Is Our Water Safe to Drink?
A View from Rural Honduras

by

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Abstract

Testing the public water supply for the presence of coliform bacteria was requested in February 2023 in the villages of San Antonio, San Francisco, and San Jeronimo in the San Jose del Negrito service area in rural Honduras by the local Health Committee to address perceptions of a higher than usual incidence of diarrheal disease in those communities. Without collection of epidemiologic data to inform health concerns, these perceptions were subjective, and testing did not reveal pathogens in the water. This essay explores how Honduras, one of the world's poorest nations, works with the international nongovernmental organization Water For People to deliver water to its most remote communities in the face of a worldwide water crisis and how one small nonprofit, Shoulder to Shoulder-Pittsburgh, has partnered with community members in San Jose del Negrito over time, using the Community Oriented Primary Care model, to address the health care needs of the region. The project reveals how outside health workers can engage with a community to improve health and how health workers can use basic public health strategies, such as community education, to enhance health status even in remote areas where health services are limited. Most importantly, this project highlights the use of epidemiologic data to characterize health concerns and calls for a dedicated effort to incorporate surveillance of basic indicator data into community healthcare in San Jose del Negrito to alert health workers when a worrisome trend emerges. Strategies are offered on how to begin this effort.

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1.0 Introduction

This paper will describe a small health project undertaken as part of a Shoulder to Shoulder health brigade visit to rural Honduras in February 2023. The project sought to assess the integrity of the public water supply in three villages where there was suspected to be an increased incidence of diarrheal disease.

Diarrhea is one of the leading causes of disease globally, with approximately 1.1 billion cases annually among children under five.[1] While deaths from diarrhea have declined impressively since 2000, diarrheal disease remains the third leading cause of death in children under five, killing almost 450,000 children in this age group each year.[2,1] Known as a disease of poverty, diarrhea is a leading cause of child malnutrition which can lead to stunting and delayed brain growth later in life, resulting in substantial economic burdens for individuals and societies. It is most often caused by bacterial, viral, or parasitic infection of the gastrointestinal tract, and 88% of cases are attributable to unsafe drinking water and inadequate sanitation and hygiene.[3] Diarrhea is quite common in Honduras, with over 18 episodes per child per year in kids under five.[3]

The water project described in this paper sheds light on the municipality's efforts to deliver clean water to its population of over 45,000 amidst the backdrop of a global water crisis in one of the poorest nations in the Western Hemisphere. The project also reveals how outside health workers can partner longitudinally with a community to improve health. Finally, by highlighting the essential role of data to better understand health concerns, it calls for the implementation of basic public health surveillance measures to alert health workers and community leaders to worrisome disease trends in the population which can inform the need to develop and implement

community-wide health interventions. This water project is, therefore, a subject of interest and of public health significance.

2.0 The Community: San Jose del Negrito, Honduras

Honduras is a nation of 10.3 million people located in the Western Caribbean region of Central America. Poverty is a major issue in the nation. The Purchasing Power Parity (PPP) Exchange Rate is one method economists use to compare metrics reported in the local currency by conversion to a common currency.[4] In Honduras, 66% of citizens live below the poverty line (US $6.85 per person per day at 2017 PPP) and 20% live in extreme poverty (less than US $2.15 per person per day at 2017 PPP).[5] Honduras is the second poorest nation in Latin America. Hunger, food insecurity, and malnutrition are important health issues, with 23% of children under five experiencing stunting of growth, defined as growth that is at least two standard deviations below median World Health Organization child growth standards.[6] As previously noted, diarrheal disease is a contributing cause to child malnutrition.

San Jose del Negrito is a remote mountain village which numbered 1,254 people according to the 2013 census and is in the Northwest region of Honduras. It is in the municipality of El Negrito, located in the Department (Province) of Yoro, which has a population of just over half a million and is one of eighteen Departments dividing Honduras. The population is 95% Mestizo, describing those of mixed European and indigenous heritage.[7]

The regional economy is predominantly agricultural, with corn, beans, and coffee as principal crops, and a smaller presence of cattle and timber industries. The major livelihood in this area is typical hillside subsistence farming[8], with a smaller proportion of crops sold in the nearby towns of El Negrito (population 50,000) and El Progresso (population 188,000).[9] Annual GDP per capita for 2022 in Honduras was $3,040, according to the World Bank.[10] While local

income data for the municipality of El Negrito is not available, it is likely well below the nationwide average.

3.0 Healthcare in Honduras

The Honduran Ministry of Health and the Honduran Institute of Social Security run public health clinics and public hospitals, which are most often located in urban areas. There is, however, one such clinic in rural San Jose del Negrito, staffed by a public health nurse, and there is a public hospital in El Progresso, over an hour's truck ride from San Jose down the steep mountainside on a rugged, unpaved road.

Healthcare is free in the government-run, public health system, and while the system has many shortcomings, its strengths can be impressive. Public health workers keep ledgers of all children and adults, what vaccines they have received and which chronic diseases they have, where they live, what kind of dwelling they live in, whether the family cooks inside or outside, and other details. They may set out on motorcycles to deliver sexually transmitted infection test results and instruct patients to return to the clinic for treatment when necessary and they track down pregnant women who have missed prenatal appointments. Routine immunization coverage of Honduran children through the public system ranges from 70-80%.[11]

However, corruption is rampant in Honduras, which ranked 157th out of 180 nations in Transparency International's 2022 Corruption Perceptions Index.[12] This may take the form of unqualified workers being given a government job with its attendant salary and status and little expectation to deliver high quality outcomes. The single public health nurse assigned to the village of San Jose del Negrito is felt to be ineffective in her role, according to conversations with the sole physician employed in the village and another physician who has been visiting the area for twenty-five years to provide care.[13]

Another problem in Honduran healthcare is the paucity of physicians. According to the US Central Intelligence Agency, there are 0.5 physicians per 1,000 people in Honduras.[14] This compares to 2.6 per 1,000 in the US and is well below the level of 2.3 physicians per 1,000 which the World Health Organization estimates is adequate to deliver primary health care to a nation.[15]

Free inpatient care in the public hospitals means there is no bill for a physician's consultation or for necessary surgery. However, families are responsible to provide for their loved ones' comfort, food, hygiene, supplies, and medications while in the hospital.[16] Medicines and supplies, like intravenous fluids and gauze pads, are sold over the counter, requiring not a doctor's prescription but a note listing what is required, and must be purchased before any needed care is rendered. The cost of all these items is often prohibitive.

