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Bringing the lab bench to the field: Point-of-care testing for enhancing health research and stakeholder engagement in rural/remote, indigenous, and resource-limited contexts

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Abstract

Point-of-care testing (POCT) allows researchers and health-care providers to bring the lab bench to the field, providing essential health information that can be leveraged to improve health care, accessibility, and understanding across clinical and research settings. Gaps in health service access are most pronounced in what we term *RIR* settings—rural/remote regions, involving Indigenous peoples, and/or within resource-limited settings. In these contexts, morbidity and mortality from infectious and non-communicable diseases are disproportionately higher due to numerous geographic, economic, political, and sociohistorical factors. Human biologists and global health scholars are well-positioned to contribute on-the-ground-level insights that can serve to minimize global health inequities and POCT has the potential to augment such approaches. While the clinical benefits of POCT include increasing health service access by bringing testing, rapid diagnosis, and treatment to underserved communities with limited pathways to centralized laboratory testing, POCT also provides added benefits to both health-focused researchers and their participants. Through portable, minimally invasive devices, researchers can provide actionable health data to participants by coupling POCT with population-specific health education, discussing results and their implications, creating space for participants to voice concerns, and facilitating linkages to treatment. POCT can also strengthen human biology research by shedding light on questions of evolutionary and biocultural importance. Here, we expand on the epidemiological and research value, as well as practical and ethical challenges of POCT across stakeholders (i.e., participant, community, health researcher, and trainee). Finally, we emphasize the immense opportunities of POCT for fostering collaborative research and enhancing access to health delivery and information and, by extension, helping to mitigate persistent global health inequities.

1 | INTRODUCTION

According to a 2018 joint report by the World Bank and World Health Organization (WHO), at least half of the world's population still lacks access to essential health services; unsurprisingly, the most pronounced gaps in access are among the world's poorest and in the most remote regions (Kieny et al., 2018). Point-of-care testing

(POCT) has been increasingly proposed as one solution for improving health-care provision in these locales (e.g., Katoba et al., 2019). "Point-of-care" refers to testing that occurs in close proximity to the patient rather than in a central laboratory, usually on portable medical devices that require a smaller biosample volume than standard lab tests, with results generated within seconds or minutes (Gildner et al., 2022; Shaw, 2016). POCT may also be broadened to include other types of devices that do not require biosamples, but that provide immediate, potentially actionable results for patients or research participants, such as ultrasonometers, pulse oximeters, and accelerometers.

Potential clinical advantages of these devices and their features are immense. For example, with central laboratory testing patients usually must wait days to receive test results which can create psychological stress as well as delay the initiation of necessary treatment. By eliminating the need to ship biological samples and expediting delivery of patient results, POCT can improve patient compliance during treatment and enhance their sense of health ownership (e.g., Gialamas et al., 2009). In this way, POCT can be viewed as "patient-centered" (in clinical settings), or "participant-centered" (in research settings),[i] prioritizing the individual's experience (rather than centering on the health care provider or organization) while improving overall health-care delivery.

For health-focused researchers working with underserved groups in rural/remote (R), Indigenous (I) peoples and/or resource-limited (R)-settings—referred to here as *RIR* settings—POCT is currently available for an array of health measures relevant to biocultural and evolutionary research (e.g., see review in Gildner et al., 2022); such devices offer enormous research value, including enhanced participant and community engagement and opportunities for health education, in addition to logistical benefits such as reduced equipment and travel infrastructural costs (Shephard, 2017).

The current article synthesizes information on the epidemiological and research value of POCT and describes its challenges, aiming primarily at human biology and global health researchers working on-the-ground in RIR contexts. We also detail the broad range of impact that POCT can have on participant, community, and student/trainee engagement, while considering the potential for such tools to help mitigate long-standing and well-documented inequities in health-care delivery (e.g., access and information). Importantly, we approach this manuscript while implicitly recognizing the wide array of contexts in which researchers work, including variation in local health-care infrastructure (e.g., resources and capabilities) and consistency of access to health care information and providers (e.g., physicians, nurse practitioners, etc.) (e.g., Urdea et al., 2006), vast range of funding opportunities across disciplines, culturally sensitive levels of engagement and collaboration with RIR populations (e.g., Tsosie et al., 2021), and variation in feasibility of regional, national, or international collaborations.

