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Using Feedback to Improve Accountability in Global Environmental Health and Engineering

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ABSTRACT: Engineered environmental health interventions and services in low-income and resource-limited settings—such as water supply and treatment, sanitation, and cleaner household energy services—have had a less than expected record of sustainability and have sometimes not delivered on their potential to improve health. These interventions require both effectively functioning technologies as well as supporting financial, political, and human resource systems, and may depend on user behaviors as well as professionalized service delivery to reduce harmful exposures. In this perspective, we propose that the application of smarter, more actionable monitoring and decision support systems and aligned financial incentives can enhance accountability between donors, implementers, service providers, governments, and the people who are the intended beneficiaries of development programming. Made possible in part by new measurement techniques, including emerging sensor technologies, rapid impact evaluation, citizen science, and performance-based contracting, such systems have the potential to propel the development of solutions that can work over the long-term, allowing the benefits of environmental health improvements to be sustained in settings where they are most critical by improving trust and mutual accountability among stakeholders.

INTRODUCTION

Many human-technology systems require regular measurement and control adjustments to ensure effective operation. This principle of measurement and control, first mathematically described by Norbert Wiener,[1] is critical to creating and sustaining resilient systems: there must be feedback on performance, and this feedback should be actionable, timely, and delivered as interpretable information to an entity that is willing and able to use it to manage the system.[2] This principle is true of those systems using technologies that require complementary human behaviors typical in environmental health[3] to achieve some desired outcome, such as improved cookstoves yielding reduced respiratory disease or continuous functionality of a water pump delivering safe water and reducing diarrheal disease.[4,5] On an institutional level, a key factor in willingness to use information to improve system performance is alignment of incentives, namely financial resources and organizational accountability. Any feedback information must be delivered to an actor with an incentive, including financial, political, or social, to intervene to correct and improve a system or service,[6,7] as observed in the healthcare industry's quality improvement[8] model. The absence of timely and actionable feedback on performance, resources to respond, and accountability often explain why some projects, services, and technologies succeed and others fail.

Environmental health and engineering interventions intended to improve health outcomes in underserved communities often have had a less than expected record of resilience, as measured by sustained, cost-effective intervention or service delivery and corresponding positive impact on health or other intended outcomes.[9−11] Examples abound of technologies whose useful lives have been cut short by preventable causes such as lack of operation and maintenance budgets, supplies and expertise, lack of supply chains for replacement parts, and conflicting management priorities.[12] This is starkly illustrated by the failure rates of handpumps in rural communities in Africa, where as many as one in three are nonfunctioning at any given time.[13,14] Other technologies have failed to scale because the supporting systems, including economic and political, are insufficient,[15,16] or because the technical or social

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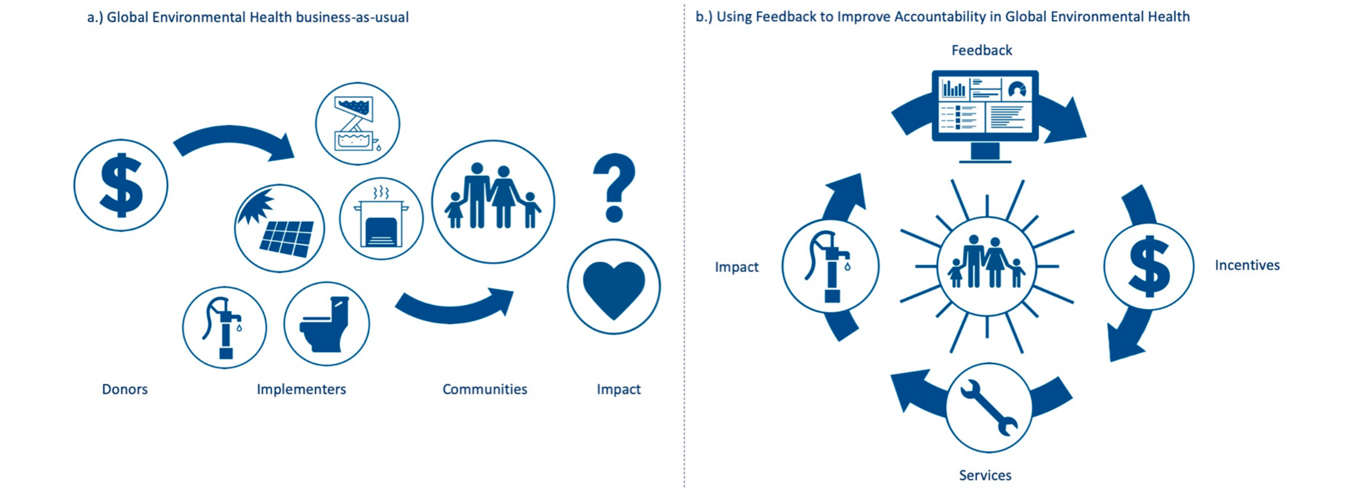