An extensive private health system, consisting of nonprofit and for-profit providers, operates in parallel to the public one and delivers more comprehensive care, covering services that the public system does not. Healthcare services obtained through the private system are only available to those who can pay out of pocket for services. Health insurance plays a minor role in Honduras, with over 90% of the population lacking insurance.[17] The healthcare system is characterized by poor coordination between public and private institutions and a substantial number of the population lacks access to either system, due to financial constraints, distance from care, or other obstacles.[18]

4.0 Shoulder to Shoulder

San Jose del Negrito is the location of La Clinica Hombro a Hombro, or the Shoulder to Shoulder Medical Clinic, which serves the population of San Jose, and surrounding 18 villages comprising a population estimated at 5,000.[19] Shoulder to Shoulder began as a project of the University of Cincinnati Department of Family Medicine in 1990, delivering basic healthcare services in the rural Department of Intibucá, Honduras.[20] Over the next several years, other US university Departments of Family Medicine joined the effort, assuming care for other villages and regions across Honduras.

The need was great and was made much more acute by Hurricane Mitch which devastated Honduras in 1998. The deadliest hurricane in Central American history, Mitch killed over 11,300 people, including 7,000 in Honduras. The storm and its catastrophic flooding and landslides destroyed 35,000 homes and damaged 50,000 more, leaving 1.5 million Hondurans, 20% of the population, homeless. Crop damage was extensive and over 70% of Honduran water infrastructure, and up to 80% of its transportation infrastructure, such as roads and bridges, was destroyed. Outbreaks of cholera, leptospirosis, and Dengue Fever followed, as did worsening food and water scarcity. Carlos Roberto Flores, then President of Honduras, estimated that Hurricane Mitch set the nation back 50 years in economic development.[21]

In 2001, in the aftermath of Hurricane Mitch, a group of family medicine physicians from Pittsburgh, in cooperation with the Shoulder to Shoulder group in Cincinnati, began to partner with the San Jose del Negrito Health Committee, a grass-roots organization comprised of laypeople seeking to improve the health of their community.[19] The Health Committee continues to play a central role in directing health services for the San Jose service area. There are currently 18

community members serving on the Health Committee. They include people from various segments of the community, such as small business owners, homemakers, shopkeepers, and the deacon of the local church. Membership is by election and committee members serve a term of three years. The Committee seeks to include members from various neighborhoods around San Jose and to include people with diverse skill sets, much like a nonprofit board of directors. Committee members serve without compensation but may benefit from the status that accompanies their civic service.[22]

The Health Committee meets monthly to identify health priorities and determines how to best address them. Some of the major health needs they identified in early years, beyond securing basic medicines, included delivery of regular medical, dental, and behavioral health care, more nutritious food for children and pregnant women, and community health education.[19]

By 2003, the Pittsburgh physicians had incorporated as a nonprofit, becoming Shoulder to Shoulder-Pittsburgh, and have since been serving, in partnership with the Health Committee, the health and development needs of the San Jose region, while working with the wider STS network.[19] STS-Pittsburgh operates according to the Community Oriented Primary Care (COPC) model of care, further described below.

In 2004, STS-Pittsburgh completed its first medical clinic building in San Jose, raising funds for the project through charitable contributions from the Pittsburgh community, where the organization is based, and employing local laborers from the San Jose community for construction. Since then, that property has been developed to include an expanded medical clinic, a dental clinic, a maternity care unit, a community meeting center, a library, apartments for a doctor, a dentist, and a nurse, and a dormitory for visiting medical staff. A full-time, permanent Honduran nurse was hired in 2005, and a full time, permanent Honduran physician, Dr. Tania Castillo, was hired

in 2007 and remains in practice at the clinic today. A half-time dentist has been in place since 2020.[19] Each of these efforts was carried out through the iterative process encompassed in the COPC model. The partnership between STS-Pittsburgh and the San Jose Health Committee has resulted in the ability to promote health and deliver health care services to San Jose and to many surrounding villages in the San Jose service area.

One of the Health Committee's earliest identified needs, was obtaining a reliable supply of basic medications for the community. A formulary was developed in collaboration between STS-Pittsburgh physicians and pharmacists and medications are purchased from international wholesale pharmacies which serve the market of under-resourced communities with common, low-cost, generic medications. Funding for the pharmacy program is provided through fundraising efforts of the STS-Pittsburgh nonprofit organization.[19]

Health brigades, consisting of medical and pharmacy students and residents from Pittsburgh and other US cities, working under the supervision of family medicine faculty physicians, visit the region twice each year for two weeks, working and living on the clinic grounds in the dormitory building. The interdisciplinary team of 8-18 students, residents, and health professionals delivers formulary medicines and supplies to the community, supports Dr. Castillo and her staff, and supplements local medical care. Major brigade activities include caring for patients with acute and chronic conditions as well as providing emergency services, conducting prenatal care, traveling to each of the villages in the service area to deliver group well-child care, performing home visits for patients who cannot visit the clinic, and participating in Health Committee meetings. Student and resident learners gain experience in providing medical care in a low-resource setting and conduct various health improvement projects, which originate from Health Committee-identified concerns.

5.0 **Community Oriented Primary Care**

STS-Pittsburgh works in close partnership with the San Jose Health Committee, utilizing the Community Oriented Primary Care (COPC) model of care. The role of STS-Pittsburgh is to serve as advisors to the Health Committee, to provide health care expertise, and to help execute those priorities determined by the Health Committee.[23] Given their experience in family and community medicine, a part of the expertise the medical workers can contribute in working with the Health Committee is to apply basic epidemiologic skills to assess patterns of, and emergence of, disease.

The COPC model was developed in the 1940s by Sidney and Emily Kark, two physicians appointed by the government of South Africa to create and implement a health care delivery system suited to rural, impoverished areas of that country.[24] It is a strategy that seeks a deliberate integration of primary health care and community medicine based on a community's assessed health needs. The approach demonstrated improvements in the health status of the poor and was expanded to other areas of the world.[25] COPC was the dominant feature of the Declaration of Alma Ata, issued at the Alma Ata Conference in 1978, jointly convened by WHO and UNICEF to focus global attention on primary health care as the key to achieving an acceptable level of health throughout the world.[26]

In the COPC paradigm, a team of community representatives and health professionals are the core agents, functioning as partners in every step of a cyclical, ongoing process. By involving community members in public health initiatives from the very beginning, COPC places community participation at the center of its process. While the team's composition may be fluid, the core

membership must be committed to taking responsibility for developing and maintaining comprehensive community health initiatives.

