The Center for Human Development in Guatemala
An Innovative Model for Global Population Health

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Keywords
• Population health • Maternal health • Child health • Global health
• Neonatal mortality • Education

Key points
• A private sector/university partnership model can successfully promote population health and sustainable development in impoverished regions of the world.
• This model can leverage the strengths of both the university and private sector.

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INTRODUCTION

Population health focuses on the health of a defined population as measured by the health outcomes of groups of individuals and an analysis of how and why these outcomes differ within the population. This approach seeks to understand how these differences are affected by social, economic, cultural, geographic, and genetic factors as well as access to health services. In order to optimize population health, traditional health care delivery systems should integrate and coordinate with other systems, such as public health, schools, transportation, water and sanitation, and social services. The population health approach, first implemented in Canada, is now being adapted in many countries, including the United States [1]. Measurement is a critical component of population health. Health care systems need accurate population denominators (population registries) and numerators (patient registries), as well as process and outcome measures that will document progress in improving population health. The project described in this article provides a model for operationalizing a population health approach using a university–private sector–community partnership and the opportunity to evaluate the effectiveness of this integrative approach to achieve significant reductions in morbidity and mortality and promote the sustainable development goals in this extremely poor Guatemalan population. This article describes the population in the region, the structure and governance model of the partnership, and the project’s activities that seek to empower the community, transform health, and create opportunity.

THE POPULATION

Guatemala is Central America’s most populous country, with 15.4 million people, of whom approximately 40% are of indigenous descent. It is a low-middle income country (LMIC) with a gross domestic product per capita of $3,478 and a human development index of 0.58 in 2012 (an improvement of only 0.1 in the past 2 decades). Guatemala has a national poverty rate exceeding 50% and an extreme poverty rate of 15% [2]. Although 46% of the total population lives in rural areas, 72% of the extremely poor live in those rural areas [2]. Nationally, the child mortality (at 30 per 1000 live births) is the highest in Central America and the third highest in the region. Maternal mortality is also one of the highest in the region. In 2010 the World Health Organization (WHO) estimated a maternal mortality ratio of approximately 120 per 100,000 live births and the more recent World Bank estimates from 2011 to 2015 are around 100 per 100,000 [3,4]. The contraceptive prevalence (at 54%) is one of the lowest in

Continued

- This model can successfully integrate service delivery, community development, research, and education.
- This model can provide a community laboratory to evaluate innovative interventions that promote population health.

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Latin America [5]. Maternal mortality, child mortality, and malnutrition are higher among rural populations such as those living in the southwest (SW) Trifinio region.

Life is especially difficult in the coastal lowlands of southwestern Guatemala near the border with Chiapas, Mexico. This region is named the SW Trifinio (triangle) for the confluence of the 3 departments (states) of San Marcos, Quetzaltenango, and Retalhuleu (Fig. 1). A few decades ago these cattle and pasturelands were transformed into large agribusiness enterprises to cultivate crops for export (primarily bananas and palm oil), attracting approximately 25,000 people who now live in this area. Given their recent migration and diversity, these aldeas (small communities) lack the community cohesion, shared tradition, and culture of older communities. The region is susceptible to flooding because of its low elevation and close proximity to the Pacayá River, which cannot contain the runoff from Guatemala’s high mountains to the northeast. Because most families use pit latrines for waste disposal and shallow wells as their source of water, flooding contaminates the water supply, spreading gastrointestinal disease and promoting mosquito-borne infections. Governmental services are limited, perhaps because of poor coordination among local governments. In 2011, no access to physician care was available in the community and a trip to the nearest city, Coatepeque, to see a doctor took 1 hour and cost more than a month’s wages.

THE AGRO-AMERICA–UNIVERSITY PARTNERSHIP

One of the largest employers in the SW Trifinio is Agro-America, a private, family-owned Guatemala agribusiness that operates banana and palm oil plantations in the region. Agro-America has been committed to social investing to improve the human development index of the families and communities in the area. The company has strong social values and pays its workers a living wage above the standard within their industry. In 2011, Agro-America approached the Center for Global Health (CGH) at the Colorado School of Public Health to replace its existing social responsibility program called Mis Mejores Familias, a community educational program developed by the sugar industry. The CGH has a strong track record in global health and is one of 2 WHO Collaborating Maternal and Child Health Centers (not Promoting Family and Child Health) in the Americas. In July of 2011, the CGH, Children’s Hospital Colorado (a hospital affiliated with the university), and Agro-America through its foundation Jose Fernando Bolan˜os Menendez signed a memorandum of understanding to “promote the development of scientific and technical activities, research and projects in the field of public health sciences, that promote the comprehensive improvement of health and human development and mitigate the impact of disasters in the area of influence in Guatemala.” The next phase created the governance and legal infrastructure for the project, titled the Center for Human Development (CHD). Agro-America created a new private not-for-profit Guatemalan foundation to run the CHD, called Fundación para la Salud Integral de Guatemaltecos-CU (FSIG; Foundation for Guatemalan Integrated
Fig. 1. SW Trífinio at the borders of the departments of San Marcos, Quetzaltenango, and Retalhuleu in Guatemala.
Health–CU). The foundation has 7 members; 4 appointed by Agro-America and 3 appointed by the CGH. The establishment of the foundation for the CHD was critical because the legal department of the university identified obstacles that did not allow the CGH to have university professional staff (faculty) live and work long term in Guatemala. The foundation is responsible for ensuring that all project operations and program activities are in compliance with Guatemalan local laws. It obtains all needed approvals and licenses pertaining to the operation of the clinic, birthing center, laboratory, and pharmacy. It is responsible for the hiring and management of all employees, including managing payroll, benefits, and taxes and maintaining all financial records. The foundation has an executive director, medical director, and chief financial officer. The foundation is also responsible for the approval of and the financial support for hosting volunteer faculty and health care providers who travel to the Guatemala site to work.

Having Agro-America as a partner has many advantages. In addition to its impact on economic opportunity, the project takes advantage of Agro-America’s existing infrastructure for human resources, purchasing, information technology, communications, and maintenance. The partnership also benefits from its prior social impact programs and community organizing efforts. Because Agro-America is the major funder, the partnership is able to integrate multiple funding streams and avoid the limitations of funding silos. The CGH, as a hub for the University of Colorado global activities, contributes to the partnership by leveraging expertise from the Schools of Medicine, Nursing, Public Health, Business, Dentistry, Pharmacy, Architecture, and Arts and Sciences. The CGH can create multidisciplinary teams to design and implement the population health strategies. The university also provides clinical support for the project through elective rotations of residents and fellows with faculty oversight.