Figure 1. (a) Business-as-usual in global environmental health programming often involves finite funding provided by donors based on varying and evolving agendas to implementers providing products and infrastructure intended to benefit communities and public health. Limited community capacity and barriers to poverty reduction reduce the sustainability of these products and services. (b) Using feedback technologies and tools could improve accountability and positive impact in global environmental health through creating mechanisms for cost-effective service delivery (figure adapted from ref 26).

components of the interventions were poorly designed at the outset and proved unacceptable to end users.[17] A symptom of this open-ended system, as illustrated in Figure 1a, is that implementers have often focused more on delivery of units (e.g., latrines, water filters, cookstoves) and may not have invested adequately in their sustained use or provided for ongoing budget requirements over time as an output or outcome in development projects.[18,19] This prioritization of delivery of products over services has many root causes, including the interests of donors who may find it easier to count products, or the absence of incentives to ensure technologies are used over time to effect change. Further, development donors and implementers may assume that local governments can sustain the costs of basic services once installed, or that cost recovery can be achieved solely through user fees, despite the reality that high-income countries subsidize basic services, such as water, for consumers.[20,21] As a result, many efforts fail to deliver on the promise of reduced exposures and improved health outcomes.[22−24] This model of donor support only for capital investments has been increasingly questioned in development discourse,[12,19] and has led to a call for smarter metrics and aligned organizational and financial incentives[25] to enhance service provision.

■ GLOBAL DEVELOPMENT AND THE CRISIS OF ACCOUNTABILITY

The prospects for improving environmental health of the world's poorest people through the application of technologies and development programming are limited by a fundamentally broken global development context. Within the technocratic culture and profession of global environmental health and engineering, many of us are either unaware of or choose to ignore the larger causes of constructed and persistent poverty, choosing to focus on addressing symptoms (e.g., the lack of basic infrastructure) with donor funds instead of drawing attention to underlying drivers such as the legacies of slavery, colonialism, resource extraction, national debt, unfair trade practices, tax avoidance, and, increasingly, climate change.[27−32] While such action may be justified in focusing on the immediate and proximal needs of communities, the context for our work is critically important to consider carefully when seeking to implement sustainable change in complex systems. We know that many of our approaches to improving environmental health have not achieved long-term, sustainable success.

The global environmental health sector is funded to a considerable extent by foreign aid and philanthropy, which are promoted as part of the solution to the persistent symptoms of poverty, including unsafe water, inadequate sanitation, and hazardous air. While national and local governments and communities invest both in-kind and financial resources toward improved environmental health services, foreign aid and philanthropy often control the allocation of funding.[33] Indeed, over $160 billion per year is provided by high-income countries to low-income countries in part to address environmental health disparities and related issues.[34] While this may seem a considerable sum, aid is balanced by financial outflows, resources provided from low-income countries to high-income countries, which exceeded inflows by over $3 trillion in 2012.[35] This $3 trillion per year in total net outflows represents 18 times the annual global foreign aid budget. Between 2008 and 2017, there was a gap in trade between 135 low-income countries and 36 high-income countries of $8.7 trillion dollars.[36] Meanwhile, a 2020 recent study found that across labor, materials, energy, and land resources, high-income countries are net beneficiaries of resource extraction from low-income countries every year.[37] In other words, *the developing world is developing the developed world.*[28]