COPC efforts are undertaken according to four process steps best depicted in the following schematic, demonstrating that community involvement is critical to, and central to, each step.[27]

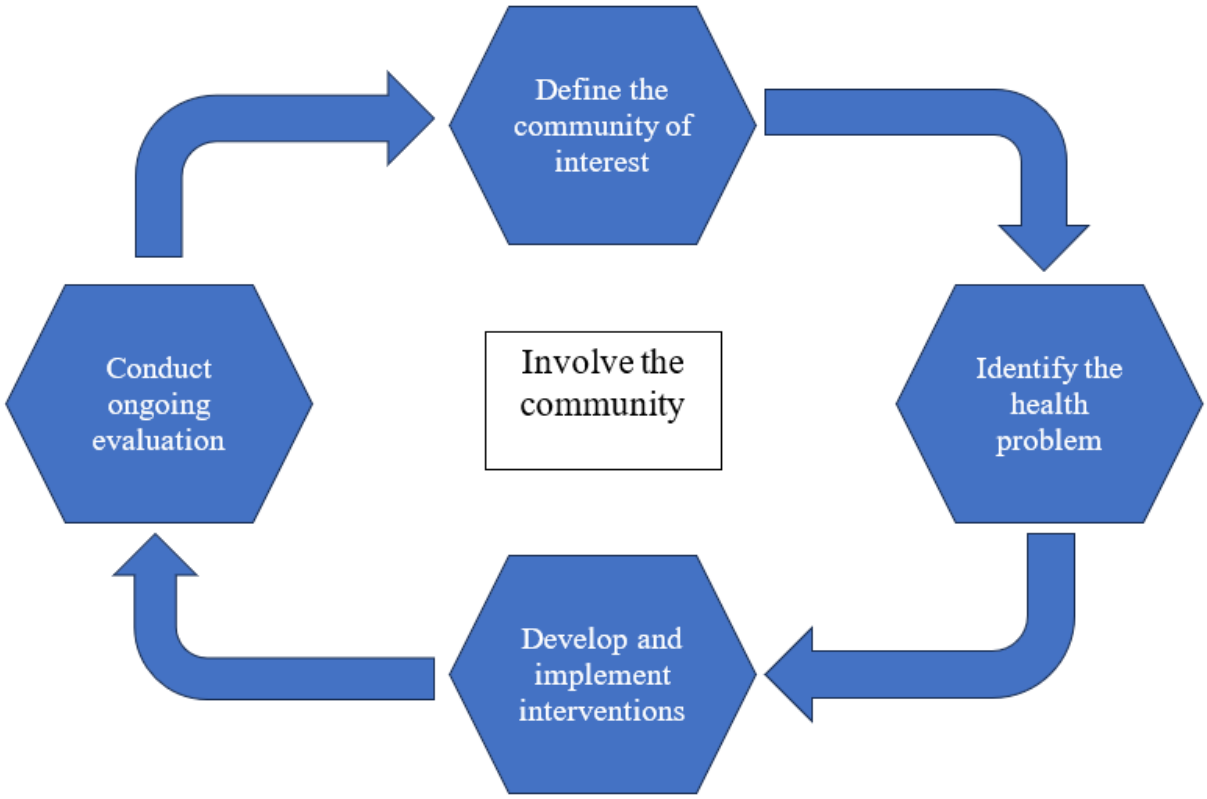


Figure 1 Community Oriented Primary Care

In the COPC model, the first step is to identify the community of concern. It may be defined in various ways, by geography or other boundaries, or by those in a certain demographic group, such as children or the elderly, or those with specified health conditions. However, it is specifically not limited to those who come to visit the doctor or clinic seeking care. Rather, team members take responsibility for every member of the community as it is defined.

The COPC team proceeds by identifying the health concern they will take on, then designing an intervention and evaluation plan for it. The same process is followed for each health problem the community wishes to address. Input and feedback from the programs' community beneficiaries are essential and community ownership is integral to any intervention. Through structured governance and institutionalization, the team approach may become part of a democratic civic infrastructure, thereby developing the community's capacity to address myriad health concerns. This has been the approach taken by the San Jose Health Committee.

Identification and prioritization of health problems is done at the community level, using key informants or focus groups. Ideally, primary data are collected to better inform the community about the scope and details of the health issue of concern, though this important step may be sometimes overlooked. While the medical team or other experts may be consulted to review the literature on existing interventions, specific interventions are selected by the community, based on their resources, preferences, and priorities. Evaluation may be simple, but is integral to the project, is ongoing, and provides feedback about successes and shortcomings and any needed changes in direction to address the health issue of concern.

COPC offers a useful framework to achieve broad ownership of interventions that tackle meaningful changes which can improve the health of a community using that community's existing capacity. In describing the central tenet of COPC as being primary care that is rooted in communities, with communities, and for communities, H. Jack Geiger, a student of the Karks and one of the architects of the COPC model, described the model's goals this way:

The need is not for the distribution of services to passive recipients, but for the active involvement of local populations in ways which will change their knowledge, attitudes, and motivation.[28]

6.0 The Global Water Crisis

That water is essential for life is axiomatic. It is a critical priority for everyone and enables all people to be healthy at home and productive at work and school. Yet, people in all corners of the world struggle to obtain the amount and quality of water they need for basic tasks like drinking, cooking, bathing, handwashing, and growing their food. Ten percent of the world's population lacks access to safe water and up to two-thirds of the world's population experiences water scarcity for at least one month of the year.[29] Water insecurity is growing more common, even in countries where water resources are adequate.[30]

The reasons for the global water crisis are multiple. Population growth and rising incomes, particularly in wealthier nations, increase global demand for water. Water-intensive products like meat and fossil fuel-based energy production further accelerate demand.[31] Poor water infrastructure, including transportation, treatment, and plumbing, creates tremendous water waste. In the US, leaky pipes alone waste nearly six billion gallons of treated water each day.[32] As water infrastructure is notoriously expensive to maintain, less affluent nations may defer repairs until systems are at their breaking point.