Public-private partnerships work properly when the following occur: (1) trust and sharing of information between parties, (2) understanding and exploitation of the competencies of each party, and (3) improvement driven by service standards and not by downdriven cost [6–10]. Although the core of the partnership includes a shared commitment to population health and sustainable development, trust is built when each partner recognizes the values and goals of the other. The university must respect and support Agro-America’s desire for their efforts and funding to be recognized by the community. The company’s goal is to have healthier, more productive employees who will enable the company to become more profitable. The company also benefits in its marketing to existing and potential customers, because buyers are becoming more sophisticated about the ethics of their suppliers and how they address issues of social justice, fairness, and climate change. In contrast, Agro-America must respect and support the university missions in education and research as well as service. Research and educational activities can increase professional resource capacity at the site and provide the expertise needed to develop effective interventions. Funded research grants can also help make the overall project more self-sustaining through indirect cost allocations and recruitment of staff.
Establishing a partnership between a US university and host country corporation is uncommon because universities traditionally partner with host country universities, governmental agencies, or nongovernmental organizations (NGOs) and obtain funding from foundations, United States Agency for International Development (USAID), Centers for Disease Control and Prevention (CDC), National Institutes of Health (NIH), or American multinational corporations. The most obvious reason our model is rare is the difficulty in identifying host country private-sector companies willing to commit to long-term social impact investing in their country’s extremely poor communities with a US university partner. If we can document success, the project may stimulate other similar partnerships.

THE STRATEGIC APPROACH TO POPULATION HEALTH
The overall strategic approach for our project is shown in Fig. 2, which displays our vision, mission, community health assessment, and the main domains of the project with their goals, strategies, and outcomes. The domains were identified by a community health assessment and include clinic medical and oral health services with a birthing center, community nursing services, employee health, the environment, economic opportunity, and education. Overarching functions include research, community engagement, and strategic planning/sustainability. This article presents the findings of the community health assessment and the resulting domain and overarching functions’ strategies, early outcomes, and challenges.

COMMUNITY HEALTH ASSESSMENT
A community health assessment (CHA) to evaluate the health status and risk determinants of people in the community is the necessary first step in developing a population approach. In September and October 2011, the CGH facilitated home interviews of 287 families using the Mis Mejores Familias homes as index households to conduct the random community sample for those having a child less than 5 years old. This CHA used a cluster sampling technique consistent with the lot quality assurance sampling methodology from the WHO for immunization program evaluation.

The CHA documented that the SW Trifinio aldeas has high levels of food insecurity, maternal depression, maternal morbidity and mortality, neonatal mortality, and child morbidity. Most mothers and children of the aldeas surveyed depended on traditional birth attendants (TBAs) and 1 form of medicine, because there are both financial and access barriers to securing timely formal health care services. Food insecurity was prevalent: of the 287 mothers interviewed, 133 (46.5%) answered that, “Sometimes we have no food to eat” and 30 (10.5%) responded that, “Most of the time we have no food to eat.” Seventy percent (n = 201) of participants agreed with the statement, “In the past three months the food we had was not sufficient and we had no money to buy more food.” The same proportion (71.5%) reported skipping meals because of insufficient money to buy food, and 148 (51.6%) reported that at
Center for Human Development in the Trifinio region of Guatemala: an innovative model for global population health

**Vision:**
Empowering communities, transforming health, creating opportunity and growing together

**Mission:**
Through the partnership of AgroAmerica, CU, and the Trifinio communities, we will develop trust, create opportunities and achieve the sustainable development goals in the Southwest Trifinio

**Domain:** Population Health

**Domain:** Clinic Services
- Reduce child and adult mortality and morbidity from CD and NCD
- Reduce maternal and neonatal mortality and morbidity
- Improve infant/childhood growth and development outcomes

**Domain:** Community Services
- Improve worker health and reduce work injuries
- Improve access to clean water and sanitation
- Improve availability of safe and healthy homes

**Domain:** Employee Health
- Improve income generation opportunities

**Domain:** Environment
- Expand income generation opportunities
- Increase CU and Trifinio educational opportunities

**Domain:** Economic Opportunity
- Have a strategy plan to sustain communities
- Carry out successful translational research
- Community engagement, leadership & organization

**Overarching Functions:**
- Strategic Planning
- Research
- Community

**Domain:** Education

**Domain:** Community Services
- Reduce childhood morbidity and mortality
- Improve infant/childhood growth and development outcomes

**Domain:** Economic Opportunity
- Increase CU and Trifinio educational opportunities

**Domain:** Community Services
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- Improve access to clean water and sanitation
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**Process Outcomes:**
- Process: Wellness and Prevention
  - Inpatient and outpatient services
  - Chronic Disease Management
  - Emergency Services

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Fig. 2. Strategy map. PA, physician assistant; WASH, water, sanitation, and hygiene.
least 1 member of the family lost weight because of the inability to purchase food. There was a direct relationship between the mother’s mental state (level of depression) and food insecurity. Among the 195 mothers with food insecurity, 64 (32.8%) showed signs of significant depression, whereas among the remaining 90 mothers with more food security only 15 (16.6%) showed any depression signs ($P = .003$). Environmental issues related to access to clean water and having appropriate sanitation were serious concerns. Most of the homes (59.6%) used a shallow well as their primary water source and only 25.4% ($n = 73$) reported access to portable water (aqueducts); 5% used rain or collection tanks and 8% bottled water as their source of drinking water. Covered latrines were the most common means of human waste disposal in 79% of the homes, and 9.8% reported the use of a flushable toilet. Approximately 10% used open latrines or open land or other methods for human waste. Trash was burned on nearby land ($n = 190; 66.2\%$) or buried ($n = 43; 15\%$), and 40 homes (13.9%) reported disposing of waste in the backyard. Only 4.2% used the community waste disposal. Wood stoves were the most common method for cooking (94.1%) (Fig. 3), whereas 5% reported cooking on gas stoves and less than 1% had improved clean-burning stoves. As expected, mothers were poorly educated. Sixty-one of the participants (21.3%) reported not having any formal education and only 52% completed second grade. Despite this, 101 women (35.2%) reported that they could not read and write, noting that the completion of the first or second grade level does not imply freedom from illiteracy. Only 7.5% of mothers had studied beyond the sixth grade.