2 | ADDRESSING A NEED: HUMAN BIOLOGISTS IN RIR SETTINGS

Human biologists and other global health-focused researchers are poised to contribute population-level insights that can serve to minimize global health inequities. Many human biologists have documented the changing epidemiological landscape among global rural/remote and Indigenous populations, who, due to historical and contemporary discriminatory practices, are often situated in resource-limited settings (such as those in low- and middle-income countries [LMICs]) (e.g., Gurven et al., 2021; Liebert et al., 2013; Schulz et al., 2006; Snodgrass, 2013; Valeggia et al., 2015; Valeggia & Snodgrass, 2015; Zienczuk et al., 2012). Even when human biologists working in RIR contexts are not directly involved with the health delivery systems available to participants, they often have anthropological understanding of how local beliefs, norms, and values operate on diseases and their treatment, maintain close long-term relationships with community members, and can document important barriers to healthcare access, such as economic or cultural barriers (e.g., Farmer, 2003; Farmer, 2020; Ji & Cheng, 2021). This local knowledge may allow human biologists to either formally or informally facilitate health service access and bridges to treatment across multiple levels. These pathways include at the participant (e.g., providing direct POCT results and health education; connecting participants to local health resources), local governance (e.g., via summaries to relevant Indigenous organizations and/or health authorities detailing community-specific issues), and regional, national, and international levels (e.g., via reports that support local requests for medical outreach or programs in underserved communities).

Research in RIR contexts is also critical for illuminating numerous broader issues of biocultural and evolutionary importance. For one, human biologists continue to unravel the complex relationships between social, political, and economic inequities that historically and continuously contribute to health disparities. These insights have shed light on the link between historical inequities and contemporary bodies (such as the effects of intergenerational trauma on health and well-being), particularly among historically subjugated populations, and have underscored that health may be shaped across generations of experience (e.g., Conching & Thayer, 2019). Secondly, casting a lens onto health in RIR contexts has allowed human biologists to address ultimate questions, including why certain physiological responses evolved and how these evolved responses might become maladaptive within the context of novel environments (e.g., those characterized by overnutrition, sedentary behavior, chronic psychosocial stressors, and environmental pollutants, among others) (e.g., Gurven & Lieberman, 2020; Pollard, 2008; Schell, 2014; Trevathan et al., 2008).

Finally, human biologists working in global health generally focus on underserved populations whose biomarker and anthropometric values are typically compared to references derived from wealthy, affluent and often homogeneous populations. Such references range across health-related measures, from reproductive hormones and immune biomarker levels to growth trajectories in children. These references are defined by the biomedical establishment as "normal" or "typical" and, consequently, impose a narrow, likely evolutionarily novel range of values onto phenotypic variation, from which to interpret "atypical" or "abnormal" levels (Wiley, 2021). Epidemiological insights from heterogeneous populations have the potential to help dispel normative judgments about what human biology "should" look like, while simultaneously promoting a more inclusive approach to understanding human biological variation and its varied determinants (e.g., genetic, epidemiological, and epigenetic) (Wiley, 2021).

In these ways, human biologists who work with diverse peoples can address immediate and practical needs (e.g., health-specific) within RIR contexts, while simultaneously addressing larger, ongoing theoretical discussions within anthropology and evolutionary biology.

2.1 | Defining RIR

Rural/remote regions, involving Indigenous peoples and/or within resource-limited (RIR) settings, are often underserved and/or socioeconomically marginalized. Whether situated in LMICs or high-income countries, a common theme persists—health and well-being are comparatively worse than in non-RIR contexts.

