge in the future.

When asked whether his research priorities in Bolivia align with priorities of Bolivian researchers, his response was nothing short of certainty. With regards to disease, Chagas is the main focus of Dr. Gilman's research in Bolivia, as Bolivia has one of the highest prevalences of the disease in the world, but he is also involved in research in HIV and TB. Enhancing human capacity is also the focus of his efforts, which he agrees is a priority in the eyes of Bolivian researchers as well. *This aligns with what the Bolivian researchers I interviewed stated as a necessity*.

2. *Carlos Zambrana-Torrelio, PhD,* is the Associate Vice President for Conservation and Health at EcoHealth Alliance and Bolivian native. EcoHealth Alliance is an international nonprofit which utilizes a One-Health approach to protect the health of people, animals and the environment from EIDs by utilizing multi-disciplinary team of scientists.

After PREDICT ended, Carlos organized the *Programa Boliviano de Enfermedades Emergentes (PBE4),* primarily funded by UMSA, which intentionally involved many researchers who had been involved with PREDICT. The intent of this program was to continue some of the research and capacity building around the detection of hantavirus and leptospirosis in rodents in Caranavi (northeast of La Paz). The development of this project was largely influenced by the absence of interdisciplinary research efforts as well as the disruptions in the natural environment associated with economical infrastructure. As a means of enhancing interdisciplinary network, this project involved training professionals at the master- and doctoral-levels (from health centers, universities, ministries of health, among others) to perform surveillance measures.[50]

Dr. Zambrana-Torrelio would like to continue preliminary surveillance efforts like these, especially after the outbreak of Machupo virus, also known as Bolivian Hemorrhagic Fever or black typhus, in the summer of 2019 when three of the five confirmed cases resulted in fatality. He believes that it would be valuable to perform rodent surveillance in that area, especially during

harvesting season, when rodent density increases, and to also perform the serologic tests in humans, since harvesting is a manual, not mechanical, process.

Carlos also provided some insight into the challenges of being an infectious disease researcher in Bolivia. Funding is integral in performing research and there is very little of it in Bolivia. Laboratory capacity drastically improved after PREDICT was implemented, however, that same laboratory equipment remains untouched because researchers lack the funding not only for itsuse but also its maintenance. Capacities are still available and eventually could be utilized in the future; however, it remains a matter of funding technicians among other resources. Researchers with limited funding have the option to use outdated models that perform the same task, however, performing a test on a sample that took 5-7 days when PREDICT was active could now take upwards of a month.

"We currently have 300 samples [from rodents] here to be tested, but no funding to do so."

Carlos also mentioned that there is a lack of interdisciplinary research efforts, another necessity that PREDICT had addressed, and lack of critical thinking for its necessity. For example, the idea that ecology and human infectious disease research is mutually exclusiveis prevalent He also mentioned that there is "no integration of disciplines, even in university curriculum." Another reason for this stems from researchers in fields like ecology, who are hesitant to associate animals with illnesses because that misconception could lead to fear ultimately death of wildlife.

3. *Erika Alandia Robles, MSc, DVM* was the country coordinator of the Phase 1 PREDICT project in Bolivia. Since PREDICT is no longer active, she is now on a 30-month contract through a local foundation, Teko Kav, where she has been involved in various projects, including *Programa Boliviano de Enfermedades Emergentes (PBE4*).

Erika has also been involved in *Networking EXTention and CAPacity Building (NEXTCAP).* She says, "by using the One Health approach, NEXTCAP aims to strengthen civil society while promoting participatory zoonotic disease research, collaborative cross-sectorial cooperation and making health information accessible and shared with an interdisciplinary group of stakeholders to improve living conditions among inhabitants of rural communities from the Bolivian Amazon region." This project began as a pilot study, addressing leptospirosis, a neglected tropical disease. Although the pilot ended in 2019, she recently received two and a half years of funding to continue this project, now addressing dengue. The objective is to develop participatory research by establishing community-based surveillance systems in indigenous communities where community members are trained on how to identify where disease vectors reside, how they thrive and how to monitor their presence. Involving the community is especially critical because, since diagnostic capacity is lacking; it is often a timely process to identify what specific species is causing a disease.