As part of the survey a modified version of the Edinburgh Post-partum Depression Scale was used, to learn about maternal mental health. The scale used 5 of the 10 original questions to detect maternal depression in the preceding 7 days. Maternal depression was frequently reported. Of the 287 mothers interviewed, 4.2% reported that “they did not see anything good
in life and could not smile”; 11.6% reported feeling guilty because their situation was not good, and 9.1% felt very frightened or anxious without reason. In addition, 8.1% were sleepless because of their unhappiness, and 2.5% thought about hurting themselves or preferred to be dead because of their current situation.

Reproductive health problems were clearly identified: 56 (19.5%) of the participants reported 6 or more children, and only 44.9% reported 2 or fewer children. Slightly more than half of the women reported their first pregnancy before the age of 18 years, and 7.8% before the age of 15 years. Sixty-nine percent of the participants reported using TBAs as the primary caregiver for prenatal care and only 9% visited a nurse in the community health center; 12.2% received care from a physician and 6.3% went to a public or private hospital. Consistently, when asked who managed their last delivery, 44.8% reported the use of TBAs, 30% a physician, and 20% received care at the hospitals. Twenty-one percent of the women reported at least 1 abortion or miscarriage, and 30% reported significant complications close to childbirth. Almost 6% of the mothers reported having a stillbirth, which was associated with the lack of adequate prenatal or perinatal care. Having a child die was a frequent occurrence. Forty participants (13.9%) reported having a child die during the first 5 years of life, with more than half of the deaths (55.6%) occurring in the first 2 months of life and 87.3% within the first year of life. Ninety percent of the participating mothers nursed their children for more than 6 months, and 61.7% for more than 12 months. No data were collected about the supplementary feeding practices during the first year of life.

Information on common childhood illness showed that 120 (41.8%) mothers reported diarrhea in the past 2 weeks for at least 1 child less than 5 years of age, and that only 25.7% of children with diarrhea received oral rehydration salts. One in 6 children received antibiotics, 15.6% home remedies, and 12.3% anti-parasitic medications. Similarly, 168 (58.8%) of the mothers reported that at least 1 of their children less than 5 years of age had a cough in the previous 2 weeks, and 65.2% reported having a cold (upper respiratory infection). Two of every 5 mothers reported at least 1 of their children less than 5 years of age having a fever in the 2 weeks before the survey. The treatment practices included oral rehydration (1.5%), antibiotics (73.8%), and acetaminophen or aspirin (7.5%). If children were ill, 27% visited the community health clinic, 24.9% a nurse, 20.4% a hospital, 13% a family doctor, and only 4.2% sought help directly from the pharmacy clerk. When medications were needed they were obtained at the local pharmacy (43.2%), community health clinic (45.3%), and for a minority in the hospital or physicians. When asked whether the family had sufficient financial resources to purchase the necessary medicines, 252 (88.7%) replied in the negative. When the CHA data were analyzed, plans were made for a community engagement process to share the results and present ideas for possible interventions.
COMMUNITY ENGAGEMENT: A RAPID ANTHROPOLOGIC ASSESSMENT PROCEDURE

After the results of the rapid CHA, it was evident that the next step was to develop an understanding of how the community was organized, its level of function, and how best to develop a partnership with the community to set priorities and build mutual trust. In 2012, the Department of Anthropology at the University of Colorado Denver assembled a team-based qualitative inquiry using triangulation, iterative data collection, and analysis to rapidly understand the situation from the community perspective. The team sought to answer 2 fundamental questions. First, in the absence of functioning state and local government, how do people in these communities organize themselves to meet their basic needs? Second, what is the social and cultural context of health in these communities? During a 2-week period the team conducted 27 formal structured interviews with community leaders and 4 informal interviews with auxiliary nurses. The formal interviews with community leaders included government officials (eg, vice mayors), water managers, disaster preparedness and response officials, Catholic Church workers and evangelical ministers, and participants in the Mis Mejores Familias program [3]. The rapid anthropologic assessment procedure (RAP) produced a visual map of the community leadership and organizational structure and described the areas of dysfunction that made certain groups more vulnerable to social, economic, health, and environmental disturbances. Based on both the CHA and the RAP, 3 major priorities emerged from the communities: (1) access to clean, safe, and sustainable water; (2) access to health care services; and (3) education for children and adolescents. Based on evidence from the CHA and the anthropologic RAP and the expertise of the CGH, the initial focus was to identify interventions that could be rapidly implemented to improve maternal, neonatal, and child health outcomes.

POPULATION HEALTH DOMAINS

The clinic and birthing center: having the facilities needed to provide a medical home.