Healthy ecosystems, which filter pollutants and provide a buffer against storms and floods, help replenish groundwater supplies and constitute the natural infrastructure. However, deforestation, urbanization, over-grazing, and over-farming on marginal lands each threaten the natural infrastructure making it less likely that each raindrop will recharge a groundwater supply.

Contamination and pollution also contribute to water waste and pose additional challenges. Due to the expense of treating contaminated water, the majority of wastewater in the Caribbean region is discharged into the environment without attempts to treat or reuse it.[33] Armed conflict

despoils water, land, and air when explosive residues from military operations contaminate the natural environment.[34]

Some argue that mismanagement occurs on a global scale as we undervalue water by charging prices that are too low. When the price of water does not reflect the true costs of supply, including production, transportation, infrastructure, treatment, and disposal, this leads to inefficiencies and misallocation of water. More accurate pricing could provide incentives for governments to invest in water infrastructure and for individuals to conserve when supplies are scarce.[35] However, full cost recovery would make it more difficult to guarantee equitable access to water for all, given the UN-recognized human right to water.

While many factors contribute to the planet's water crisis, one of the most significant is global climate disruption which is jeopardizing the availability of clean water where it is most needed, while simultaneously producing rising sea levels and destructive storms and flooding.[36] The growing frequency of extreme weather events like severe and prolonged draughts, wildfires, floods, and hurricanes stresses ecosystems and threatens all plant and animal species, including the human species. These trends are projected to worsen in the coming decades as we are only beginning to recognize the need to ameliorate the human contributions to our warming planet which drive water scarcity.

While the global water crisis is felt by everyone, women and children are disproportionately affected, as they are most often the family members tasked with water collection.[29] More distant water supplies require spending increasing time on retrieval, leaving less time for education or productive work. Carrying water over long distances also imposes significant physical burdens on those who do it. Access to safe water therefore especially

empowers women, children, and families. Water access has profound implications for health, education, gender equality, migration, and economics.

In 2010, the UN General Assembly explicitly recognized the human right to water and the associated right to sanitation. Sustainable Development Goal target 6.1 calls for universal and equitable access to safe and affordable drinking water. The target is tracked with the indicator of "safely managed drinking water services" – that is, drinking water from an improved water source that is located on premises, available when needed, and free from fecal and chemical contamination. As of 2022, there were still 2.2 billion people who lacked access to safely managed water services.[37]

7.0 Water in Honduras

The water cycle is a familiar description of how water evaporates from the earth's surface and rises into the atmosphere, where it cools and condenses into rain or snow and precipitates back to the surface, collecting in rivers and lakes, soil, and porous rock where much of it flows back into the oceans to repeat the cycle. Topography determines watersheds, or divisions between drainage areas. Water available for human use typically exists as surface water above ground, found in lakes, streams, and swamps, or groundwater, below ground level, including springs, artesian wells, and aquifers.

Honduras is divided into two large drainage basins. The Atlantic-sloping side of the country includes 13 major watersheds and the nation's largest rivers. It accounts for 87% of total surface water runoff. The remaining 13% drains toward the Pacific and consists of five watersheds, including those that supply Tegucigalpa, the capital city.[38]

Reduced availability of water is a global phenomenon, but the impact is especially profound in geographies nearest to the equator, like Honduras. In what is known as the Hadley Cell Expansion, the climate crisis is driving clouds and rainfall away from the mid-latitudes near the equator and toward the North and South poles.[39] This has already had implications for agricultural production, upon which Honduras relies, as well as industrial and energy output and municipal water access. This worsening water stress threatens crops, undermines food security, drives out-migration, and creates political tensions which destabilize governments. One noteworthy demographic trend in the El Negrito region of Honduras, and elsewhere in the nation, is that working-aged men in the agricultural economy have been leaving home for the US and other northward destinations, in part because of rising agricultural costs of production, including

those related to water, in the face of stagnant prices for global commodities like coffee and bananas.[40]

In 2005, when the San Jose Health Committee became concerned about inadequate water supplies in their community, they raised the issue with their partners in the Shoulder to Shoulder-Pittsburgh organization. After exploring possible solutions, the group determined that achieving control over the watershed in the mountains above the village would help to secure reliable water access for the town and for its medical clinic. However, at that time, the 22-acre plot was divided into three parcels, each owned separately, and had been deforested and was being used for animal grazing. STS-Pittsburgh again sought charitable donations to fund this project and proceeded to purchase the land in three separate transactions between 2006-2008.[41] Now, the wedge-shaped valley is lush with trees and shrubs and fenced in to keep out grazing animals and prevent fecal contamination. It contains a collection tank at its nadir, collecting groundwater from an artesian spring beneath ground level. From there, water is piped into the town through a system of plastic pipes and valves.

Because of increased water demand in the village and declining yields from the watershed since that time, STS-Pittsburgh is currently planning a construction project to collect rainwater from the rooftop of the medical complex, filter it, and direct it into a 50,000-liter cistern. From there, it will be pumped upward into a raised storage tank to provide adequate gravity-fed water pressure so that it can then be used for clinic operations like handwashing.[41] The lead builder identified for this project lives in San Jose and the plan is to use local laborers for construction.[42]

8.0 Water for People

The district of El Negrito has enlisted the help of Water For People, an international nonprofit, nongovernmental organization headquartered in Colorado, USA, that is motivated by the belief that access to water is a human right. Their motto is Everyone, Forever, reflecting the goal of providing everyone in the regions in which they operate access to safe water over the long term. The NGO operates in nine countries across the world, and it strives to bring sustainable water, sanitation, and hygiene services to everyone in the communities it serves.[43]

Water For People enters into consulting partnership with local communities, business, and governments to develop water and sanitation systems, then seeks to provide the training and resources needed to ensure that the systems are maintained over generations. Their typical interaction with a district on a water project lasts for 3-5 years, ending only when the local community has the appropriate water infrastructure to provide water to all its residents and can maintain it.

In El Negrito, Water For People has been active in 24 villages, including all those in the San Jose service area. The NGO helps to secure the water source for each community by tapping groundwater where it collects in high mountain springs. This involves locating and drilling wells and pumping the water to the surface for collection into tanks, filtering the supply to eliminate toxins and pathogenic organisms, and then piping it downhill into communities where it is split into each residence, school, or business. Because of the sporadic nature of the water supply, which depends on rainfall, the water tap for end users often empties into a pila, a concrete collection and storage basin that can hold perhaps 200 liters. This volume might be sufficient for 2-3 days use for a family and provides stored water for times when the public system is not flowing.