2.1.1 | Rural and remote

While both "rural" and "remote" refer to locations outside major metropolitan and urban areas, rural regions have lower population densities than urban locales, whereas remote areas typically have lower density across a more dispersed population (Dijkstra & Poelma, 2008; Wakerman et al., 2017). Rural and remote areas are generally separated from urban ones by distance due to lack of travel infrastructure, geographical or political barriers (Kelly & Dade-Smith, 2007; Shephard, Causer, & Guy, 2017). These barriers result in greater relative isolation, with people from rural/remote areas having to travel greater distances, times, and/or via more physically and economically-taxing transport—including by foot—and thus paying higher social, financial, energetic, and opportunity costs to access health services. These factors add additional burden onto often already economically stressed populations, thus contributing to lower rates of medical treatment, higher prevalence of disease and disability, and lower life expectancies than those with greater access (RHIhub, 2019).

Beyond spatial isolation, these health disparities can also be rooted in non-spatial barriers. Differing social, lifestyle, and environmental factors—including limited employment opportunities, lower income levels, and poorer access to housing, education, and transport—can all significantly influence the mode of health service delivery and patterns of disease (Shephard, Causer, & Guy, 2017; Strasser, 2003). Importantly, these determinants vary widely across racial/ethnic groups in rural/remote settings. For instance, disaggregated data from the US Behavioral Risk Factor Surveillance System (BRFSS) and National Center for Health Statistics (NCHS) show that rural minority populations are more likely to self-report poor health, to be uninsured, and to have comorbidities compared to non-minority rural populations (James et al., 2017; Murray et al., 2006). Anthropological and epidemiological research have also demonstrated the ways in which systemic and individual-level discrimination, coupled with a lack of voice and power, intersect with other determinants of health, further exacerbating these health inequities (Gee & Ford, 2011; Gravlee, 2020; Phelan & Link, 2015; Williams & Rucker, 2000).

2.1.2 | Indigenous populations

Disparities characteristic of rural/remote health exist across all regions in all countries around the world, yet nowhere is that health divide more pronounced than for Indigenous peoples (Marrone, 2007; Shephard, 2017; Valeggia & Snodgrass, 2015). Despite the considerable diversity across Indigenous[2] cultures and ecosystems around the globe, they share disparities across all dimensions of health (Egeland & Harrison, 2013; Valeggia &

Snodgrass, 2015). Many Indigenous communities are isolated in rural/remote locations and, as such, the determinants of poorer health described for these settings intersect with Indigenous identity and disadvantage (Marrone, 2007; Tsosie et al., 2021). It should be noted that Indigenous health disadvantage is also pervasive in urban regions, and evidence indicates that some health problems may be different from Indigenous peoples living in rural/remote areas (e.g., such as higher rates of asthma documented among urban Indigenous Australians) (e.g., Vos et al., 2008).

While a multifaceted and complex issue, factors including poor nutrition, poverty, environmental contamination, and cultural and linguistic barriers synergistically lead to poor levels of health among Indigenous groups globally (see Valeggia & Snodgrass, 2015). The intergenerational and persistent sociological and biological effects of colonization, disassociation from native land and cultural/linguistic heritage, and separation from families (and associated trauma) are additional assaults on Indigenous bodies that further contribute to poor health and well-being (Egeland & Harrison, 2013; Reyes-García et al., 2014; Marrone, 2007; Tsosie et al., 2021). Compared to non-Indigenous peoples, this translates into lower life expectancies (e.g., Tjepkema et al., 2019; Valeggia & Snodgrass, 2015), and higher rates of maternal and infant mortality (Kozhimannil, 2020), over- and under-nutrition (e.g., Egeland & Harrison, 2013), non-communicable diseases (NCDs) (Lucero et al., 2014), mental health issues (CDC, 2019), and infectious disease burden (Power et al., 2020). Even when factors like socioeconomic status, insurance coverage, and comorbidities are controlled, disparities between Indigenous and non-Indigenous health persist (Mayberry et al., 2000; Tsosie et al., 2021).