Clinic services

Establishing a clinic was a high priority for both the community and the Agro-America–University of Colorado partnership. Mr Fernando Bolaños, the founder of Agro-America, dreamed of establishing a clinic for his workers and the community before he died. Therefore, the Bolaños family considered establishing a clinic as a tribute to their late father’s memory. A multidisciplinary collaborative process that included Agro-America, its local Guatemalan architect, faculty and students from the College of Architecture and Planning at University of Colorado Denver, and CGH clinical faculty designed the clinical facilities. The facility includes a front check-in area; pediatric, adult, and obstetrics/gynecology examination rooms; a dental room; birthing center; physician workstations; pharmacy; laboratory; and office/conference room space. Architectural plans are shown in Fig. 4 and construction was completed in April...
Fig. 4. Clinical facilities floor plan. AU, ambulance unloading area; CA, common area for doctors; CONT, control room; CR, computer room; DENT, dental clinic; DO, doctor office; EC, emergency care; EQ, equipment; IDR, infectious disease room; LR, locker room; M, maternity/women clinic; MW, midwives rest area; NS, nurses station; NU, nursery; P/C, pediatrics/Clinics; P, parking; PC, pediatric clinic; S, storage; ST, sterilization room; T, treatment room; W1, natural waste; W2, medical waste; WS, work station; X, radiography clinic.
2014. The CGH funded the delivery of 2 Project CURE (Commission on Urgent Relief and Equipment) containers that transported donated equipment, furniture, and supplies for the clinic. A server-based electronic medical record, Clinical Fusion, used in school-based clinics in the United States is being implemented and it is close to functional given the remoteness of this site. The clinic started caring for patients on March 14, 2014 (Fig. 5), with staff that included a clerk, 2 nurses, and a laboratory technician. Medical care was provided by University of Colorado pediatric residents and a Guatemalan-American family physician, Dr Marco Celada. As the project became established, the number of students, residents, and faculty traveling to work in Trifinio increased, as shown in Fig. 6. Although the clinic initially focused on children, half of those seeking care were adults with noncommunicable diseases, which provided an opportunity for the pediatric residents to experience family medicine in the global arena, and fostered the need to involve more family and internal medicine residents. One of the principles in establishing this clinic was to avoid competition with the existing, limited public health services (mostly immunizations) staffed with auxiliary nurses. Therefore, the clinic was established as a collaborating second-level facility for outpatient care, safe pregnancy care, and deliveries. The fees were set lower than those of comparable services in Coatepeque, even without considering the saved transportation costs. However, the poverty in the region is so great that any fee may be a significant barrier to seeking care. In trying to balance these concerns, the clinic compromised by setting the cost for employees of Agro-America at $2 and nonemployees at $3. However, mothers and children enrolled in the community outreach maternal and child programs are referred and seen without charge. The laboratory services expanded to include the tests Agro-America required for its employees, as well as routine prenatal testing, Pap smear collection (processing is done by APROFAM), and human immunodeficiency virus and syphilis screening. In addition, the clinic nurses were trained in fetal ultrasonography and the scans were printed so that women could take them to the hospital. A prenatal package with a small monthly payment plan was implemented for visits, laboratory, and ultrasonography costs. The patient volume was initially

Fig. 5. Checking in the first patient at the clinic.
Fig. 6. Residents (A) and students (B) working in the Trifinio 2012 to 2015. OB-GYN, obstetrics/gynecology.
modest but has steadily increased. In the summer of 2015, several positive activities began. The pharmacy became operational; the community nurses began a stronger outreach effort to let families know about the clinic services; clinic leadership met with local leaders regarding clinic offerings; and the clinic’s capacity increased as family medicine, internal medicine, and physician assistant rotations began in addition to those of the pediatric residents.

There were several design challenges in building the clinic facilities in an extremely hot climate with torrential rains, annual flooding, and high rates of mosquito-borne illness (dengue and chikungunya). The University of Colorado Denver architecture students came up with several creative ideas about using local materials such as bamboo and river stones enclosed in wire mesh. However, building this way was more expensive than using more traditional cinderblock construction. There were many political problems in obtaining needed licenses and approvals for the clinic, laboratory, and pharmacy operations, which caused delays, and we were under-resourced in terms of on-site management because of financial limitations. After the clinic opening, patient volume was less than expected because there was an initial perception that only corporate employees and their families could receive services at the clinic, as well as confusion as to whether the clinic would see adult patients. We lacked a clear strategy for how to communicate to the community about the clinic services available.

Birthing center

The reasons for excessive maternal mortality and morbidity have traditionally been framed by 3 major delays: (1) delay in recognition that there is a problem, (2) delay in accessing care when the problem has been recognized (financial, physical, transportation barriers), and (3) delay of appropriate care delivery when at the referral facility (caused by supply issues, health worker shortages, or clinical knowledge deficits) [11,12]. Because the CHA found that about half of the pregnant women were delivering at home with a high rate of maternal complications, the project began designing a birthing center based on the midwifery model of care, with TBAs working together with trained delivery nurses within a system of referral and emergency transportation. This approach avoided or ameliorated the traditional 3 delays [13,14]. In April 2012, focused interviews were held with local TBAs to further understand the context in which women receive prenatal care and care during childbirth. Follow-up interviews with the TBAs and a qualitative project collecting birth narratives from community women and TBAs in 2013 increased our understanding of pregnancy behaviors around delivery and common complications. Given this background, the TBAs were recognized as important women of influence in their communities, and we sought to involve them in our ongoing efforts around healthy birth through skills building and clinical team collaboration. This information on pregnancy and delivery complications also helped to design the birthing center and trainings related to healthy pregnancy and childbirth for TBAs, nurses, women, and community members. Protocols and
guidelines were adapted from the university, regional birth centers, and WHO standards to our situation and a training and education program was started for the current TBAs, the skilled birth attendants (SBAs), and the community health nurses (CHNs). Ongoing training in emergency obstetric care has been conducted since July 2013 for TBAs and SBAs. A repetitive curriculum that incorporates the principles of Helping Babies Breathe, Jhpiego’s Helping Mother’s Survive, and WHO Essential Newborn Care were implemented [15–18]. The curriculum uses simulation and drills to keep practitioners’ skills in emergency obstetric management current and promotes team-based practice [19,20]. Evaluations of emergency obstetric skills of CHNs, TBAs, and SBAs are conducted via objective structured clinical examinations at least once per year by faculty visiting the area. Community health and clinic-based nurses were also trained to perform basic ultrasonography scans in pregnancy, identify ultrasonography abnormalities, and to perform pap smears and pelvic examinations. Because access to women’s health physicians is severely limited in this area, the task shifting has improved the scope and access to care for the population.

Scheduled to open in May 2016, the birthing center will allow some of the TBAs to shift their patients from home deliveries to the birthing center, providing low-risk patients with the ability to access a culturally appropriate and safer delivery facility closer to their homes, and with assurance that any complicated or high-risk delivery will be referred to the regional hospital in Coatepeque. However, several issues must be resolved for the birthing center to open under the following preestablished guidelines. First, there must be staff to cover 24 hours a day, 7 days a week, with SBAs (physicians, nurses, or trained nurse midwives) who are willing to collaborate with the community TBAs, and there must also be housing accommodation for the staff close to the birthing center. Second, an ambulance with a dedicated, trained driver must be available to transport mothers in labor with complications to a hospital in Coatepeque. An ambulance was purchased and retrofitted but an on-call system for drivers needs to be developed. In addition, an agreement of affiliation with a public hospital in Coatepeque will be established to ensure the proper coordination and referral of patients. Extensive relationship building has already occurred with the obstetrics/gynecology residency program there, to coordinate referrals of outpatient clinical emergencies. Along with the agreement, there is the hope to implement a rotation for local obstetrics/gynecology residents through the birthing center beginning in 2016.

