Innovating to improve primary healthcare and reduce the burden of disease in low-resource communities
The Global Health Technologies (GHT) portfolio of Global Good focuses on the conception, development, adaptation, and deployment of technological innovations to address major global causes of illness and mortality in low-resource countries.

**FOCUS & APPROACH**

We’re developing tools that enable primary care clinics and communities to reduce their burden of disease and accelerate elimination of malaria and other tropical diseases. Our work addresses environmental risk factors that affect health and disease vulnerability, such as vector control, nutrition, and quality of water and air. And we seek to provide clinics with more effective equipment, supplies, and other resources so as to empower quality care for all people, especially those at the periphery of the health system—from remote villages and districts to high-density urban environments.

The GHT approach is to invent and adapt technologies for clearly defined target product profiles. A solution may be attainable through innovative application of an existing technology, thus providing more immediate benefits with less risk in the development process. Alternatively, we may see the need to invent entirely new technologies and products. Regardless, our ultimate aim is to provide solutions appropriate to the needs of low-resource settings—easy to use, robust, stable, and affordable.

**AGILITY & CAPABILITY**

In several respects, GHT is differentiated from other organizational models in academic, NGO, and private sector environments. Our unique business model and capabilities enable us to focus on otherwise underserved areas of health product development. Supported by flexible funding with an agile development mindset, we’re able to quickly redirect resources as needed while remaining accountable to short-term milestones.

By leveraging the use of our multipurpose technology platforms, we can more efficiently support a broad spectrum of work types, including diagnostics and screening, non-drug
therapies, biometrics, and environmental influencers of disease. To facilitate this work, GHT is directly partnered with the highly versatile Intellectual Ventures Laboratory (IV Lab), which is comprised of a multidisciplinary staff and physical lab spaces—all collocated within a single facility. Our immediate access to IV Lab enables flexibility to transfer staff and priorities across projects along with the capacity for rapid prototyping.

TEAMWORK & PARTNERSHIPS

In addition to forming internal teams based on domain expertise, we leverage external partner proficiencies in research, product development, field evaluation, and commercialization. Our partners range from individual technical advisors to commercial partners with regional market expertise and influence.

We establish long-term partnerships with key public health and research institutions in the U.S. and abroad. In addition to providing their strategic and technical inputs, these institutions collaborate with Global Good to conduct high-quality field evaluations in the countries of intended product use. These evaluations result in valuable practical feedback to guide further product development.

Key experts are also engaged through individual consultation or in advisory panels working to collectively discuss and refine target product profiles, advise on development options, and establish market awareness and support. And sometimes we look to a selected institution for specific high-level expertise working in collaboration for a specific product development project or geographical site.

LOOKING AHEAD

The pages that follow include examples of Global Good’s health-related work and areas of investigation—ranging from previous projects completed to future possibilities under consideration. Feel free to contact us for additional information about any of these.

Advancing into the future of global healthcare, our emerging capabilities apply leading technologies—as seen in our work with AI-assisted diagnostics for malaria detection, pulmonary care, and cervical cancer detection.

These new directions build on the momentum of our more traditional work addressing environmental and nutritional risk factors that contribute to poor health. Following are a few examples of these foundational projects.

**Household air quality**

Poor indoor air quality is a known major contributor to many health problems. Our improved cook stove design seeks to significantly reduce indoor smoke and emissions while also conserving household fuel.

**Insect control**

Our vector control program has helped toward malaria elimination goals and supported vector-free living and work spaces—reducing the entry of harmful pests while also maintaining airflow and security.

**Malnutrition assessment**

Targeting childhood needs for nutrition support and growth monitoring, we’ve improved on tape devices for measuring upper-arm circumference—a common indicator of possible malnutrition.
Therapeutic Oxygen
Supply reliability and delivery efficiency

The use of oxygen is vitally important in clinical care—especially for supporting the treatment of acute respiratory infection, a leading cause of child mortality. However, resource-constrained areas have difficulty maintaining a reliable oxygen supply. Electrically powered concentrators can create oxygen supplies from ambient air, but most low-resource clinics have unreliable power grids. Alternatively, oxygen delivered in high-pressure tanks requires no electricity, but the supporting supply chain is unreliable. To overcome the drawbacks of each of these supply modes, Global Good has developed an approach that applies the advantages of both modes. When power is available to run a concentrator, the system generates oxygen quantities beyond immediate patient needs and stores the reserve in pressurized tanks to use during power outages.

We have also developed an improved oxygen reservoir cannula that can accommodate variances in children’s nostrils for a dramatic reduction in oxygen loss that is typical to other oxygen delivery systems.