Other macro trends continue to exacerbate inequalities and increase barriers to improving environmental health. COVID-19 is anticipated to push as many as half a billion people back into poverty, at least on a temporary basis,[38] while at the same time income inequality is increasing within countries and globally. Oxfam reports that the richest eight people have more wealth than the poorest half of the world's population,[39] and that the richest 1% of people emit more than double the carbon emissions of the poorest half. Meanwhile, climate change is exacerbating and accelerating poverty in some regions of the world. The World Health Organization (WHO)

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Table 1. Proposed Characteristics of Feedback of Greatest Utility in Environmental Health and Engineering for Global Development

feedback criterion	comments
developed in partnership with communities and service providers	project stakeholders should agree at inception which quantities will be measured, how the data will be interpreted, and the actions taken to course-correct as the project unfolds to support mutual accountability
incentivized	feedback on project or intervention performance can and should be directly linked to incentives among key stakeholders, so that influential information is used in course-correction
cost-effective	feedback mechanisms, while potentially increasing project costs, may result in more cost-effective service delivery through more accountable and responsive operations and maintenance
transparent	measurement and data on project performance should be accessible to all project stakeholders, especially those who stand to be harmed if the project is unsuccessful
actionable	feedback should provide interpretable information that can provide the basis for timely action by stakeholders
timely	feedback must be delivered in time to make a difference in program activity to achieve desired ends
objective	objectively measurable data—ideally measured automatically or independently from program staff—may be able to reduce or eliminate bias in measurement
relevant	feedback data should be on the causal pathway between the intervention and the intended outcomes or should be directly relevant in the causal chain represented in the project's theory of change

conservatively estimates that climate change-driven increases in temperature (heat waves), diarrhea, malaria, and malnutrition due to crop failure will result in over 250 000 additional deaths each year between 2030 and 2050.[40] A further 100 million people could be pushed back into poverty by 2030 because of climate change.[41] Most of these deaths and hardships will e occur in developing countries, which are among the populations least responsible for climate change and least economically able to manage its impacts.

The unequal and disproportionate environmental burdens borne by lower-income countries and their populations highlight the responsibility of actors in high-income countries to avoid exacerbating the problems through ineffective aid programs that fail to deliver. We acknowledge that no new water filter product, social enterprise intended to support sanitation services, elementary school rainwater catchment tank, electricity grid, or lecture to a local government on the importance of water pump maintenance will fundamentally change the inequities that characterize the aid sector. However, there are compelling opportunities to make our work more effective, made possible in part by new approaches and technologies to transparently and effectively monitor how well interventions are working to improve living conditions among the world's poorest and most vulnerable people. Using these emerging methods to increase accountability in environmental health and environmental engineering programming—between donors, governments, NGOs, and the communities who stand to gain or lose as a result of programs—can help create an enabling environment for more successful projects that ultimately result in healthier communities over the long-term. Improving accountability relies on incorporation of feedback mechanisms to drive change as approaches are refined and programs adapt to their human and environmental context (as illustrated in Figure 1b). The model we propose underscores the need for *institutional behavior change* among donors and governments who fund and implement programs to improve environmental health. Therefore, we do not view feedback methods and technologies as simply new tools to assist in project management or to further devolve responsibilities down to those with the fewest resources. Instead, we propose that feedback can strengthen mechanisms of mutual accountability, responsibility, and effectiveness among many stakeholders, including among donors from high-income nations whose economies have benefited from resource export, trade imbalances, and the energy use that contributes to climate change, and who may now have an opportunity to share responsibility for improving global health.

The need for appropriate feedback in improving environmental health programming is evident in the humanitarian and global development sector, broadly including professional service providers, implementers, donors, governments, and other actors whose remit includes the design and delivery of programs and services. Feedback can take many forms and can range in utility with respect to course-correction in development programming; we describe ideal characteristics of feedback mechanisms in Table 1. In the following sections, we describe how feedback can be useful to professional service providers, implementers, donors, and governments who plan and roll out programs; to individuals and communities that expect to benefit from programs; and to the research community who study these interventions in controlled and real-world settings. We provide illustrative examples supporting these identified opportunities. We do not provide a detailed review of all available methods or technologies. Instead, we highlight the utility of leveraging emerging tools for feedback across varied applications and stakeholders to improve accountable and effective programming.