Oral health program
The prevalence of dental problems is very high in the SW Trifinio area. Guatemalan dental professionals can be found in Coatepeque, more than an hour away, but dental care is costly and the lack of transportation limits access to oral health care for most residents. The University of Colorado School of Dental Medicine collaborates with the CGH by funding and providing dental
services at the clinic 3 to 4 times per year. A board-certified pediatric dentist serves as the dental program director at the clinic and has implemented a school-based oral health program (based on WHO guidelines), direct patient care services, and population evaluation. Before opening the dental clinic in June 2014, an oral health needs assessment was performed on schoolchildren attending the Fernando Bolaños Elementary School for the workers’ children using previously published experiences [21,22]. A very high incidence of dental disease was noted, with 96% of children having 1 or more decayed teeth. In addition, 44% of children self-reported having dental pain and 20% had visible dental abscesses. An oral health focus group was conducted with the school teachers. The group reported a need for accessible dental care, a high prevalence of toothaches, missing school because of toothaches, facial swelling, and difficulty sleeping at home. A 2-pronged approach to implementing the school-based oral health program was taken: (1) training of the teachers and clinic nurses about oral health and prevention, and (2) a school-based education and brushing program. In June of 2014, 10 teachers and nurses were trained on the causes of dental caries, prevention strategies, and how to identify dental problems and make referrals as needed. In addition, the teachers began a school brushing program, which includes all students keeping a toothbrush at school and brushing their teeth daily. Each time the University of Colorado dental team visits, they hold a school assembly and review oral health via flip chart with all of the children at the school. Also, new toothbrushes and toothpaste are brought to the school to sustain the school brushing program.

**Oral health care for workers and the community**

The University of Colorado School of Dental Medicine conducts a minimum of 3 dental mission visits per year to provide comprehensive dental care for patients at the clinic. Dental teams consist of School of Dental Medicine faculty, dental students, and volunteer community dentists. Dental services offered include prevention, oral health counseling, and dental treatment, as well as basic fillings and extractions. There have been 4 dental visits since August 2014. Over the course of the first year, the dental team screened 303 school children; had 213 patient visits; and performed 40 preventive visits, 122 fillings, 26 primary tooth crowns, and 274 extractions.

**Population evaluation**

The initial needs assessment that was performed at the Fernando Bolaños Elementary School in June 2014 was repeated in August 2015. Some students have graduated and new students have been enrolled but the comparisons can be made to show the success of the dental program (Fig. 7). Periodic evaluations will help determine the prospective impact of this program to reduce oral and dental disease in children in the area [23].

The greatest challenge is the lack the funding and resources to use the dental clinic more than 3 to 4 times per year.
Community services
The community nursing services program for prenatal care, neonatal home visitation, child visits, and monthly mother-child care group visits, called Cre-ciendo Sanos (Growing Healthy), is a key component of the strategy to reduce maternal, neonatal, and child morbidity and mortality. Both the maternal program component (Madres Sanas [Healthy Mothers]) and child program component (Niños Sanos [Healthy Children]) developed flip charts (with pictures, recognizing the high rates of illiteracy) to deliver educational content to mothers. The front side of the chart has information for the women and the reverse has prompts for the nurses. There are also nurse training manuals for both programs and a manual for the mother-child care group visits. A mobile platform data collection system was established. The community nurses enter data on each visit and care group into a cell phone application that transfers the data to a database using the android-based Open Data Kit (ODK) open source platform. Because ODK is not secure, only the women’s project numbers are entered and later matched with the women’s names and demographic information stored on a secure platform in REDCap. The data collection system is integral to the community nursing program and allows the assessment of the quality of clinical care delivered; the measurement of key maternal, neonatal, and child health metrics; and evaluation of the programs [24].

Maternal health community nursing programs
Prenatal and delivery care are both critical for maternal and newborn health. Therefore, this maternal community nursing program focuses on improving prenatal care, screening pregnant women for complications, establishing a referral system for high-risk pregnancies, and shifting away from home deliveries. The Madres Sanas program uses a home visiting prenatal and newborn care model with CHNs who deliver 4 prenatal individual or group prenatal care visits, as well as an assessment of the mothers in their immediate postpartum periods. During this visit, CHNs also screen and refer for maternal

Fig. 7. Impact of a school oral health program at the Fernando Bolanos Elementary School in SW Trifinio in Guatemala.
depression (using the Edinburgh Postnatal Depression Scale). The nurses enter visit data into the prenatal clinical quality improvement database, which allows health information and outcomes on women to be monitored during pregnancy. This monitoring allows for action and/or educational counseling by CHNs for abnormal findings. Based on feedback from mothers participating in this program, the authors developed an Agro-America male worker reproductive education project (piloted in November 2015) on the topics of gender equality, the father’s role in a family, and birth spacing methods. The pilot curriculum focuses on the father’s role in promoting family health, including the use of birth spacing to encourage optimal health for the child and mother before the next pregnancy, rather than limiting the number of children.

Fig. 8 shows the number of pregnant women registered in the program per month and the number of post-partum visits. Program evaluation occurs in an ongoing manner via the pregnancy and neonatal registry to measure maternal and neonatal mortality and morbidity and the impact of the programs using the following key indicators: number and percentage of women completing 4 prenatal visits during each pregnancy; number and percentage of women less than 19 years old with a pregnancy; number and percentage of women delivering via cesarean; number and percentage of women delivering in a health facility with an SBA; and number and percentage of women choosing a modern form of contraception after delivery.

Pediatric community health nursing program
The Niños Sanos program is an integrated early childhood health and development program that has been specifically designed for the Trifinio population.
and is based on evidence from the WHO as well as similar programs in other developing regions [25–29]. The importance of integrated interventions to improve early childhood development, health, and nutrition is widely recognized at an international level [30–34]. The first 3 years of a child’s life are a critical period for brain growth and development, and this period has significant consequences for long-term functioning. Such interventions have the potential to enhance children’s physical growth and socioemotional and cognitive development, as well as the overall economic productivity of a society.