Low-Resource Incubator
Improving culture-based diagnostics

Microbiological incubator devices are helpful for culturing and detecting pathogen growth in tissue samples and for determining susceptibility to specific antibiotics. This diagnostic information is valuable for guiding the preferred treatment for individuals—and potentially for the surrounding community, too. However, low-resource clinics generally lack effective incubation equipment. Typical incubators have poor temperature monitoring, are susceptible to fluctuations in ambient temperatures, and cannot hold stable temperature when the power supply is unreliable. In response to this need, Global Good has collaborated with industry partners to develop a bacteriological incubator that is optimized for use in low-resource environments. The device can operate effectively on unreliable electrical grids at broad ambient temperature ranges. In a full power outage, with ambient conditions ranging from 10° C to 45° C, it holds a set temperature within 2° C for more than 8 hours.
AI-Assisted Ultrasound
*Breakthrough diagnostic capabilities*

Ultrasound imaging is highly effective for medical diagnostics, such as in primary care and emergency triage. Portable ultrasound systems are now serving clinics that could otherwise not afford a traditional full-scale ultrasound system. But there is still a shortage of the skilled staff that is needed for image analysis. To help overcome this shortage, Global Good is developing an AI-based system to assist health workers in performing ultrasound diagnostics. The system will support image capture and diagnosis by minimally trained personnel in low-resource settings.

Our initial focus is on lung pathologies, including pneumonia, pneumothorax, and pleural effusions. Going forward, Global Good’s AI-development platform technology could serve as a foundation for other diagnostic capabilities such as ultrasound obstetric examinations.

Cervical Cancer Screening
*Saving lives with improved early detection*

Every year, cervical cancer causes the death of more than 300,000 women—mostly in low-resource areas where advanced diagnostic methods are unavailable or impractical. Delays or inaccurate test results can impede proper follow-up and treatment. Global Good is working on technologies to provide more immediate and accurate identification of cervical pre-cancer.

**AI-Enabled Diagnostics**

In current practice in many low-resource settings, healthcare workers apply acetic acid to the cervix and look for color changes that may indicate pre-cancer. Global Good has developed an algorithm that improves on the sensitivity of the visualization approach and is further developing the algorithm to work on affordable and readily available devices. Automated Visual Examination (AVE) will allow healthcare workers to take cervical images with a smart phone, and the AI-based algorithm will provide near-immediate results with very high diagnostic accuracy.

**Detection of High-Risk HPV Oncotypes**

Cervical cancer is caused by persistent infection with one or more high-risk types of the human papillomavirus (HPV). Early detection of this slow-growing virus is a key to avoiding eventual cancer. Global Good is developing a DNA-based test that can detect the 14 most high-risk HPV types. The test is designed to support same-day screening and treatment by providing results in under one hour.

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*Cancer Prevalence*

2018 estimated incidence of cervical and uterine cancer *(age-standardized, females all ages)*

**ASR (World) per 100,000**

- ≥ 26.0
- 18.1-26.0
- 11.5-18.1
- 7.3-11.5
- < 7.3

Source: WHO-IARC
Actionable Information
Data quality and connectivity supporting patient care and community health

The Strong Clinic approach includes improving on the connectivity and effective use of information throughout all healthcare systems and processes. This methodology comprehensively considers the many aspects of gathering, storing, accessing, analyzing, and applying information.

Sensing and Diagnostics
Improved diagnostic devices will provide more useful information and will typically do so more rapidly, so as to support better patient treatment decisions. Examples of our work in this regard include pioneering new technologies to develop an AI algorithm for malaria detection via digital microscope along with similar algorithms for lung ultrasound diagnostics and cervical cancer screening.

Handling Information
We envision systems by which patients can be positively identified for access to their digital health records. To identify infants, whose appearances change rapidly, we’re exploring suitable biometric modalities. And for all patients, records will ideally be stored in a regional database, accessible from any clinic. This would enable cross-clinic data analysis, which could potentially reveal community-wide health concerns.

Equipping Clinics
The capture and rapid analysis of digital information is foundational to several improvements in clinical capabilities. Health workers will benefit from immediate access to digital records, including patients’ diagnostic results, as well as online assessment tools. Digital devices, such as Global Good’s NIR drug quality testing tool, can support clinicians in validating the quality of many types of medicines.

Patient Identification
Supporting longitudinal care

Reliable identification of patients enables healthcare workers to access health records and provide relevant patient care. Global Good has collaborated on the development of a biometric software solution for infant identification that can integrate with other electronic health record systems. Built to work on mobile devices (smartphones and tablets), the system was developed for babies and children up to four years old and can identify them using ear, foot, or palm biometric modalities.
Tuberculosis (TB) continues to impose a significant global burden of illness and death, especially in low-income nations. In 2017, WHO estimated 10 million new TB cases worldwide, which included more than a million children. Fortunately, international efforts for TB prevention and patient care are making progress; WHO estimations indicate a 42% reduction in TB-caused death between 2000 and 2017. Global Good seeks to further improve TB diagnostics as well as patient care and the systems that support global TB programs.