Other Infectious Disease Researchers

1. *Faustino Torrico, MD, PhD,* is a Professor of Parasitic Diseases and Infectious Diseases and the head of the Congenital Chagas Project at the Universidad Mayor de San Simon (UMSS) in Cochabamba, Bolivia. Dr. Faustino is also the coordinator of the cooperative agreement between UMSS and French-speaking Belgian universities, which helps maintain bilateral cooperation with Belgium. His main areas of infectious disease research in Bolivia include Chagas, tuberculosis, leishmaniasis and HIV. Dr. Gilman has collaborated with Dr. Torrico in the past and describes his work as the best research in Chagas disease in Bolivia.

2. *Alfonso J. Rodriguez-Morales, MD,* is a Professor at the Technological University of Pereira in Colombia, the President of the Travel Medicine Committee, and the Vice President of the Colombian ID Association. Much of his work is specific to arbovirology in Latin America and is oriented towards epidemiology, medical ecology, clinical, diagnosis, treatment, prevention, ecoepidemiology, and space and satellite epidemiology. His primary areas of research related to infectious and tropical diseases include malaria, Chagas, leishmaniasis, dengue, toxocariasis, chikungunya, Zika, and Mayaro. His most recent publications relevant to infectious disease in Latin America pertain to Chapare hemorrhagic fever,[42] hantaviruses hemorrhagic fever,[41] chikungunya,[40] Zika,[35] and visceral leishmaniasis.[39]

3. *Daniel Bausch, MD, MPH/TM*, is an associate professor in the Department of Tropical Medicine and Section of Infectious Diseases and Department of Internal Medicine at Tulane University. Currently, he is also seconded to the U.S. Naval Medical Research Unit 6 in Lima, Peru, where he is the director of the Emerging Infections Department, specializing in research and control of emerging tropical viruses. Formerly with the Special Pathogens Branch at the CDC, Dr. Bausch has extensive experience in sub-Saharan Africa, Latin America, and Asia combating pathogens including Ebola and Lassa viruses, hantavirus, and severe acute respiratory syndrome coronavirus.[49] Much of his ongoing research is around viruses in regions of Peru, like the Peruvian Amazon Basin, addressing viruses like Rickettsia,[45,48] Leptospira,[45,47] Hantavirus,[44] and dengue.[46] Previous research collaboration specific to Bolivia pertained to Hantavirus Pulmonary Syndrome, specifically in Santa Cruz.[43,44]

Research Infrastructure

Ministry of Health and Sports (MoHS)

The Ministry of Health and Sports is the governing body that regulates and executes policies for access to intercultural health for all individuals without exclusion or discrimination. Bolivia's Ministry of Health has established the National Arbovirus Surveillance System, a component of PAHO's Integrated Management Strategy - Dengue strategy, as a means of reporting positive cases

of Dengue, Chikungunya and Zika in real time.[5] The National Institute of Health Laboratories (INLASA) and National Center for Tropical Diseases (CENETROP) fall under the MoHS.

The National Institute of Health Laboratories (INLASA) – La Paz[52,53,54]

INLASA supports disease surveillance and prevention by performing diagnoses and producing immunobiologics in laboratories including Clinical Analysis, Clinical Bacteriology, Human Genetics, Culture Media, Immunology, and Cancer Diagnostics and Research as well as:

1. The *Laboratory of Parasitology and Entomology* – performs epidemiological and entomological surveillance at the national-level through the National Malaria, Chagas, Dengue, Zoonosis and Leishmaniasis Programs.
    - Named National Reference Laboratory for the diagnosis of Leishmaniasis in 2017.
    - Named National Reference Laboratory for the diagnosis of Malaria in 2005.
2. The *Laboratory of Virology* - an integral part of the Network for Surveillance of Rabies, Enteropathogens, Respiratory Pathogens and Influenza. Laboratory is capable of diagnosing dengue, zika, chikungunya, yellow fever in humans, animal hosts, and vectors (i.e. Aedes aegypti, Haemagogus), Leptospira in rodents, Coronavirus, Norovirus, Adenoviruses and Hantavirus.
    - A National Reference Laboratory for entero- and respiratory pathogens and influenza.
3. The *Center for Molecular Genetics (CIGMO)* - capable of an array of genetic tests, the most relevant including:
    - Genotyping and strains of T. Cruzi, in triatom molecules (conventional PCR)
    - Molecular diagnosis of Leishmania (conventional PCR)
    - Yellow Fever, Dengue, Zika, Chiungunya molecular diagnosis (real-time PCR)