Water For People strives to promote comprehensive resource management skills in regions where it operates. In addition to developing water collection and sanitation systems at the village level other typical projects include conducting workshops for local water authorities on utility management and community education on safe water handling and sanitation. The NGO also provides community education through schools and community gatherings, offering monthly talks on subjects including hygiene, tooth brushing, separating animals from the water source, and latrine building.[44]

9.0 The San Jose Water Project: Is Our Water Safe?

In the weeks leading up to the STS-Pittsburgh spring 2023 brigade trip which I attended, members of the Health Committee in San Jose expressed concern to leaders of the upcoming brigade over what they thought was an elevated incidence of diarrheal illness coming from some villages in their service area. In preparation for the brigade visit, they asked our team to bring water-testing materials to investigate if this might be coming from the water in those villages.[45] We did not know it at the time, but several of the villages in the San Jose service area had recently received newer municipal water systems, through their partnership with Water For People. Without considering other possibilities, the Health Committee suspected that contamination of the water supply was the likely explanation. E. coli and other coliform bacteria are known causes of infectious diarrhea, although evidence directly linking diarrheal illness to measured fecal contaminants in drinking water is still inconclusive.[46]

Before the trip, the team purchased commercially available AquaVial test kits (Figure 2) to test water samples for coliform bacteria.[47] These are inexpensive (US$53.54 for 8-pack) tests that demonstrate a colorimetric change in the presence of even one colony-forming unit per milliliter of E. Coli or other coliform bacteria after 48 hours of incubation with the water specimen.

Figure 2 AquaVial Test Kit

Once on site during the brigade trip, I interviewed members of the Health Committee. It became clear that no numbers of diarrhea cases had been collected to substantiate the concern raised about possible water-borne illness and that this concern was based only on perceptions of some Committee members. Further, they felt that there were certain villages where this was a problem and others where it was not. The clinic oversees care for people from 18 villages spread across the region, some only accessible on foot.

During the brigade trip, I also interviewed the local physician, Dr. Tania Castillo, who sees all the patients who present for care in San Jose. She too felt that she had seen a larger than usual number of cases of diarrheal illness in patients living in three villages: San Antonio, San Francisco, and San Jeronimo. While Honduras does have a system for reporting deaths, no data are collected

to categorize or quantify routine illnesses. With no epidemiologic reporting system in place and no electronic health record to query, the suspicion of higher-than-average rates and geographic concentrations of diarrhea could not be easily confirmed.

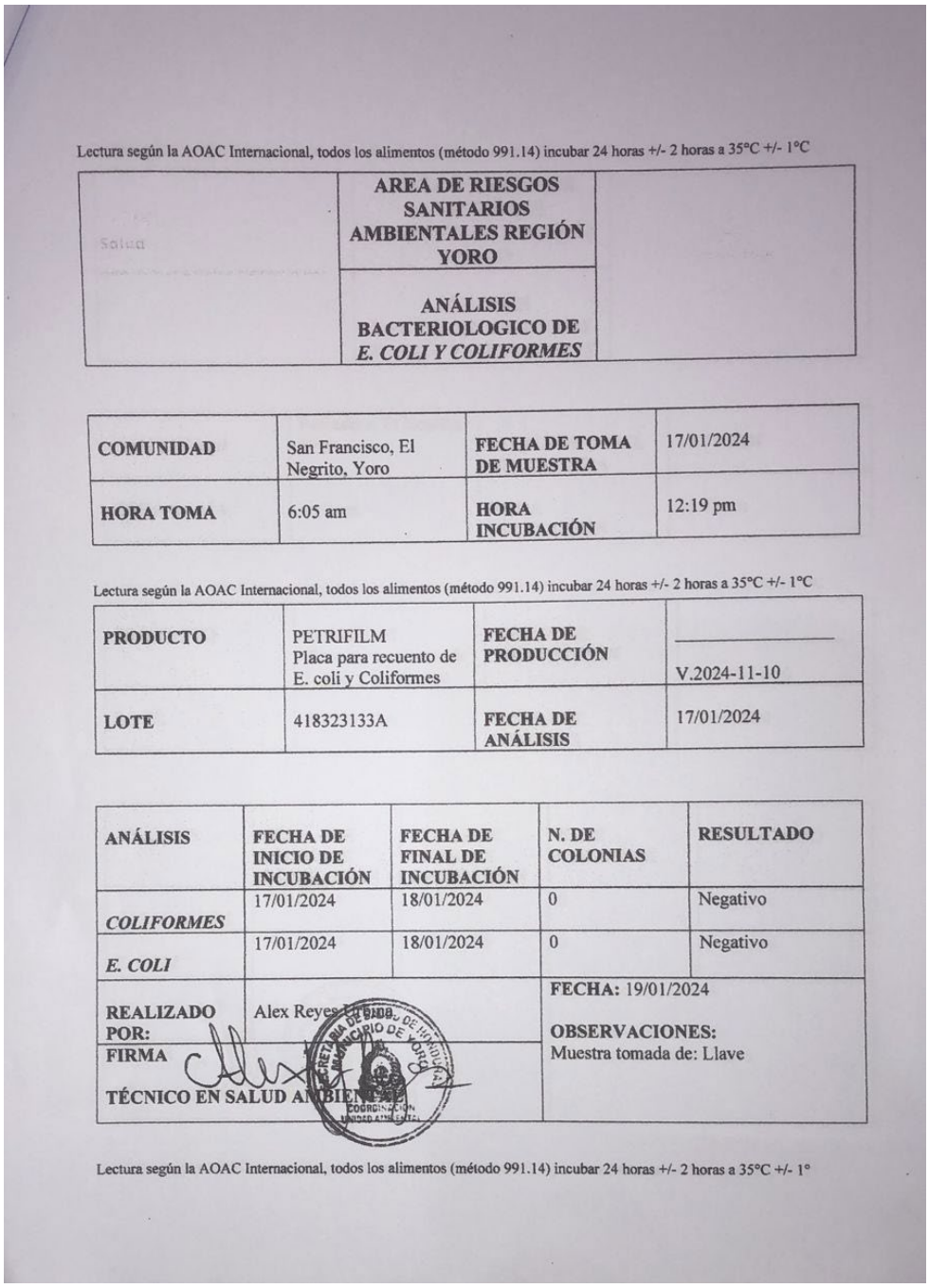
Dr. Castillo does maintain a log of patients seen each day and the clinic keeps paper records for all patients. We considered the possibility of reviewing the charts of all patients that had been seen from the three villages in question over a specified time interval to measure the rate of diarrhea diagnoses coming from those locations. As the clinic cares for 30-40 patients daily, this would be a very labor-intensive task. Another obstacle to this approach is that there is no known baseline rate of diarrheal illness with which to compare the rates in the three villages of San Antonio, San Francisco, and San Jeronimo. Given our few remaining days on site, we determined that we did not have the necessary time and human resources to collect the data necessary to fully explore and understand this problem.