FEEDBACK TO IMPLEMENTERS AND SERVICE PROVIDERS

In standard development practice, programs may be expected to perform as planned from inception to conclusion, with program design, planning, and technology development and selection occurring months or years before deployment. Programs may well be designed based on the best available information, perhaps reflected in a *theory of change* or *logical framework*.[42] Few opportunities may exist for course correction, even if the implementation design includes measurement and a plan for interpreting early results to adjust for experience on the ground, and often changes to programming are contractually difficult or impossible. A theory of change may prove to be the wrong one, or behaviors that are key to an intervention's protective effects are not observed.[43] Intervention roll-out may continue despite evidence that the program is not working, and this insight is only possible if such things are being measured and interpreted in time to make appropriate changes to influence outcomes.[44−46]

Program performance is usually tracked via *monitoring and evaluation* frameworks of varying sophistication and rigor, as well as impact evaluation.[47] Monitoring and evaluation, while usually occurring nearly concurrently with program delivery,

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may or may not measure parameters that can identify performance with respect to the project's overall goals.[48] Impact evaluations, often using controlled trial designs and conducted over years, may be even less amenable to proactive use of data to influence program outcomes: study designs typically require that programs do not evolve over time, so that causal relationships can be identified via hypothesis testing that requires isolation of variables.[49] We suggest that standard monitoring and evaluation and impact evaluation are usually not well suited to iterative program evolution or accountability. Further, program funders, implementers, and evaluators—the professionals of the global development sector—are not generally directly accountable for the longer-term outcomes and impacts, which are often reported, if at all, years after program implementation when most everyone (besides the beneficiaries) have moved on. Enhanced feedback could improve mutual accountability and performance, and require greater commitments from program implementers, donors, governments, and communities toward sustaining the benefit of programs. It may also help programs evolve quicker, or "fail fast", by rapidly identifying what does not work to achieve outcomes of interest.

Effectively using real-time data to improve basic environmental services requires that this information be incorporated into local management policies and practices.[50] Study designs that allow for adaptation in program delivery can still collect credible data, but the goal is in improving service delivery when and where opportunities for course-correction exist and not necessarily rendering a final verdict on a static implementation plan. Such an approach is consistent with core methods in implementation science, an emerging field that seeks to advance the effectiveness of programs and interventions in a range of sectors.[51] In the context of environmental health, implementation science seeks to narrow the "know-do" gap between a given intervention and observed results under real-world conditions.[52] A useful framework for determining the impact of feedback on service while simultaneously evaluating and refining methods to implement these data into local management practices is the hybrid effectiveness-implementation design.[52] This study design retains the ability to identify causality in impact evaluation without being bound to a static randomized controlled trial-type design, ones that often can take years to report null results.[16] This class of study designs combines rigorous summative evaluation of the effectiveness of a given intervention with formative evaluation of the progress and effectiveness of intervention implementation.[53] Importantly, unlike traditional trial designs like the randomized controlled trial (RCT), this approach allows information from formative evaluation to be utilized during the conduct of the study to optimize implementation and creates a framework for assessing the impact of evolving implementation strategies.[54]

Sensors. In recent years, electronic sensors have been developed and applied within environmental health programs to support both health studies and provisioning of basic services.[50,55,56] While hardly comprehensive or sufficient measurement tools on their own, these electronic sensors have provided some novel insights that can help measure and refine interventions. They can provide the most basic and yet an often-missing piece of data: whether a pump, tank, pipe, or other device is working correctly or not, and if/when people are actually using the products or services. Critically, they have the potential to be coupled with increasingly prevalent communication tools—including mobile networks—creating a pathway for the transmission of actionable information to stakeholders with an interest in course correction. In the right context, sensors have been used to inform stakeholders regarding the use of sanitation technologies,[57−59] to establish new methods for higher-efficiency sanitation service delivery,[60] to understand actual user behaviors around new WASH technologies,[61] to support measurement of the health impacts of interventions,[62] to improve service levels and operations and maintenance practices for water infrastructure,[4,63] and to examine water use behaviors in the face of climate change.[64,65]