2.1.3 | Resource-Limited settings

Rural/remote and Indigenous peoples are often situated within resource-limited settings, further contributing to health inequities (Marrone, 2007). “Resource-limited” in this context refers to locales where the capacity to provide basic care for illness or injury is severely constrained. Constraints may include insufficient health care infrastructure (ranging from minimal to no electricity or clean water; inadequate or non-existent health clinic) and/or dearth of qualified health care providers (including physicians and other trained health workers) (Urdea et al., 2006). Though not unique to LMICs, limited resources for health care services are the most pressing issue in these regions (e.g., Bright et al., 2017), and can be exacerbated by barriers such as war, conflict, economic strife, as well as geographical obstacles to health services (Geiling et al., 2014).

Given these challenges, it is within the RIR health sector that POCT may offer the greatest benefit, by beginning to address inequities in access to health information and delivery, a critical step toward improving global health (e.g., Williams & Rucker, 2000). Of course, for large-scale health improvements to be enacted, enhanced resources, facilities, and rights must be prioritized by international organizations and national, regional, and local governmental agencies (i.e., top-down). These improvements are enabled and reinforced by people and institutions embedded within local communities (i.e., bottom-up) who call attention to inequities and priorities, as well as implement culturally appropriate community-informed public health interventions, local health training, and promote parity in health leadership and care (e.g., Sidik, 2022).

Health researchers, including human biologists, can complement and augment these efforts by acknowledging the health concerns in RIR contexts, providing basic health information in conjunction with POCT use, generating data to illustrate problems (e.g., conveying results that indicate emergence of disease states in a community while simultaneously mitigating stress about health concerns that may not be major issues), and collaborating on solutions that align with local interests, values, and capacities (e.g., offering culturally competent and salient health education; transferring knowledge such as through active training of qualified community members).

To be clear, POCT is not proposed as *the* solution to deeply entrenched disparities in infrastructure and access to health services. Rather, POCT represents an important tool with potential to enhance health autonomy by facilitating individual access to health information, promoting dialogue, health awareness and understanding across participants/patients, communities, health researchers and clinicians, and spotlighting specific on-the-ground health needs in RIR contexts.

3 | TAKING THE LAB BENCH TO THE FIELD WITH POCT

Point-of-care testing offers several clinical and research advantages compared to centralized laboratory testing. These devices are generally smaller than standard equipment found in central laboratories, although they vary in size from portable handheld units (e.g., for measuring cholesterol and other lipids, hemoglobin, glucose, etc.) to slightly larger benchtop devices (e.g., for analysis of protein signatures of various pathogens, enteric bacteria, and parasites, etc.) (Gildner et al., 2022). The simplest tests are equipment free and use paper-based assays (e.g., dipstick pregnancy tests). Other POCT devices typically require only a small volume of blood, urine, or other bodily fluid, which may be beneficial for younger individuals, individuals who have trouble with venipuncture, and when working in communities with concerns about blood draws (e.g., Boahen et al., 2013; Wiencek & Nichols, 2016). Further, POCT devices requiring only minimally invasive finger prick blood samples can be administered by researchers and local health promoters with minimal risk to participants and without the need for a phlebotomist.

Point-of-care tests are commercially available to address a range of conditions of public health importance, including both infectious and NCDs. For example, rapid testing is available to screen for infectious diseases such as HIV (Wu & Zaman, 2012), malaria (Kim et al., 2015), and syphilis (Marks & Mabey, 2017). Most recently, the development of novel POCT has aided public health efforts to curtail the transmission of the SARS-CoV-2 virus during the COVID-19 pandemic. Rapid, reliable detection of the SARS-CoV-2 virus allows health care providers to immediately identify and isolate infected community members instead of waiting hours or days for polymerase chain reaction (PCR) results. POCT for COVID detection, though not without challenges (e.g., Valera et al., 2021), is therefore a powerful tool for contact tracing and for informing local governance to make health-related decisions meaningful to their communities. Yet, access to COVID-19 testing is notably limited in under-resourced regions, exacerbating the impact of the current pandemic (e.g., Bateman et al., 2021). Implementation of a decentralized POCT model in geographically dispersed populations, such as the one described by Hengel and colleagues (2021) for remote Australian Aboriginal and Torres Strait Islander communities, can significantly bridge disparities in access for undertested and socially vulnerable populations during the current COVID-19 pandemic as well as in future pandemics.