Optimally, we would have routinely collected data measuring rates of diarrhea diagnoses by village for all villages and surveyed patients to identify their water source as well as their use of hygiene measures, such as hand washing, latrine use, latrine quality, food preparation practices, and other behaviors related to infectious diarrhea. However, no data had been collected and doing so did not seem feasible given time and resource constraints.

I next met with Omar Cerrato, a resident of San Jose, an officer with the municipal water authority, and a member of the San Jose Health Committee. He explained the nature of the El Negrito Water Authority's ongoing work with the Water For People NGO which has involved installation of modern, hygienic water delivery systems in nearly all the region's villages, including the communities of San Antonio, San Francisco, and San Jeronimo. In each village, the system collects water from its own watershed that is filtered through gravel and gathered into a main

collection tank in the village, from which it is then piped directly into each home in the village. To date, 22 of the 24 communities in the San Jose del Negrito service area have piped household water available through this system. The final two villages in the San Jose del Negrito service area have water systems under development that are due to be completed by 2025, as are all communities in the Department of Yoro.

Mr. Cerrato described that the municipal water authority tests the supply in each village regularly for 14 analytes, including microbes, and issues a water quality report biannually to the leadership of each village. An example of a water quality report from the village of San Francisco is included below (Figure 3). He told me that every village has a water committee that decides whether to chlorinate their public supply based on regular testing for microbes from a sample of 5-10 homes in the village. While inexpensive and effective as a disinfectant, added chlorine can impart an unfavorable taste and smell to water and can combine with other organic substances in drinking water to create disinfection byproducts which can cause negative health effects with prolonged exposure.[48] He explained that, because these water systems are newer, not everyone had yet grown to trust the integrity of the municipal supplies.



Lectura según la AOAC Internacional, todos los alimentos (método 991.14) incubar 24 horas +/- 2 horas a 35°C +/- 1°C

	AREA DE RIESGOS SANITARIOS AMBIENTALES REGIÓN YORO	
	ANÁLISIS BACTERIOLOGICO DE *E. COLI Y COLIFORMES*	

COMUNIDAD	San Francisco, El Negrito, Yoro	**FECHA DE TOMA DE MUESTRA**	17/01/2024
HORA TOMA	6:05 am	**HORA INCUBACIÓN**	12:19 pm

Lectura según la AOAC Internacional, todos los alimentos (método 991.14) incubar 24 horas +/- 2 horas a 35°C +/- 1°C

PRODUCTO	PETRIFILM Placa para recuento de E. coli y Coliformes	**FECHA DE PRODUCCIÓN**	V.2024-11-10
LOTE	418323133A	**FECHA DE ANÁLISIS**	17/01/2024

ANÁLISIS	**FECHA DE INICIO DE INCUBACIÓN**	**FECHA DE FINAL DE INCUBACIÓN**	**N. DE COLONIAS**	**RESULTADO**
COLIFORMES	17/01/2024	18/01/2024	0	Negativo
E. COLI	17/01/2024	18/01/2024	0	Negativo
REALIZADO POR:	Alex Reyes		**FECHA:** 19/01/2024	
FIRMA **TÉCNICO EN SALUD AMBIENTAL**			**OBSERVACIONES:** Muestra tomada de: Llave	

Lectura según la AOAC Internacional, todos los alimentos (método 991.14) incubar 24 horas +/- 2 horas a 35°C +/- 1°

Figure 3 Water Quality Report, Village of San Francisco

Based on results of the routine testing for pathogens that the water authority performed, Mr. Cerrato was confident that there was no contamination of the municipal water supplies with

pathogenic organisms. But the question remained: was there actually an increased incidence of diarrhea and, if so, what factors might produce such an increase?

In trying to understand what might explain a rise in cases of diarrhea, which had not been proven, Mr. Cerrato speculated that it was possible that some people may have consumed water that did not come from the public system, which could have led to illness. Alternate water sources could include streams or underground springs accessed by digging in the ground, and which could be readily contaminated by human or animal waste or agricultural chemicals. He stated that community members must purchase their own soap and that hand washing is still a novel idea, suggesting other ways people may fall ill with diarrheal disease.

He was quite proud of the municipal systems, showing me numerous photographs of the professionally constructed collection cisterns, valves, and plumbing systems and was eager for me to test water from the three villages where cases of diarrheal illness were suspected to have originated. He brought me samples of water from the public tanks of San Antonio, San Francisco, and San Jeronimo, in collection jars labeled with the name of the village from which the sample had been collected. I performed testing for coliform bacteria using the AquaVial tests and they were negative in each sample. Using those same water samples, I repeated the AquaVial tests and each sample remained negative on repeat testing. Mr. Cerrato believed that presenting these results to people in the villages might help to build their trust in the public water systems.

This water safety project certainly lacked the features of a robust epidemiologic analysis. Without the resources to pursue the claim properly, the suspicion of a rise in diarrhea cases from specific locations offered by the Health Committee and the local physician was never confirmed using data and thus remained unverified. Further, while we could speculate on explanations that could plausibly underly an increased incidence of diarrhea, we were not able to properly

investigate to see if any of these were true problems in the communities in question. Mr. Cerrato, the representative of the Health Committee and the water authority, believed that the municipal water supply was safe. But, was his belief any more accurate than the opinions of those who suspected water contamination? The coliform tests I performed provided only a small measure of reassurance on the safety of the water from the three villages in question. The most trustworthy source of information came from the routine microbial testing done in each village and these tests did not show pathogens present.