As one example, in 2014 we installed cellular connected sensors on rural handpumps in Rwanda capable of measuring handpump use and function with accelerators and water pressure transducers (n = 181 pumps), in order to more quickly identify pumps that were broken so that repair teams could be mobilized. Before the sensors were installed, some 44% of the area's pumps were broken at any given time, and it took an average of about seven months to get a pump repaired. Using sensor data, the repair interval was reduced to 21 days with mean of nearly 91% maintaining functionality.[4] We then deployed sensors on handpumps in Kenya, and leveraged statistical machine learning to try and predict when a handpump would fail (n = 42 pumps). We were able to demonstrate that functionality could be improved to greater than 99% using a machine learning model.[5]

FEEDBACK TO RESEARCHERS

Critically, feedback methods that provide objective data are playing an increasing role in two important domains of environmental health research: (1) environmental hazards across scales and (2) behaviors (consumption, compliance),[3] both of which are required to estimate exposures. Air and water quality data are usually not available at the level of the household or individual, where it is most relevant with respect to outcomes, and self-report of safe or protective behaviors is subject to bias and unreliable. Coupled sensing and communication platforms are advancing to reduce these weaknesses in environmental health research, providing critical links in the causal chain tying interventions to outcomes.

Examples include air quality exposure measurement techniques using spectroscopic, light scattering, gas sensing, or gravimetric techniques,[66−68] which have received the most attention in recent years,[69,70] allowing researchers to evaluate whether intervention strategies are likely to translate into health effects.[71−73] In sanitation research, motion activated sensors have demonstrated that self-reported data can result in significant over-reporting of latrine utilization by more than 50−100%.[57−59,74]

FEEDBACK FOR CITIZENS AND COMMUNITIES

In a consumer-based market, feedback on product acceptability, viability, utility, and pricing are addressed through consumers purchasing (or not purchasing) products, products that are often regulated by a tax-supported agency (e.g., EPA, FDA) to ensure quality and function. However, in many environmental health interventions, often the consumer of the product or service is not the customer, they are instead the "beneficiaries", and the customer is instead an international donor, with some further coordination of responsibility with national government ministries.[75] These contracting models negate the feedback of consumers speaking with their wallets

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to urge the improvement of a product or service. In lieu of bona fide market based consumer feedback, we have identified other essential qualities of feedback that may be usefully deployed to support both individual and community behaviors, and feedback to program implementers (Table 1). Near-time feedback to individuals and communities—those who can directly act on this information to reduce exposures when and where they occur—is a critical but underutilized application of feedback in environmental health.[76] In some cases, such information can be an intervention itself, because direct knowledge of actual or potential exposures can incentivize those at risk to take action: to put technology into use, to change behaviors, or to advocate for community action.

Timely and actionable information on individual risk has been shown to positively influence health-related behaviors and decision-making in a variety of contexts.[77] Individual tailored health feedback as an informational intervention—often delivered via mHealth methods made possible by mobile devices—is now widely used in public health research and practice. Such methods have been trialed as a strategy to increase adherence to medical treatments,[78,79] promote physical activity[80] and healthy diet,[81] support safe driving,[82] improve clinical care practice,[83] promote sexual health,[84] and otherwise contribute to supporting public health in contexts where risk is driven partly or wholly on human behaviors.[85] Such methods are starting to reach scale. For example, insurance companies are capturing sensor data[86] and user feedback to promote behaviors that may reduce risk of accidents[87] or other adverse (and costly) health outcomes.[88]