"[INLASA] is one of the labs of reference for rabies diagnosis. In the past they got a lot of technical and economic support from the French cooperation, specially to work on Chagas and leishmania." Erika Robles, MSc DVM

National Center for Tropical Diseases (CENETROP) – Santa Cruz[55,58]

CENETROP is the National Reference Laboratory in Serology of chikungunya, dengue, yellow fever, hantavirus, sarampion, rubeola, and zika, and categorized as a BSL-3, with the ability of:

- Isolating Zika, Chikungunya, Mayaro virus, Yellow fever, Dengue 1-4

- Inactivation and biocustody of samples suspected of Ebola virus (EVE), Machupo virus (FHB), Hantavirus
- Obtaining viral seeds of Dengue 1-4, Yellow fever, Zika, Chikungunya, Adenovirus, respiratory syncytial virus, Parainfluenzavirus, Pmeneumovirus
- Antigen production in cell culture of Dengue, Zika, Chikungunya.
- Investigation of respiratory viruses, arboviruses, flaviviruses, bunyaviruses, alphaviruses and arenaviruses in cell culture

CENETROP's *Virology Laboratory* is capable of identifying an array of viruses including HIV, Hepatits, and Rubella by means of ELISA, western blot and flow cytometry. The *Parasitology Laboratory* provides serological diagnoses through ELISA, HAI and IFI tests for detection of IgM and IgG antibodies for Chagas, Toxoplasmosis and Leishmania, among others. Integral in the surveillance of reemerging diseases, CENETROP also supports an *Emerging Viruses Laboratory* which provides serological diagnoses through ELISA for Chagas, zika, dengue, chikungunya, yellow fever, hantavirus and Leptospira.

"After the PREDICT lab team visited Bolivia, we agreed to work with the Biomolecular Lab (IBMB) from UMSA in La Paz. [Once PREDICT ended], we left the protocols at CENETROP to test 12 viral families of zoonotic importance, and we also provided them with the primers, so in principle they could test samples of those family viruses, which in fact they used last year (2019) to confirm the cause of death of 3 people who had Chapare Hemorrhagic Fever in the North of La Paz (the first cases of the disease reported in that part of the country)." -Erika Robles, MSc DVM

University of San Andrés (Universidad Mayor de San Andrés (UMSA)[56]

At UMSA, there are 50+ research institutes, including the Institute of Molecular Biology and Biotechnology (IBMB), Institute of Services for Diagnostic Laboratories and Health Research (SELADIS), and the Institute of Health and Development Research (IINSAD).

"After the PREDICT lab team visited Bolivia, we agreed to work with the Biomolecular Lab (IBMB) at UMSA in La Paz. There we provided some equipment, protocols and primers, and just before the government ended PREDICT, we had started to test the samples, but we then had to stop everything. The lab capacities still being there and eventually we could use them (if we get access to funds to pay the lab technicians and some lab material, of course)."

-Erika Robles, MSc DVM

Institute of Scientific Technical Research (IITCUP) of Police University – La Paz[57]

IITCUP supports research planning, implementation and evaluation in their fifteen divisions. While it primarily functions as a forensic laboratory, it's worth noting that it has been utilized for genetic sequencing in animals with infectious diseases.

"We contacted [IITCUP] to do the sequencing of the primates with yellow fever in order to confirm the diagnosis and identify the viral strains. I have been working with them also for the pilot project on Leptospirosis (NEXTCAP). It is an interesting partnership of course, since they depend on the head of the Police, [and currently] they don't have funds for health projects, so you also need funding in order to run research there."