With no verifiable information on whether an actual health problem existed nor on the presence of risk factors for that problem, it was not clear how to proceed to address the concerns raised in the remaining days of the health brigade visit. Mr. Cerrato and I discussed how we might work together to develop health messaging to the local population on ways to minimize risk factors which could lead to diarrheal illness. We also believed it was reasonable, based on the water authority's routine testing, to reassure the population that the municipal supply was safer than using unimproved water sources, which are not tested and therefore offer no assurance of safety. As one of his roles with the water authority is community education, Mr. Cerrato committed to developing educational posters and we agreed to display them in the patient waiting area of the Shoulder to Shoulder Medical Clinic in San Jose.

Within days, he created a large display (Figure 4) that included patient educational materials from the World Health Organization, UNICEF, Water For People, and the El Negrito Water Authority. Using graphics and minimal written language, the materials depicted how water is collected from mountain springs, filtered, and piped into homes, how to construct and use high quality latrines, how and when to perform proper hand hygiene, and some recent water quality reports produced by the municipal water authority demonstrating the absence of pathogens in the

supply. These educational materials were promptly displayed at the medical clinic during the spring health brigade visit.

Figure 4 Patient Education Display

The patient education display was still present when I returned to the area six months later in October 2023 on the subsequent brigade visit. My team from STS-Pittsburgh met with the San Jose Health Committee again to assess current health concerns. No longer were they worried about unexpected rates of diarrheal disease. Rather, their concerns had moved on to other perceived health needs in San Jose and surrounding communities, such as providing nutritional support for weaning babies, developing low-cost interventions for people with musculoskeletal complaints, providing community education on proper trash management to combat litter, addressing growing behavioral health needs, and other priorities.

10.0 Moving Forward: Integrating Data into Healthcare Decisions

The reality of evolving health concerns and shifting priorities from the Health Committee raises important questions about deciding which health issues merit attention and how they are identified in the COPC model of care. The San Jose Health Committee is comprised of laypeople. While their input and ideas are essential in the COPC paradigm, members are not trained in community medicine skills and should not be expected to substantiate their concerns with data before bringing them to the attention of their medical partners. Rather, it falls on the local physician and the medical team from STS-Pittsburgh to seek ways to corroborate Health Committee concerns with evidence before pursuing interventions. This concept is central to the COPC care model as originally described.[27] However, given the absence of any routine disease surveillance system in rural Honduras and the desire to address any reasonable concerns raised by the Health Committee in order to remain an active and responsive partner, the medical team from STS-Pittsburgh may not always include this important step of confirmation. Yet, confirmation that a problem exists before taking steps to ameliorate it is a cornerstone of public health practice.

One of the key features distinguishing COPC from routine primary health care is its effort to coordinate and integrate care of identified populations within a community, beyond just caring for individuals. In the COPC model, health care workers go out into the community to investigate the relevant health status, attitudes, and practices, rather than waiting in the office or hospital for patients to present seeking care. As such, the defined population becomes the denominator for assessing any health needs and for the evaluation of any services provided. This population is therefore the ideal target for surveillance. This practice requires integration of epidemiologic skills that are complimentary to clinical skills.

Sidney Kark, the father of COPC, outlined the centrality of clinical epidemiology to a robust COPC practice. He described using techniques of clinical epidemiology to establish patterns that help determine a community diagnosis much like a physician would use the clinical interview and examination to make a clinical diagnosis in an individual patient. Whereas epidemiology is traditionally defined as the distribution and determinants of disease in a population, Kark applied a more expansive definition of epidemiology within the COPC paradigm that is concerned with promotion of health through behavior changes, prevention of harmful exposures, and disease prevention and treatment, as well as care of the disabled.[49] In alignment with that concept, the definition of the term "epidemiology" has itself evolved and broadened over time to include greater emphasis on concepts of "control" and " health".[50]

The concept of recording and monitoring health data is not new in the San Jose community, but it may be underutilized. Since 2005, STS-Pittsburgh has conducted group well-child visits in San Jose and the surrounding villages during biennial brigade trips. Depending on the size of the community, provision of ample notice to families, and other factors, as many as 200 children may be assessed at a well child visit. At these events, typically held at the village school, the medical team organizes stations to manage the large number of children efficiently. The stations include: measuring height and weight, assessing vision, application of dental varnish and teaching dental hygiene, administering anti-parasitic medication, and medical evaluation. At the anthropometric station, z-scores are calculated for each child, assessing the relationship of that child's height and weight to age-identified mean measurements.

Starting in 2019, the team began using a dedicated computer system called a portable field unit, brought to each group well-child visit, to record anthropometric values for each child over time.[51] This not only allowed the team to identify individual children who were growth delayed,

but also enabled the team to evaluate height and weight trends in the population of children from each village in the service area. This allowed identification of patterns of malnutrition and growth disruption by village and has led to targeted efforts by the STS-Pittsburgh team to offer nutrition supplements in villages experiencing greater than usual burdens of those outcomes. Unfortunately, that computer system has been plagued by problems with power reliability during remote village visits. Efforts to collect the data on paper and enter them later once the computer is connected to power have been uneven due to duplication of data recording. Newer lithium-iron phosphate battery technology offers better performance in batteries that are smaller and lighter than older lead-acid batteries and could help address power reliability. Wider application of such basic data collection would certainly allow identification of other patterns of health and disease occurring in the region.

The challenge in San Jose and other under-resourced settings is to develop a strategy for local care providers to monitor the incidence of illnesses and disease indicators that can more objectively identify when a worrisome pattern is emerging without adding excessive data collection work. Apart from brigade visits, the San Jose Medical Clinic is staffed by one physician and one nurse, who are already quite busy with patient care responsibilities and who have little time for additional surveillance data collection. This means that any surveillance system must be simple and not overly burdensome for the staff to utilize.

One such technique is keeping a chart or table of acute illnesses identified in the medical clinic, recording any variable that could be related, such as location, age, occupation, etc. This could provide a simple and useful means of infectious disease surveillance, helping the health care team move from suspicion of a problem to recognition and verification of a problem relying on a minimal collection of data. Such application of basic epidemiologic principals would help

establish when the community's concern reflects a true pattern of disease requiring further action by the health care team.

The local physician and nurse team do keep a list of patients who are too ill or too frail to travel to the clinic and the local physician makes home visits to them, as does the brigade team during twice yearly trips. This is a start. However, this practice of maintaining a registry to identify a population is not carried out routinely at the Shoulder to Shoulder Medical Clinic in San Jose, where record keeping is focused on the individual patient.