In our own studies, we have observed the utility of providing actionable, health-informed feedback to individuals in households. In an RCT in India (n = 589 households) we found that sharing results on microbial water quality tests increased reported water treatment (i.e., boiling) and resulted in a 76% decrease in microbial contamination of household drinking water. In a RCT (n = 170 households) in Rwanda we observed a 63% increase in number of uses of a household water filter per week among households that were aware an electronic sensor was monitoring their use,[61] a phenomenon known as the Hawthorne effect.[89,90] Recently, we have used air quality sensors to try and influence households to use cleaner cookstoves.[91]

New feedback methods can be coupled with citizen science[92,93] serving both at-risk communities as well as the broader community of researchers, practitioners, and advocates in environmental health. We suggest that such approaches directly benefit those with the greatest stake in environmental health—those living in high-risk settings—by involving them directly to collect and communicate data that provide the basis for risk assessment and feedback to stakeholders or to the public at large via within-app or mobile-to-web platforms. On 21 July 2015, Leo Heller, then the United Nations Special Rapporteur on the Human Right to Safe Water and Sanitation, released an open letter to UN member states calling it "essential that people freely and actively participate in and contribute to monitoring including the data collection, analysis and dissemination" for water and sanitation,[94] reflecting increasing interest in this approach and also the lack of data that exists generally where exposures are greatest. One such mechanism for this engagement is Integrity Action (www.integrityaction.org) where "citizens to monitor the delivery of vital projects and services where they live, and to solve the problems they find."

FEEDBACK TO DONORS

There is emerging alignment between rigorous performance measures and donor supported funding incentives. Such approaches can increase accountability among both donors and implementers, and scale of effective interventions.[95] Sometimes these are called performance-based-payments, output-based aid (OBA), or formed as development impact bonds (DIBs). Ideally, these mechanisms can safeguard the interests of both donors and communities that receive interventions by tying financial resources to delivery of better outcomes. However, these mechanisms also run the risk of reinforcing existing donor-beneficiary power imbalances, and allow donors to retain control and authority over programs and services, in the worst case providing unreliable and fickle support. To span this gap between improving mutually accountable incentives and reducing power imbalances, organizations including Uptime (https://www.uptimewater.org), Feedback Laboratories (www.feedbacklabs.org), Measure What Matters (www.measurewhatmatters.info), and Proof of Impact (www.proofofimpact.com) are emphasizing better measurement, feedback, program improvements, and, critically, working to support the tying of program funding to measured outcomes. For example, the Uptime consortium is developing performance-based contracting models to support rural water services by linking verifiable data on system functionality with payments to water service providers,[96] while iDE, a U.S.-based technology and social enterprise innovator, recently launched the first development impact bond for sanitation, with support from the Stone Foundation and USAID.

These financial incentives and opportunities are aligned with the intent of improved environmental services. Through measuring and paying for performance, donors and service providers become mutually accountable for cost-effective development programming and community benefit. Indeed, investing in services can return significant economic, health, and livelihood benefits to communities, dramatically outweighing costs.[97−102]

Data as a Donor Service. In high-income countries, the cost of data collection and dissemination is often considered a public good, even when subsequently monetized by the private sector. For example, weather data is collected by radar stations and satellites supported by NASA, NOAA and the European Space Agency, and is used by citizens, companies and service providers globally. Within the development sector, there are some initiatives that squarely consider data and decision aids a donor service, including the Famine Early Warning Systems Network (FEWS NET, www.fews.net), a USAID funded effort to improve food security monitoring in service of low- and middle-income countries to the tune of about $180 million dollars per year.

Therefore, the current model of expecting the operational costs of a service, including a data service, to be supported wholly by a beneficiary government or community is, perhaps, not a viable assumption. Instead, donors could provide both a service, and improve shared accountability, through accepting a long-term responsibility for providing data as a public good.