-Erika Robles, MSc DVM

USAID's PREDICT Project

The USAID Emerging Pandemic Threats Program PREDICT project was established in 2009 as a means of strengthening early detection and response to emerging and reemerging zoonotic infectious diseases, specifically strengthening surveillance and laboratory capacity in areas with a high prevalence of EIDs. PREDICT utilizes the One Health Approach, investigating behaviors and practices as well as ecological and environmental factors that drive disease emergence and transmission.[26,27] PREDICT had created an extensive transdisciplinary network of One Health professionals with partners in over 30 countries, training over 6,000 people in biosafety, field epidemiology and surveillance, laboratory diagnostics, and social and behavioral sciences, and modeling and analytics.[26] The program strengthened the zoonotic disease detection capabilities of laboratory system in over 60 labs globally, detecting over 1,000 viruses (931 novel & 218 known), including Bombali- and Zaire ebolavirus, Marburg virus, and MERS- and SARS-like coronaviruses.[28]

In Bolivia, PREDICT was active for three years, and in those three years, capacity for detection of and response to emerging zoonotic pathogens was greatly enhanced, including laboratory capacity, protocol development, molecular diagnostics and detection of virus families. Prior to this, laboratory capacity in country was lacking in that lab capabilities were limited to single pathogen detection, and only in humans. In 2012, PREDICT was integral preventing a potential yellow fever outbreak, when six dead Red Howler Monkeys were found at Ambue Ari Wildlife Refuge Park. Genetic sequencing occurred at the University of San Andres' Institute of Molecular Biology, (IBMB) where it was confirmed that the infections were caused by yellow fever viral strains. A public health response was immediately mobilized in the region and ultimately no human cases were reported. This suggests that local laboratory capacity and transdisciplinary collaboration plays an integral role in preventing human cases and ultimately disease outbreak.[29] Unfortunately, in 2019, all funding for the project was ceased.

PREDICT's final report noted major achievements including:

- Building laboratory capacity at the Institute of Molecular Biology (IBMB) at the University of San Andres for detection of 12 different viral families in bats, rodents, and nonhuman primates.[26]
- Transferring diagnostic technology to the two most important national public health labs, National Center for Tropical Diseases (CENETROP) and National Institute for Public Health Laboratories (INLASA).[26]
- Partnerships were formed with nine institutions including IBMB, IITCUP, USMA, and Universidad Catolica Boliviana.[26]
- 178 field staff, veterinarians, biologists, laboratory technicians, public health government personnel, wildlife rescue centers staff, and indigenous community residents were trained.[26]

NIAID's Presence in Bolivia

Currently, there are six ongoing NIAID-funded grants. *AI107028* is an extension of a longitudinal study involving Chagas-infected subjects, which involves echocardiogram (ECG) and serum samples for biomarker analysis as a means of understanding the progression of congenital Chagas disease. *AI113197* involves using blood samples to characterize cellular immune responses to Chagas, utilizing Dr. Gilman's Iquitos laboratory in Peru, funded by his R01 grant (AI136722). This project also involves amplifying the tcsc5d gene in samples from congenitally infected infants, which has provided preliminary data for Dr. Gilman's R01 grant (AI107028). *AI123070* involves screening *T. cruzi* proteomes and deconvoluting antibody binding patterns into individual immune responses as a means of understanding how the diversity in *T. cruzi* antigen responses in Chagas-infected people. *AI129783* is a phase II clinical trial involving adults with chronic Chagas in Cochobamba, Tarija, and Sucre, who are currently receiving new benznidazole and nifurtimox regimens and identifying biomarkers of a treatment cure. *AI136722* is intended to enhance diagnostic capabilities of toxoplasmic encephalitis (TE), tuberculosis meningitis (TBM) and CNS Chagas in patients in HIV. Lastly, *AI136172* is a small business innovation research grant for Kephera Diagnostics to evaluate point-of-care diagnostic testing for Chagas. Additionally, there are eight NIAID-funded grants that are no longer active in Bolivia, which are summarized in the appendices.