A step forward in caring for the community would be to create a registry of selected acute and chronic illnesses and indicators by village. These are measurable factors that would allow health workers to estimate the magnitude of a health problem or the effects of an intervention more objectively.[52] For example, number of cases of rash illness or diarrheal illness, percentage of adolescents who smoke, number of teen pregnancies, or cases of sexually transmitted infection. Determining exactly which indicators should be monitored is probably best undertaken collaboratively by the Health Committee, the local physician, and the visiting health workers. Such syndromic disease surveillance would be inexpensive and would enable more informed decision making and appropriate public health intervention. Shoulder to Shoulder-Pittsburgh's partnership with the San Jose Health Committee has led to many successful projects over the years. Developing a disease surveillance system could be a productive next step in promoting health and preventing disease in the communities in the San Jose service area.

Once basic surveillance is undertaken and the relative burden of various health concerns is better understood, the next challenge is in determining which issues warrant the attention of the community and its health care partners. The US Centers for Disease Control and Prevention describes a participatory planning and consensus building model for prioritizing health problems

that merit a community's attention. Criteria include scope and seriousness of the health problem, social and economic impact on the community, and availability of resources and interventions. In this model, stakeholders apply a simple scoring system to each of these parameters to assign an overall weight to the various problems competing for resources. Comparing weights across different health threats, for example diabetes, cancer, malnutrition, and infections, can help a community determine where best to focus its efforts.[53]

Another strategy to enable initiating disease surveillance is incorporation of an electronic medical record. The growth of global health informatics over recent decades has led to the dissemination of electronic health records throughout the world, with the promise of reducing medical errors and improving quality of care. However, low resource settings have been a persistent service gap in electronic health technology. Despite experiencing the greatest burden of infectious diseases, developing countries frequently lack the financial, structural, technical, and human resources to develop robust, high-tech, electronic systems to manage the health sector. Computer hardware and software, reliable electricity, and adequately trained personnel are among the resources that may be lacking in low-resourced environments.[54]

In 2004, medical informatics researchers conceptualized and began to develop an electronic health record to manage the HIV/AIDS epidemic in western Kenya. That system has since grown into OpenMRS, a free, open-source, and extensively customizable patient record system that requires limited programming and is supported by a large, global network of developers, implementers, and users.[55] It is now used in over 8,100 sites in more than 80 countries.[56] There is an extensive literature on efforts to implement and utilize OpenMRS in various settings, including primary care.

The leadership team at STS-Pittsburgh has been in discussions with a small team of medical informatics-trained family physicians at the University of Pittsburgh Department of Family Medicine about implementing an OpenMRS system in the San Jose Medical Clinic.[57] While this would be a significant undertaking, it would enable the possibility of more routine data collection to support a disease surveillance system. OpenMRS requires only a computer with the software installed and this could be a battery-powered laptop computer. If a server were located at the medical clinic in San Jose, users there could access the system without requiring an active internet connection. With a server located remotely, any computer with an internet connection could connect to the system. Additional mobile electronic devices, including smartphones, could be used for data entry in sites more distant from the medical clinic, if they are able to connect through the internet. Internet connectivity in Honduras remains a challenge but is expanding. While just 56% of Hondurans had internet access in 2022, this was up from 25% in 2017.[58, 59] However, the digital divide between urban and rural populations is great, with an estimated 14% of the rural population with internet access.[58]

The University of Pittsburgh biomedical informatics team is currently working to perform the initial setup of the OpenMRS software. Priorities for early application of this system include recording of growth data obtained during well-child visits, tracking pregnant patients who are receiving prenatal care, and monitoring growth parameters of patients who are receiving eggs through a supplemental feeding program targeting malnutrition.[60]

If these initial applications of the system prove to be favorable, utilization of OpenMRS could be expanded to serve as the electronic health record for patient visits to the Shoulder to Shoulder Medical Clinic, supplanting the paper record system currently in use. This would allow the local physician and the supporting health care team to query the electronic system to obtain

objective data on any information that had been entered, including physical measurements, laboratory values, diagnoses, medications dispensed, and more. This could even be done remotely, enabling the Pittsburgh physicians to examine data in between brigade visits. In a future where health records are maintained electronically, many perceived health concerns could be confirmed or refuted with a data inquiry much more readily than is currently possible. This would enable the San Jose Health Committee and their partnering health workers to gather basic data on incidence and prevalence of disease before developing interventions. It would allow the health care team to focus its efforts where they are truly needed and able to have an impact.

11.0 Conclusion

This essay has presented how people living in a remote mountain region in one of the world's poorest countries have worked with an international NGO to secure a safe and reliable water supply during a time when many communities around the world are struggling with adequate water access. It also discusses how Shoulder to Shoulder-Pittsburgh has worked with the San Jose Health Committee under the framework known as Community Oriented Primary Care to promote health in the region.

In that context, I have described how a suspicion of a rise in diarrheal illness in three villages that was not based on objective criteria led to an exploration of potential causal factors. A review of existing reports on the quality of the water supply in those villages and specific testing for pathogens in the water supported the conclusion that the water supply was not likely to be a causative factor. In response, a modest but ongoing effort was undertaken to provide community education posters to address possible causes of diarrhea.

Missing from this approach was an effort to quantify cases of diarrhea to know if there was truly a rise in cases from the villages in question. Incorporating surveillance of key indicators of illness as a basic epidemiologic strategy could assist the health team in knowing when an outbreak is occurring and when public health interventions are required.

The fact that the Health Committee had turned its attention to other concerns when I returned to San Jose on a subsequent health brigade visit highlights the reality of trying to manage the long list of competing health issues demanding consideration in their community. While it reflected the ability of the COPC model to address a variety of health problems, it also demonstrated that it is quite challenging to know when a concern merits the attention of the health

care team in the absence of basic epidemiologic data and calls for establishing a system of surveillance of key indicators of disease to inform public health efforts.

In the final section of this paper, I have proposed a framework for how to begin to build a surveillance system for important diseases and indicators which would allow the San Jose Medical Clinic to utilize epidemiologic evidence to recognize when a suspicion of an emerging health concern represents a true problem that warrants the attention of the health care team and which should precede any disease control strategy. The possibility of undertaking this through an electronic medical record system opens the possibility of doing such surveillance within the scope of work already being done by the limited clinical staff so as not to add the burden of unnecessary data collection tasks to their efforts. This more routine utilization of data to inform health decisions is a promising next step in making the partnership between the San Jose Health Committee and STS-Pittsburgh more effective in advancing the health of the community.

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