Niños Sanos was informed by 2 initial pilot studies conducted by CGH faculty and medical students from the University of Colorado School of Medicine. An initial early childhood developmental screening study in the Trifinio region in July 2012 found that children had high rates of developmental delays (as defined by the Ages and Stages Questionnaire) and further suggested that families that do not provide adequate cognitive stimulation for their children would benefit from an intervention educating mothers in responsive parenting. Intervention materials integrating ways to promote early childhood development, health, and nutrition were then developed and piloted during a July 2013 study. This study showed that mothers in the Trifinio were able to significantly increase their knowledge about health and development topics following a short interactive flip-chart talk promoting responsive parenting. Mothers further increased their knowledge 1 to 2 weeks after the talk, without any re-exposure to the intervention materials, presumably by informal reinforcement with other mothers in the community.

Given the need for an intervention to promote early childhood development and health and the success of early pilot materials in the Trifinio region, Niños Sanos was designed to include an integrated approach to early childhood health and development, combining a series of neonatal home visits, mother-child care groups, and community education sessions to enhance the health and development of children from 0 to 3 years of age. The program starts with 3 neonatal home visits by the CHNs in the first month of life (birth, 2 weeks, and 1 month), based on WHO Essential Newborn Care guidelines, to assess neonates, provide appropriate referrals for sick newborns, and screen for maternal depression (Fig. 9). Small group talks given by the CHNs then occur when the child is 6 months, 12 months, 24 months, and 36 months of age to teach, promote, and reinforce caregiver knowledge of age-appropriate topics, including developmental milestones, good hygiene and hand washing, home management and recognition of common illnesses (including fever, cough, and diarrhea), timely immunizations, safety and injury prevention, and responsive parenting techniques. These visits also include growth monitoring and promotion (with referral for severely malnourished children) and developmental screening. In addition to the community health nurse visits, monthly mother-child interactive care groups start at 2 months of age and continue until the child reaches 3 years (Figs. 10 and 11). These groups use participatory learning to promote cognitive stimulation, provide peer support for the mothers,
reinforce caregiver knowledge of health topics, and perform growth monitoring and promotion.

Niños Sanos currently has more than 400 children enrolled. Monthly enrollment is shown in Fig. 12. More than 250 children have received a nurse home visit in the first 2 weeks of life. Program evaluation measuring outcomes and indicators is ongoing. Short-term and midterm goals include increasing identification of sick neonates with referral to the hospital, increasing rates of exclusive breastfeeding before 6 months of age, increasing responsive parenting behaviors (talking, praise, reading, and play), decreasing the incidence of diarrhea, and increasing hand washing with soap. Long-term goals include decreasing neonatal mortality, decreasing infant mortality, decreasing developmental delays, decreasing stunting and the incidence of severe malnutrition,
decreasing iron deficiency anemia, and decreasing hospitalizations for pneumonia.

**Challenges: community health nursing program**

Initially, 3 community health technicians and 1 manager were employed to direct the community outreach clinical activities. These technicians had backgrounds in fields outside of medicine (ie, business and social work). Teaching nonclinicians how to diagnose and treat pregnancy, neonatal, and childhood complications was a difficult task. As the program expanded, CHNs who had a more extensive clinical background replaced the community health

**Fig. 11.** A community health nurse demonstrates talking to a young child using a finger puppet during a mother-child group visit.

**Fig. 12.** Total number and cumulative enrollment per month of children less than 1 year of age in the Niños Sanos program at the SW Trifinio, Guatemala 2014 to 2015.
technicians. This change improved the number and quality of patient referrals to the clinical facility and improved the trust of the community. As of February 2015, 6 community nurses and 1 nurse manager had been hired for the maternal and child programs. Transportation for the nurses was another challenge. The usual form of transportation was by motorcycle and the nurses had to carry heavy flip charts, scales, and measuring boards. The center purchased tuk tuks (3-wheeled motorcars) to address this problem (Fig. 13). Finding an appropriate nurse coordinator to supervise the community nurses was difficult but eventually one of the new nurses was promoted and given additional training and ongoing mentoring. In addition, weekly meetings with the community nurses are held via the university’s telehealth program, Vidyo, to ensure that program questions and issues are addressed in a timely fashion, and this has improved team morale and communication. An incentive program that rewards both individual effort and team goals has also been developed.

Employee health

**Total Worker Health program (adult and occupational health for Agro-America)**

CGH and the Center for Health, Work, and Environment of the Colorado School of Public Health have proposed a collaborative project to address total worker health in partnership with Agro-America. Total Worker Health (TWH) is a framework developed by the National Institute for Occupational Safety and Health of the CDC that is designed to integrate occupational safety and health protection with workplace policies, programs, and practices that promote health and prevent disease to advance worker safety, health, and well-being. The project seeks to improve the health, safety, and well-being of Agro-America workers, their families, and the communities in which they do business using the evidence and experience of the Center for Health, Work, and Environment at the University of Colorado [35–37]. The program will incorporate evidence-based guidelines derived from WHO and CDC for the

Fig. 13. Tuk tuks; transportation for CHNs.
certification of healthy businesses (Health Links). The goal is to build from the company’s strong corporate social responsibility program and the services of the CHD to establish best practices for leading the industry and developing a sustainable model that not only has measurable impact but is scalable to others across industries. Much of what we intend to do has not been tested in LMICs so the experience will provide valuable information about the effectiveness of this approach. Based on an occupational health site visit conducted on June 10, 2015, the following objectives for developing the Agro-America TWH program were determined.

The TWH program will seek to improve the health, safety, and well-being of Agro-America and its workers and consequently improve the health, safety, and well-being of employees and their families. Evidence from similar programs in the United States has shown improvement in worker health and work-related injuries, as well as company performance, via increased employee morale, productivity, employee recruitment and retention, corporate culture, company reputation, and client retention. This program will establish Agro-America as an industry leader and founder of a new global model. To achieve these objectives, focus will be placed on the following 3 main priorities: (1) collect and analyze data to understand the most common work-related injuries and health conditions that have the potential to be addressed through workplace health promotion and health protection activities, (2) identify a multilevel TWH program to address the most urgent needs to improve worker health and safety, and (3) train administrators (managers, supervisors, and foremen) on core skills for supporting TWH on the job.