Summary of NIAID's Current Extramural Research Activities

Award No.	Code	Title	PI + Parent Institution	Disease	Start + End Date	FY 2020 Direct Cost
AI107028	R01	Predictors of cardiomyopathy progression in a Chagas disease cohort in Bolivia	*Robert Gilman* JHU	Trypanosoma Cruzi	2/15/2014 - 6/30/2024	$517,649
AI113197	K23	The pathogenesis of T. Cruzi in HIV-infected persons in Bolivia	*Natalie Bowman* UNC Chapel Hill	HIV/AIDS | Trypanosoma Cruzi	9/15/2014 - 8/31/2020	Unavailable
AI123070	R01	High-Throughput Epitope Discovery: Use of Next-Generation Peptide Chips for Fast Identification and Fine Mapping of Diagnostic and Prognostic Markers for Chagas Disease	*Fernan Aguero* Institutes/ Research/ Biotechnology FDN	Trypanosoma Cruzi	3/15/2016 - 2/28/2021	$98,250
AI129783	U01	New chemotherapy regimens and biomarkers for Chagas disease	*Igor Almeida* University of Texas El Paso	Trypanosoma Cruzi	8/17/2018 - 7/31/2023	$1,031,496
AI136722	R01	Novel nanoparticular diagnostics for cerebral toxoplasmosis and Chagas in HIV patients living in Latin America	*Robert Gilman* JHU	Toxoplasma | Trypanosoma Cruzi	6/18/2018 - 5/31/2023	$508,599
AI136172	R43	Point-of-Care Diagnostic Test for T. Cruzi (Chagas) Infection	*Andrew Levin* Kephera Diagnostics, LLC	Trypanosoma Cruzi	08/07/2018 - 07/31/2020	$213,798

4. Discussion

Expanding Collaboration in Bolivia: Things to Consider

In exploring possible collaboration opportunities in Bolivia, it is important to consider Bolivia's geographic location, vast topography and climate, ongoing political instability, little monetary resources and economic infrastructure influences on the natural environment. Bolivia is landlocked, has a maximum altitude of 21,463 ft and a minimum of 295 ft, three different climates, a transient government that does not prioritize infectious disease research, is lacking upper-level biosafety research infrastructure and has various economy-enhancing projects in motion that if implemented will have significant implications for emerging and reemerging diseases. This makes for a very vulnerable country.

Vulnerable populations, like those in low-income rural areas and indigenous communities, are particularly vulnerable to infectious diseases, lacking healthcare infrastructure as most expansions in healthcare infrastructure occur in urban areas. Additionally, there is little financial capacity to expand research infrastructure, especially now that USAID is no longer funded in the country. Some of the laboratory equipment which stemmed from PREDICT is infrequently used because it is expensive to utilize and maintain; however, partnerships remain, and collaboration and laboratory use can resume with appropriate funding.

Ongoing infectious disease research efforts often occur in areas where mining and harvesting take place since environmental disruptions like these displace wildlife, thus have initiated outbreaks like Bolivian hemorrhagic fever and yellow fever. Environmental disruptions of even larger magnitudes have also been proposed. Until his resignation in late 2019, the Morales Government was in the midst of planning various economy-enhancing projects, one being the mega-dam project, involving 35 hydroelectric plants in 4 regions of the country to export electricity. Since there is an interim President, the mega-dam project is at a standstill;however, the result of the election will impact whether the project continues. A disruption of this magnitude would drastically influence the emergence and reemergence of zoonotic diseases as it would displace more than 5,000 Indigenous peoples, increase deforestation and result in a loss and displacement of habitat.