Effective diagnosis of TB is quite challenging due to the complexity of the disease and difficulty in obtaining suitable specimens. TB appears in several variations and levels of progression across infected populations. For example, while it is typically evidenced in the lungs, TB can also exist in extra-pulmonary forms—especially in HIV-infected individuals.

Unfortunately, currently available diagnostics fail to detect about 36% of new TB cases and miss about 49% of HIV-TB combination cases. The tests also insufficiently indicate whether, or to what extent, the TB cases are drug-resistant. In fact, current TB programs fail to identify 71% of multi-drug-resistant cases. TB diagnosis methods can also be expensive and time-consuming as the work is referred to higher level facilities in the healthcare system; it cannot be done at the local clinic.

To enable more accurate, informative diagnosis of TB in its many forms, Global Good is developing solutions intended to be more accessible at the community level. Our TB efforts employ some of the same approaches that we are developing to combat malaria.

Rapid diagnostic paper-strip tests
Our high-sensitivity Lateral Flow Assay (LFA) rapid diagnostic tests will provide more effective, affordable detection of TB-specific biomarkers at the community level.

Bacteria growth detection platform
Our new culture technologies aim to offer affordable, rapid testing for TB bacteria viability in collected samples. This capability will help to monitor treatment efficacy and provide individualized, patient-centered case management.

Solution-scenario modeling
Our Institute for Disease Modeling computationally simulates disease transmission dynamics specific to TB and HIV. Their studies address the effectiveness of treatment programs and the potential impact of new strategies and tools.

New molecular point-of-care tests
Nucleic acid amplification tests (NAATs) aim to simplify rapid detection in TB-suspected cases along with rapid prediction of drug susceptibility or resistance.
Malaria poses a significant health threat to nearly half of the world’s population. In 2017, an estimated 219 million cases of malaria occurred, causing nearly a half million deaths, with the highest mortality occurring in sub-Saharan Africa. In all populations, the risk of life-threatening infection is higher for pregnant women, infants, and children under five years of age. Available anti-malaria tools include diagnostic tests and drug treatments; indoor spraying with human-safe insecticides; and insecticide-treated bed nets to deter nighttime mosquito bites. Meanwhile, Global Good scientists and inventors are applying new technologies, developing a suite of diagnostic tools to support case management, surveillance, and elimination.

When a mosquito bites a human, its saliva can infect the body with *Plasmodium* parasites which will slowly incubate and eventually cause malaria. Modern diagnostic methods seek to discover the presence of these invaders in patient blood samples (serology). However, detection of the malaria antigens can be challenging for several reasons. Some kinds of malaria parasites can hide within internal organs and incubate undiagnosed for many weeks with no presence of symptoms. A certain antigen may appear for several strains of *Plasmodium*, whereas another may be unique to only one strain. And in some populations an otherwise common antigen does not occur at all, even upon infection.

### Rapid Diagnostic Tests

**Ultra-sensitive parasite detection**

Global Good is developing several new malaria diagnostic assays in an LFA test-strip format. These new tests seek to respond to many specific challenges and unmet needs in low-resource areas.

We’re working on an ultra-sensitive test to detect the HRP2 protein, an indicator of the deadliest *Plasmodium* strain, *P. falciparum*. The ability to detect very low levels of this protein in blood samples will be useful in specialized applications, such as antenatal screen with pregnant mothers and possible detection of hidden latent-phase infections. The sensitivity of this test will also be helpful toward malaria elimination efforts—assessing stratification or pockets of infection so as to guide efficient allocation of resources such as mosquito nets and sprays.

Existing available malaria assays seek the presence of the PLDH antigen, which can appear with multiple strains of *Plasmodium*. While not particularly sensitive, these tests can

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**LFA Basics**

Advanced diagnostics under development at Global Good apply our shared “platform” capabilities in Lateral Flow Assay (LFA) systems.

In LFA technology, a sample liquid—such as a drop of blood—flows laterally across a test line that can indicate the presence of the chemical substance it is designed to identify.

The versatility of our LFA platform technologies enables us to develop specialized assays for detection of multiple specific *Plasmodium* parasite strains.

Going beyond the initial malaria focus, Global Good could potentially develop a suite of ultrasensitive serology LFA assays for the diagnosis and elimination of many other diseases.