Other POCT are available for NCDs such as diabetes, cardiovascular disease, and anemia. While studies have demonstrated the efficacy of POCT for monitoring NCDs among individuals and within communities, such tools are more widely available in high-income countries; again, this differential access represents one intervention point through which POCT can help curtail inequities in disease states within RIR settings. However, availability, usability, affordability, and sustainability of POCT, as well as a relatively recent emergence of NCDs in many RIR settings (and subsequent lack of infrastructure in place to address these conditions), are among some of the key barriers that limit access to and justification for POCT use in these contexts and consequently, contribute to global health inequities (Bernabé-Ortiz et al., 2021).

3.1 | POCT application in underserved RIR settings

Recognizing these barriers to health service access in RIR contexts, the WHO and other global health institutions (e.g., the World Bank) have called for improved POCT tools for use in settings with limited central laboratory access, and other challenges such as scarce clean water or reliable electricity (Drain et al., 2014). This mission is shared by numerous non-governmental organizations and initiatives such as Diagnostics for All (www.dfa.org), PATH: Center for Point-of-Care Diagnostics for Global Health (GHDx Center) (www.path.org), and *Médecins Sans Frontières* Transformational Investment Capacity (https://msf-transformation.org/). All have common goals of developing and implementing new POCT technologies and, ideally, multiplex devices that can simultaneously perform numerous diagnostic tests in resource-limited settings around the world (Chen et al., 2019).

Guidelines have been offered by the WHO in the form of seven core criteria outlining the ideal diagnostic testing in such settings; these guidelines, referred to as the "ASSURED" criteria (Affordable, Sensitive, Specific, User-Friendly, Rapid and robust, Equipment-Free or minimized, Deliverable), are described in Table 1.

Despite the value of ASSURED as "ideal" guidelines for POCT, few devices that are needed in RIR contexts fulfill all criteria (Peeling & Mabey, 2010). For example, while POCT for syphilis, chlamydia, and gonococcal infections have been developed, none of the available tests comply with every ASSURED criterion (Heidt et al., 2020). For this reason, some researchers have challenged the applicability of the ASSURED framework, arguing that it imposes artificial restrictions that may be unnecessary given the particular contexts in which the devices are used (Pai et al., 2012). Mabey and colleagues (2001), for example, argue that the specificity and sensitivity of a diagnostic test should depend on what is being tested, and relevant treatment cost and availability. If a treatment is cheap and side effects are rare, it is more important for tests to have a higher sensitivity than specificity (i.e., generate fewer false negatives than fewer false positives). The authors maintain that, ultimately, increasing access to diagnostics may have greater positive health impacts than improvements in test accuracy (Mabey et al., 2001).

In a rapidly evolving industry, the ASSURED criteria may also be applied to devices conventionally used in

TABLE 1 Summary of ASSURED criteria for development of point-of-care testing (POCT)