Lastly, and as previously mentioned, there is little longevity in some of the bilateral relationships with other countries with regards to research and academia, the most extensive likely being with France and Belgium. Both CENETROP and IPPA were established in Bolivia by the French embassy. Additionally, Bolivia contains one of the largest offices of the French Research Institute for Development (IRD) in Latin America. Additionally, a bilateral research relationship with Belgium also exists as Faustino Torrico is the head of the Congenital Chagas Project at the Universidad Mayor de San Simon (UMSS), a joint project with the Free University of Brussels (ULB) that began in 1998. Integration of this project into Bolivia's health systems is partially funded by the French Community of Belgium cooperation project (WBI). It is also worth noting that in December 2019, the Universidad Mayor de San Andrés (UMSA) and Universidad Mayor de San

Simón (UMSS) in Cochabamba completed letters of intent for Research Training Partnership Programme with Sida, a Swedish International Development Cooperation Agency.

Recommendations

Much of NIAID-funded extramural research comes from Dr. Gilman's research efforts around Chagas disease, which infects approximately 3 million people. While Johns Hopkins University has the largest presence of any U.S. academic institution, academic institutions in Bolivia are also prioritizing Chagas research. Perhaps it is now worth placing resources towards understanding other infectious diseases as there is a multitude of other infectious diseases that impact the health of the country including dengue, leptospirosis, tuberculosis and hantavirus that are not being addressed in any active NIAID-funded projects, rather, are being addressed by Bolivian researchers with minimal resources. Such diseases are necessary to address, especially in a country with very little internal support and very vulnerable populations.

As a means of increasing human capacity and using existing infrastructure, many ongoing projects involve establishing interdisciplinary partnerships and training interdisciplinary teams, both professional and community-based, to perform surveillance and laboratory diagnoses. This is especially pertinent in a low-income country like Bolivia where funding for infectious disease research is lacking. Continuing these primary and tertiary efforts where we are furthering our understanding of infectious diseases and discovering treatments for them, while also enhancing preliminary surveillance, will be fundamental in preventing the emergence, reemergence and transmission of infectious diseases.

PREDICT initiated many interdisciplinary partnerships and enhanced laboratory capacity and community-based preliminary surveillance, much of which remains and could be much more impactful if additional funding were available. While much of NIAID's funding supports research around diagnostics and therapeutics, it is worth noting the necessity of community involvement and education in research, and their influences on the interrelationship between health literacy and disease transmission (i.e. limiting the interaction between humans and vectors of disease). Picking up where PREDICT left off would be an ideal step in furthering NIAID's presence in the country. Furthering successful projects that stemmed from PREDICT could potentially occur through the NIH-USAID interagency agreement or seeing whether any of the aforementioned projects are of programmatic interest to intramural scientists or extramural program officers at NIAID.

Lack of monetary resources is a common theme when identifying the challenges of performing infectious disease research in Bolivia. Researchers in Bolivia typically describe the reasoning for this as the government having little invested interest in the health of the country, and that the

health of the economy remains the priority. With very little presence from U.S. institutions, collaboration between the United States and Bolivia remains challenging to initiate. Additionally, it is not common for Bolivian researchers to be the primary PI on NIH-funded grant awards. R03 and R21 grants have the potential to benefit these researchers since they are smaller-scale developmental and exploratory grants. Additionally, programs through Fogarty International Center (FIC), such as the Ecology and Evolution of Infectious Diseases Initiative (EEID) as well as the Global Infectious Disease Research Training (GID) program, could potentially benefit both Bolivian researchers and individual U.S. researchers as these programs support basic and applied research as well as training initiatives. Projects that involve training seem particularly relevant as enhancing human capacity is a priority of ongoing efforts in Bolivia. Therefore, I have identified grants that foreign researchers, like those I have spoken with, could possibly pursue in the future.

Opportunity No.	Opportunity Title	Agency	Close Date	Eligibility
PAR-19-362	Global Infectious Disease Research Training (GID): D71 Planning Grant for Global Infectious Disease Research Training Program	HHS-NIH11	Oct. 28, 2020 (letter of intent due Sept. 28, 2020)	Apply with a collaborating US institution
19-592	Ecology and Evolution of Infectious Diseases (EEID)	NSF	Nov. 18, 2020	Unrestricted
PAR-20-108	International Research in Infectious Diseases (R01 Clinical Trial Not Allowed)	HHS-NIH11	Jul. 15 2020 *(letter of intent due June 15, 2020)*	Applicant organizations must be headquartered in foreign (non-U.S.) resource-constrained countries
PAR-19-052	NIH Small Research Grant Program (Parent R03 Clinical Trial Not Allowed)	HHS-NIH11	Jan. 07, 2022	Unrestricted
PAR-19-053	NIH Exploratory/ Developmental Research Grant Program (Parent R21 Clinical Trial Not Allowed)	HHS-NIH11	Jan. 07, 2022	Unrestricted