Cost Implications. The per-unit or per-project cost of purchasing, deploying, maintaining, and interpreting data is dependent on technical and project complexity, sampling strategy, technology maturation, and commercialization status, and market size.[50] In our experience, electronic sensors or other custom feedback systems designed for specific research

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projects or applications will invariably have an effective per-unit cost considerably higher than a mass-produced consumer product, despite an apparently low-cost "bill of materials" accounting. We also observe that many of these technologies and methods are delivered by experts from donor countries, potentially reducing direct budget support for field programming. However, the unit cost of these products, or even the bottom-line budgetary impact to a project, is meaningful only when weighed against the benefits of a potentially more cost-effective, accountability and responsive program, service, outcome, or impact. For example, the mechanical failure of water pumps in arid regions of East Africa can result in a direct increase in the cost of water service delivery to all parties—consumers, governments, and donors. USAID and UNICEF estimate that measures taken in advance of drought in this region, including improved operation and maintenance of water pumps, can save hundreds of millions of dollars compared to emergency relief efforts.[103,104] By extension, the increased project cost of improved monitoring can be plausibly justified by the decreased per-person cost of a service. These proactive measurements and actions may influence policy as well as practice in delivering cost-effective services (e.g., ref 59). Ultimately, these sorts of feedback technologies can facilitate and empower citizenry to demand the accountable and responsive services that have been promised.

Feedback in the Time of Pandemic. In this time of pandemic, feedback approaches are relevant to disease surveillance, including wastewater based epidemiology as an early warning system for COVID-19 outbreaks,[106,107] vaccine administration,[108] and toward the more basic services described in this paper, ensuring that these billions of people are finally served with soap and water, benefits known to society for at least a hundred years. The World Health Organization and the Centers for Disease Control and Prevention have provided clear guidance on one of the most critical measures we can all take to protect human health and reduce the spread of COVID-19: "Hands should be washed with soap and water." While clear and simple, this directive is far from attainable for the 3 billion people around the world who lack access to soap and safe water at home.[109,110] Supply chain, water service, and sanitation behavior monitoring can hold the global community accountable for ensuring these basic dignities and disease prevention methods are available to all.

MOVING FORWARD

Actionable, timely feedback mechanisms in environmental health initiatives can be critical for donors and governments to ensure programs are delivering on their promise, for beneficiaries to make changes that may be directly relevant to household-level exposures, and to researchers for better understanding whether and how interventions can lead to change. We cite a few examples, but there are many more and they are currently underutilized in the development space where such tools can help realize the promise of environmental interventions to improve health outcomes at scale. Importantly, these data collection and feedback mechanisms can support existing measurement standards, including the indicators toward the United Nations Sustainable Development Goals (SDGs).[111] For example, the WHO and UNICEF Joint Monitoring Programme provides indicators for measuring progress toward the United Nations Sustainable Development Goal 6, "clean water and sanitation." These indicators, such as consistent and exclusive use of clean water, have a variety of potential measurement tools including biomarkers, sensors, surveys, observations, and institutional records.[50] The mechanisms described in this paper can be used to support and improve accurate and timely SDG indicator monitoring, across a range of goals. We suggest that more timely feedback can support an enabling environment wherein financial incentives are aligned with accountable and responsive services. Feedback that is actionable and acted upon will help increase accountability among many stakeholders, and propel the development of solutions that can work over the long-term, allowing the benefits of environmental health improvements to be sustained in settings where they are most critical. Ref 105.

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Notes

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Biography

Evan Thomas is the Director of the Mortenson Center in Global Engineering, and holds the Mortenson Endowed Chair in Global Engineering at the University of Colorado at Boulder. He is a tenured Associate Professor jointly appointed in the Civil, Environmental and Architectural Engineering and the Aerospace Engineering Sciences Departments, and an affiliate faculty in Environmental and Occupational Health at the Colorado School of Public Health. Evan is currently a member of the NASA and USAID SERVIR Applied Sciences Team and a member of the board of the Millennium Water Alliance.

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Evan has a PhD in Aerospace Engineering Sciences from the University of Colorado at Boulder, is a registered Professional Engineer, and has a Masters in Public Health from the Oregon Health and Science University. Evan's technical background is in water and air testing and treatment applied in developing communities through to operational spacecraft. Evan's research has been funded by NASA, the National Science Foundation, the World Bank, USAID, the UN Foundation, the CDC, the United Kingdom Department for International Development, the Gates Foundation, and others.

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