Affordable	Cost is a major driver in the development, approval, and use of POCT; this criterion is most salient in resource-limited environments although there is no common benchmark for what qualifies as affordable. Moreover, since tests are generally developed and produced in high-income regions, there exists a disconnect between what is considered affordable in these regions compared to resource-limited settings (Land et al., 2019)
Sensitive	POCT should minimize or avoid generating false negatives (i.e., incorrectly indicating that the condition being tested for is not present when, in fact, the condition is present)
Specific	POCT diagnostic tools should have low false positive rates (i.e., minimize the likelihood of a test indicating a condition is present when, in fact, the condition is not present). Ideally, sensitivity and specificity achieved from the POCT device should approach those of assays run in central laboratories (Land et al., 2019)
User Friendly	The ease of use should allow for rapid training of staff across the spectrum of medical and research experience
Rapid and robust	Rapid refers to results that are generated within seconds or minutes after sample collection. Robustness indicates an ability to withstand the supply chain (such as temperature and humidity) (Land et al., 2019)
Equipment-free/ minimized	The test should not require any specialized equipment (i.e., no large electricity-dependent instruments). Ideally, POCT devices are self-contained, packaged with all required reagents, and test results are either visually interpreted or read by relatively inexpensive battery-powered devices. This criterion is especially important in settings where purified water and uninterrupted power may not be available
*D*eliverable (to those in most need)	POCT should be portable, allowing them to can be used in temporary or part-time clinics that may be set up in tents or villages ensuring they reach the end-users in RIR contexts

clinical settings, but that are becoming increasingly compact and portable and thus feasible for use in field-based research and rural/remote settings. Devices such as bone ultrasonometers (e.g., Madimenos et al., 2012; Madimenos et al., 2015; Madimenos et al., 2020; Stieglitz et al., 2015; Stieglitz et al., 2016) and accelerometers (e.g., Gurven et al., 2013; Madimenos et al., 2011; Raichlen et al., 2020; Urlacher et al., 2021), are not typically classified as POCT devices, yet nevertheless satisfy most ASSURED criteria. Moreover, they can generate immediate health information that may be useful/relevant for research, clinicians and patients or research participants. Such devices are becoming increasingly important in RIR contexts because of the rapidly changing epidemiological landscape in these regions. For example, use of bone ultrasonometers among non-clinical populations have generated data to document the increasing global burden of osteoporosis risk, often described as the so-called "disease of civilization" (Madimenos, 2015). Accelerometers have tracked reductions in activity expenditure that accompany economic development across the globe—important insight as shifts toward increased sedentism contribute to NCD risk (e.g., metabolic syndrome, obesity, cardiovascular disease; e.g., Gurven et al., 2013; Urlacher et al., 2021). These technological advancements are increasingly facilitating access to key health data that will continue to enhance our understanding of human biological diversity and global health.

Several cross-sectional and longitudinal human biology research projects have incorporated both traditionally and broadly classified POCT devices in their methodology to address questions of epidemiological, biocultural, and evolutionary importance. Ongoing projects such as the Tsimane Health and Life History Project, Shuar Health and Life History Project, and research among the Hadza of Tanzania and Toba of Argentina, among others, have offered insight into issues related to reproduction, aging, and skeletal health (e.g., Madimenos et al., 2012; Madimenos et al., 2020; Stieglitz et al., 2016), life history trade-offs and growth (e.g., Blackwell et al., 2010; Gurven et al., 2017; Gurven et al., 2021; Urlacher et al., 2016) including trade-offs among different branches of immunity (e.g., Blackwell et al., 2011), and socioeconomic and epidemiological transitions (e.g., Lagranja et al., 2015; Liebert et al., 2013; Pontzer et al., 2018). One example includes research by DeLouize and colleagues (2022) who gathered hemoglobin data for a large sample of >1600 Indigenous Amazonian participants (aged 6 months to 86 years) using a HemoCue Hb201+ analyzer. Their results show that prevalence of anemia, a serious global health problem, is relatively low compared to other South American populations and comparable to European and Canadian rates. These findings suggest that subsistence-based lifestyles are not always associated with high rates of anemia and thus have implications for developing approaches that could mitigate high anemia rates among at-risk global populations.