Limitations

While I was able to obtain insightful firsthand information into infectious disease research in Bolivia, it is worth noting some challenges. First, overall, Bolivian websites (.bo) are challenging to navigate and lacking in information. For instance, UMSA listed their institutes on their homepage, all which were all hyperlinked, but the individual institution websites solely contained contact information. Therefore, I had to contact institutes via email as a means of obtaining information on laboratory capacity. Another example stems from the IITCUP website through Police University, which was not interactive nor informative. Fortunately, everyone I spoke with provided insight into the county's laboratory capabilities.

Additionally, many institutes did not respond to my emails asking for laboratory information. For instance, after realizing that institution websites through UMSA only contained contact information, I emailed IBMB, IINSAD and SELADIS (in Spanish with an English translation), those I thought were relevant to this report, but received no response. With regards to PIs on active NIAID-funded grants, I only received a response from one researcher, Dr. Gilman at JHSPH, who has two active NIAID-funded grants in Bolivia and also one active Fogarty grant.

Lastly, while CENETROP is likely the only BLS-3 laboratory in Bolivia, Dr. Gilman provided some insight into the High Altitude Pulmonary and Pathology Institute (IPPA) outside of La Paz, which could potentially be a BSL3 as well. Unique to Bolivia, the IPPA is a small institute within Zubieta University, which specializes in the physiological effects of hypoxia. Like CENETROP, IPPA is funded by the French Embassy. Unfortunately, the website was not extremely informative, and I did not receive a response from the provided contact, so its biosafety capacity remains unclear.

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Summary of NIAID's Past Extramural Research Activities

Award No.	Code	Title	PI + Parent Institution	Disease	Start + End Date	NIH-Supported Publications
AI050410	P30	UNC Center for AIDS Research	*Ronald Swanstrom* UNC Chapel Hill	Cryptosporidium | HIV/AIDS | M. Tuberculosis | Pneumocystis	8/20/2001 - 7/31/2016	1,992
AI052683	R44	Geographically robust rapid assay for T. Cruzi infection	*Syamal Raychaudhuri* Inbios International Inc	Trypanosoma Cruzi	8/1/2002 - 8/31/2012	2
AI057266	U19	Vaccine Induced Immunity in the Young and Aged	*Rafi Ahmed* Emory University	Bacillus Anthracis | Basic Immunology | Biodefense Research| Dengue| Yellow Fever	9/30/2003 - 4/30/2014	301
AI074285	P50	Innovative Approaches to Diagnosis and Control of Chagas Disease (Peru TMRC)	*Cesar Naquira* University Peruana Cayetano Heredia	Reduviidae (Triatoma, Rhodnius, Panstrongylus) | Trypanosoma Cruzi	8/15/2007 - 7/31/2013	34
AI079231	R01	Risk of Viral Emergence from Bats	*Peter Daszak* Ecohealth Alliance Inc	Corona Viruses | Emerging/Re-emerging Diseases | Parmyxovirsuses | Rabies	9/18/2008 - 8/31/2013	46
AI087724	K01	Effect of Nutrition, Immunity, and Vaccines on Pediatric Enteric Infections	*Juan Leon* Emory University	Noroviruses | Rotaviruses	7/1/2010 - 6/30/2015	37
AI087776	R01	Early Detection of Congenital Chagas Disease	*Robert Gilman* JHU	Trypanosoma Cruzi	3/15/2010 - 2/28/2017	12
AI039780	P01	Epizootiology of Machupo Virus in Bolivia	*Clarence Peters* University of New Mexico	Machupo Virus	09/24/1999 - 07/31/2001	12