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Mosquitoes are the “vector” by which malaria-causing parasites are transferred from one infected person to another.
Malaria

recognize high levels of infection but not which specific strain is involved. Global Good is creating more-sensitive PLDH tests that will specifically indicate the presence of *P. falciparum* and *P. vivax* strains. Eventually, these two separate assays may be administered concurrently on one single LFA strip. Targeted for a low per-patient cost, they will be helpful for improved case management in everyday clinical usage. Also, some populations exhibit a “gene deletion” condition by which the HRP2 protein does not occur, so HRP2 tests fail to detect infection. The PLDH tests will help to overcome these false-negative results.

Delivering improved detection sensitivity within the familiar LFA form factor, Global Good’s next-generation malaria tests will help improve individual patient outcomes, community surveillance, and overall disease elimination. Field trials of these new diagnostics are already demonstrating highly effective detection of *Plasmodium* parasites.

Microscopy

*Enabling malaria diagnosis*

The standard optical microscope is one of the most affordable and effective tools for diagnosing infectious diseases in low-resource areas. However, analysis of blood films requires significant time from trained WHO-certified microscopists. And very few of these experts exist in the areas that need them most.

**AI-POWERED MICROSCOPE**

Global Good has developed an automated microscope that can examine sample slides and provide diagnostic accuracy that meets the standards of WHO Level-1 expertise.

The advanced system captures ultra-high-resolution images which are then interpreted into diagnostic decisions by an artificial intelligence algorithm that’s been “trained” with a database of thousands of real malaria parasite images.

![Image of AI-powered microscope](image)

**MICROSCOPY SKILLS TRAINING**

In response to the need for improved microscopy skills, Global Good has worked with several collaborating organizations to create accessible microscope skill training that is fully focused on malaria diagnostics. The resulting Worldwide e-Learning Course on Malaria Microscopy (WELCOMM) provides self-instructional education for health workers to strengthen their skills in laboratory diagnosis of malaria.

Whether for initial education or refresher training, the course presents informational material and simulated practice for individual or team study. WELCOMM may be provided through a national malaria-control program.

Students learn about specimen collection, film prep, blood components, parasite detection, species identification, and parasite quantification—as well as recognizing non-malaria pathogens and other common blood film artifacts. Realistic practice is accomplished using a large library of microscopic malaria images for virtual microscopy training consistent with WHO standards.

The course is available to all individuals and organizations around the globe. International distribution and administration is now fully managed by Amref Health Africa.

Drug Quality Testing
Detect falsified medicines in the field

Surveys of anti-malarial drug supply in sub-Saharan Africa indicate a significant level of counterfeit pills that contain fake ingredients or are otherwise substandard. Low-income countries often lack the laboratory capacity required for routine centralized testing, and available “mobile lab” products are generally cumbersome and costly.

Global Good is developing a low-cost handheld device to assess drug quality in the field. The near-infrared (NIR) spectroscopy system can rapidly analyze the chemical composition of a pill. The test method transmits NIR waves into a pill, then compares the resulting wave reflection and absorption with a database in a mobile phone app. Results appear immediately.

Successful application of this technology could help prevent treatment failures resulting from use of falsified medicines, improve confidence in health systems, and strengthen pharmaceutical supply chains.

Computational Modeling
Simulating the paths to malaria eradication

Applying high-power computing capabilities, the Institute for Disease Modeling (IDM) at Global Good generates data-derived insights to guide malaria elimination efforts. Focused on helping low-income populations, their work supports resource-efficient reduction of disease burden, optimized combinations of malaria elimination tools, and elimination-related surveillance and response systems.

IDM spatial mapping programs enable static and dynamic visualization of human infections and vector populations. Micro-simulation modeling of malaria transmission, based on historical patterns, can help to anticipate more-likely areas of future outbreaks and guide preventative measures. For example, in the administration of a mass antimalarial drug campaign, IDM modeling can recommend an optimal approach to deployment. Their custom-developed systems include advanced data analysis tools that quantitatively compare the effects of curative, prophylactic, and transmission-blocking elements in suppressing malaria.

Additional forward-looking projects include predicting the potential impact of emerging technologies that could help to prevent infection, reduce symptoms, or inhibit the cycle of retransmission.

In one study, working with local partners in Southern Zambia, IDM analyzed the operational effectiveness of large-scale antimalarial drug campaigns. Using a spatial model of the region, IDM can project the impact of switching to alternative drugs and distribution modes.

This image is a single frame from a multi-year simulation video. The sequence provides dynamic visualization of important features of an outbreak: locations of malaria-affected households, timing and severity of emergent cases, and movement of parasites in the region.
Millions of people suffer and die each year in poor countries from causes that humanity has the scientific and technical ability to solve. Funded by Bill Gates and focused on a shared vision with Nathan Myhrvold, Global Good invents technology to solve some of humanity’s most daunting problems. We do this by collaborating with leading humanitarian organizations, forward-looking governments, research institutions, and corporate and private sector partners that help to bring our inventions to market.