The TWH program will address the needs of 3 groups. First, the company at large, including key performance indicators to improve worker performance, employee morale, job satisfaction, and contributors to productivity, including retention, reduce absenteeism, and improved return to work, which will position Agro-America to serve as a model for others and to communicate best practices to clients and to the industry. The program will also assist the company in meeting global standards for occupational health and safety and comply with future industry regulations. Second, their employees as administrators (managers, supervisors, foremen), collaborators (field and plant workers), clinicians, community nurses, clinic staff, and office employees will all benefit from having reduced risk for work-related injuries and illnesses. Employee outcomes will include improvement in health risks, overall health, job satisfaction, quicker return to work, and improved quality of life and productivity. In addition, the families of workers and the communities will benefit directly by having access to the clinic, and will therefore have access to new services and better care. They will also benefit indirectly, through the programs that are benefitting employed family members.

Environment: water and sanitation

Agro-America made several attempts to address the clean water issue in the past by providing pumps and pipes to several communities. However,
households receiving this water system were either unable or unwilling to pay the small fees needed to maintain the system. As a result, the systems broke down and were abandoned. Agro-America then distributed filters to the homes of employees but in many cases the filters are not being used properly. Given community concerns about the climate and geographic conditions of the area that result in frequent flooding and the recurrent pollution of water sources, the University of Colorado initiated contacts with various NGOs that perform water, sanitation, and hygiene (WASH) projects to conduct a baseline evaluation of needs in the area and propose the development of a water project with 100% coverage in conjunction with communities, local governments, and organizations like Agro-America. Because CGH did not have expertise in this area, several WASH NGOs were consulted and 1 made a site visit. All stressed that a strong community organization would be needed as well as government commitment to a WASH effort. Because we were not able to fund a partner with WASH expertise, the CGH elected to concentrate on the health care priorities first and continue to explore opportunities to make progress on WASH. A program to train local Guatemalan high school students to work on WASH projects in their communities is being explored as part of a leadership program to be started in local schools based on the Reading Village model developed by Larry Dressler in Guatemala.

Economic opportunity
A CU Denver Business School faculty member facilitated a course on entrepreneurship for students to develop a business plan for start-up endeavors at the Trifinio site. The possible endeavors included a transportation company that would serve visitors to the project, a catering service to feed volunteers and visitors, a bakery to make banana bread and muffins, and a company to make sanitary napkins from the banana leaves. Several of these ventures are currently under consideration. The project is creating jobs for local community members in the clinic (clerks, nurses, technicians, drivers, gardeners, maintenance, housekeeping, cooking) and these opportunities will increase as the project expands. Mapping and research projects have provided employment opportunities for many local people. The project is also providing staff with advanced training that will be a valuable asset and result in more opportunities and higher salaries. We also hope to develop additional training programs in laboratory technology and pharmacy, and a physician assistant training program (described later). The TWH program will also generate new positions within Agro-America and, if successfully franchised to other companies, will generate new well-paid employment opportunities for local people.

Education
The project’s educational activities have 3 components: (1) CU students, residents, and fellows; (2) Trifinio CHD staff and Coatepeque Hospital staff; and (3) Trifinio secondary and high school students.
CU students, residents, and fellows
The most engaged trainees spending time at the Trifinio site have been pediatric residents and fellows. As of September 2015, 18 pediatric residents participated in rotations at the CHD clinic, and during the 2015 to 2016 academic year, 19 residents elected to take this experience (see Fig. 6). Residents rotating at the site have an on-site Guatemalan physician faculty member and for part of their rotation they also usually have a CGH faculty pediatrician. The residents use a telemedicine system to give case reports to the residency program during noon conference or morning report. This system increases global health exposure to residents not participating and provides the rotating resident with a teaching opportunity. The CGH compiled a handbook for residents and fellows traveling to SW Trifinio. The handbook reviews documentation that residents must provide to the CGH for processing temporary licenses; university requirements for educational travel abroad, including emergency medical and evacuation insurance; and the process for arranging international and in-country travel and accommodation. There is also a structured global health curriculum with appropriate readings and resources.

In 2013, pediatric resident experiences at the CGH SW Trifinio project site catalyzed the creation of a Global Health Track for the University of Colorado pediatric residency program that provides career-focused training and experiences in global health for up to 4 pediatric residents per class. This innovative global health program was designed for those residents who plan to focus their career in global health, or plan to incorporate care of international populations into their practice. Residents in the Global Health Track complete 6 months of global health curriculum throughout the 3-year residency. This curriculum includes 2 months of international experience in Guatemala at the clinic at CHD, a 2-week intensive Global Health and Disasters course (in Denver), experiences in various clinics with global populations, and a continuity clinic at a site with a diverse patient population. Participants also work on a scholarly project that is global health related with mentoring from a faculty member active in global health. The success of the pediatric Global Health Track program and the Trifinio rotations led to having similar rotations for residents in internal medicine, family medicine, obstetrics/gynecology, and occupational and environmental medicine.

Obstetrics and gynecology residents have participated in global health rotations within the site, focusing on specific reproductive health initiatives. One to 2 residents each year have rotated at the site for 2 to 4 weeks at a time, collecting data for research or quality improvement projects. Examples of projects thus far completed include a qualitative family planning needs assessment, a study of the pregnancy database examining factors associated with facility delivery in our population, and a quality improvement project that conducted a needs assessment of the obstetric and neonatal wards at the regional hospital in Coatepeque using a modified WHO hospital survey tool. The findings were reported to the hospital administration. Ongoing women’s health projects, including an educational curriculum for the local TBAs, community nursing
staff, and a pilot curriculum for male reproductive health education, have been built from the prior resident’s findings.

The Physician Assistant (PA) Program in the School of Medicine in collaboration with the CGH has also developed a global health rotation for PA students at the CHD. This rotation includes Spanish language instruction and allows students to gain an understanding of culturally appropriate and interpersonal behaviors under the mentorship of pediatric and family medicine residents and faculty.

**Trifinio Center for Human Development staff and Coatepeque Hospital staff**

The CGH faculty are providing lectures to the CHD nursing staff and creating a curriculum specific to their role in the community. The lectures are done weekly via telemedicine software and focus on topics such as healthy breastfeeding and childhood illnesses. Faculty from the CGH have also conducted training workshops for the CHD nurses in obstetric emergencies, ultrasonography in pregnancy, and the Helping Babies Breathe program. A group of 10 to 12 TBAs from the community have received specific training in prenatal care practices and normal and emergency delivery skills using the Mama Natalie Birthing Simulator and the Helping Babies Breathe model. CGH faculty have conducted an obstetrics/gynecology residency educational curriculum assessment for the Coatepeque Hospital residency program. The CGH is working with the hospital residency to improve training opportunities via conferences and focused trainings. An external assessment of obstetric services was conducted in February 2015 using a modified WHO Making Pregnancy Safer hospital assessment tool, and the results were presented to the director of obstetric services and head of the hospital.

The CU PA Program is now exploring a partnership with a Guatemalan medical school to establish a joint PA training program at the SW Trifinio site. A needs assessment conducted in 2015 showed that a PA-like professional would be well received by most other health professionals, local leaders, and community members, especially if coming from the community and trained under the US-adapted model.

**Southwest Trifinio secondary and high school students**

One of the 3 primary concerns surfacing from the CHA and our community engagement activities is school education. A highlighted concern documented by our school survey performed in July of 2015 is the need for a school curriculum on health and sex education. CGH faculty are working with local school officials and community leaders to develop and implement the curriculum in the next school year. CGH faculty are also planning with local leaders a leadership program for 20 high school students that will provide school scholarships and hold biweekly Saturday classes. The students will be trained in basic microbiology and water filtration systems, and will assist families in obtaining and correctly using home water filters. They will also learn about the importance of community organizing and gain leadership skills.
OVERARCHING FUNCTIONS

Research

The CGH established the Translational Global Health Research Initiative (TGHRI) to build the research infrastructure at the SW Trifinio site. The TGHRI was funded by the University of Colorado School of Medicine to enhance the Guatemalan international research facility and to encourage multidisciplinary research within the School of Medicine as well as the schools/colleges of nursing, pharmacy, and dentistry. It offers opportunities for students, residents, fellows, and faculty to investigate the incidence, risk factors, and natural history of communicable and noncommunicable diseases in the Trifinio communities and explore innovative preventive and curative therapies and interventions [38]. Having this infrastructure makes CGH and School of Medicine faculty more competitive in obtaining research funding from international organizations. Faculty at the CGH are now conducting 3 funded research projects totaling $1.37 million: (1) dengue and norovirus disease epidemiology, (2) a randomized clinical trial of a new therapy for acute childhood diarrhea, and (3) a vaccine eHealth trial. A community advisory board has been created to review all proposed research and then assist with community outreach regarding new studies. It is important to properly engage the community in participatory research decision making [38]. Therefore, both a bricks-and-mortar and community engagement foundation are in place to build a significant translational research center at this site.

One of our challenges in designing and building research facilities has been the need to have gasoline-powered generators because interruptions in electrical power occur frequently in the area. However, when power goes off during the night and weekends when the clinic is closed, a system that will automatically supply power to the refrigerators and freezers that store vaccines, medications, and research specimens is needed. Solar power options are currently being explored for the facilities but these can be costly.

Community organizing

The research community advisory board and other community leaders requested that we perform a geographic information system mapping project to identify households and collect census data of the approximately 25,000 people living in the region. This information would help the communities to advocate for government services, assist in disaster preparedness and response, and more adequately plan and implement population health initiatives. This census helps to gain a better understanding of the demographic make-up of the community, including age and gender distribution, number of current and recent pregnancies, and reach of existing services. This project was performed by the CHD with the assistance of faculty from the CGH. Community leaders spoke about the mapping at local meetings and helped to identify local census workers. These workers were employed by FSIG to collect global positioning system coordinates (latitude, longitude, and altitude) of all residences in 13 communities within the catchment area of Trifinio. Leaders from each community
accompanied census workers providing the necessary community engagement and receptiveness. More than 95% of the people living in inhabited homes agreed to participate. The census workers did an excellent job and clearly had the trust of the people. We hope to be able to hire them to work on additional community organizing and service projects. Maps will be provided to local community leaders and the local Ministry of Health to improve their capacity to deliver routine services or aid during natural disasters, which are common in the area. The census and mapping was a successful joint project with the community, and meetings are currently underway to consider how communities would like to use the information. One option under discussion is to name roads and footpaths, assign numbers to the houses, and ask Agro-America to fund signage. The mapping is becoming a community organizing and empowerment tool.

Strategic planning and sustainability
The CGH/University of Colorado, Children’s Hospital Colorado, and Agro-America all made a long-term commitment to their partnership. Agro-America set aside 10 acres of land where the clinical, research, educational facilities, and volunteer housing would be built. Agro-America assumed responsibility for the construction of the facilities, clinic maintenance, security, information technology management, and transportation within Guatemala. In addition, Agro-America committed a $200,000 per year fund for 5 years to support development, implementation, and evaluation of FSIG programs by the CGH. Once the clinical services became operational, Agro-America agreed to fund 100% of the clinic and community program cost for the first year, 80% the second, and 60% the third. The financial sustainability of these services will require multiple funding streams in addition to Agro-America, including clinical revenue generation (mostly from patients with social security insurance), indirect cost funds from research, and philanthropic funds. It will be important to have a clear development/fund-raising plan in place with both the CU Foundation and Children’s Hospital Colorado Foundation.

Strategic planning and sustainability are used to set priorities, focus energy and resources, strengthen operations, and ensure that collaborators and other stakeholders work toward the common goal of population health. The strategic work plan developed by the CGH management committee specifies the goals; strategies to achieve the goals; and the data system to monitor quality and process outcomes. We will follow best practices for dissemination and implementation science whenever we replicate these interventions and take our programs to new communities. Specifically, we will use the RE-AIM (Reach, Efficacy/Effectiveness, Adoption, Implementation and Maintenance) framework for dissemination and translation.

SUMMARY
The CHD project provides an innovative model for how a host country private agribusiness can partner with a US academic center to improve the population health and the human development index of impoverished communities in
Guatemala. Private sector–academic partnerships can combine the private-sector strengths of managerial efficiency, entrepreneurship, and social responsibility with academic strengths of innovation, technical knowledge, and research capacity to alleviate poverty and improve population health [9,10]. Although the first 3 years show great promise, the challenge of sustainability and achieving significant reductions in maternal, neonatal, and child morbidity and mortality are formidable and will only become apparent over the long term. This project provides a community laboratory to attempt innovative and transformative interventions. Those that prove to be successful and financially feasible can be taken to scale. Therefore, maintaining the commitment to our common goal of improving population health and continuing to build respect and trust with the community and between Agro-America and the university over the next decade will be essential to the success of this project.

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