Importantly, the application of POCT devices must be tailored to the unique challenges of a particular field site or region. Handheld devices (e.g., for measuring lipid and glucose levels [such as with the CardioChek PA analyzer], and hemoglobin [such as with a HemoCue analyzer]) are easily transported and deployed in most RIR settings. Even the heaviest and most energy consuming POCT devices may be employed, sometimes creatively, in remote locations. For instance, the Hologic Sahara Bone Densitometer, which estimates multiple parameters of calcaneal bone density (Madimenos et al., 2012, 2015; Stieglitz et al., 2015, 2016), weighs 22 pounds (lbs) (10 kilograms [kg]; upwards of 50 lbs [22.7 kg] in a protective carrying case) and uses 35 Watts of energy when actively in use (Hologic, 2014). It can be powered by an electrical grid or if necessary, using deep cycle batteries charged via solar panels (albeit introducing additional physical and financial costs) where sunlight and temperature permit (e.g., Madimenos et al., 2012, 2015). Sufficient sunlight is seldom a problem in equatorial zones (although high temperature can reduce efficiency and lower output) but can be problematic in field sites at higher latitudes, or those with significant cloud coverage. As each field site and research project presents its own unique challenges and limitations, the feasibility, benefits, and pitfalls of using specific applications must be determined by researchers who understand the research goals, setting and specific needs of the population with whom they work and thus determine best practices and approaches for POCT application (see Gildner et al., 2022 for overview of devices across variable field settings).

4 | POCT BENEFITS AND APPLICATIONS IN RIR CONTEXTS

Given the limited diagnostic and treatment capacities of most RIR contexts and the growing burden of poor health in these settings (e.g., Valeggia & Snodgrass, 2015), the use of POCT has numerous practical advantages for various stakeholders, including patients/participants, health researchers and professionals, local trainees, and the community more broadly (summarized in Table 2).

4.1 | Enhancing patient and participant experience and engagement

Recognizing the need to both envision and create more patient-focused health care systems is an ongoing global trend (e.g., Epstein & Street, 2011); this recognition is predicated on the idea that health care must be organized around the needs of patients rather than providers (i.e., clinicians, hospitals/clinics, health care systems). Such sentiment can be extended to participant-researcher relationships, so that the concerns, perspectives, and experiences of participants are foregrounded in the research process (i.e., participant-centered research) (Broesch et al., 2020). Within this framework, POCT can be viewed as a means of emphasizing participant needs and satisfaction while engaging them more directly in their health and facilitating access to health information and education in populations constrained by spatial and non-spatial barriers (including challenges imposed by disaster scenarios).

4.1.1 | POCT for improving patient and participant engagement with their health

An immense benefit of POCT by health-care providers and researchers is enhanced patient/participant understanding and health awareness through immediate delivery of basic health information and on-site discussion of results. While certainly important for high-income settings with robust health infrastructures, this benefit is especially critical in RIR settings with limited access to clinicians or basic health services. POCT allows delivery of health information that can guide next steps for linking at-risk patients or participants to necessary services and treatment and/or can serve as a foundation for basic health education. For example, among Indigenous Amazonian Ecuadorian Shuar living in towns and cities, obesity and type 2 diabetes have become growing concerns over the past two decades (e.g., Lindgärde et al., 2004; Rivero, 2012). However, Liebert et al. (2013) found virtually no cases of elevated fasting glucose (using a CardioChek PA system) among ∼100 Shuar participants residing in remote communities (at time of study, located ∼9 h by bus and 6–12 h by motorized canoe from central health services). Nevertheless, many participants in these remote communities were aware of diabetes and voiced concern, asking pertinent questions such as: *What is diabetes?, Is there a medication to cure it?*, and *Why are Shuar getting it now when our grandparents and ancestors never had it?* In this case, a study on the effects of market integration on metabolic health that incorporated POCT provided an invitation by participants for education on diabetes, even when neither the individual, nor segment of the population had yet been directly affected.

Health information and education can be empowering in that they may lead to changes in behavior that can improve health. Within the context of a global increase in rates of NCDs (e.g., cardiovascular disease, type 2 diabetes, and obesity), particularly in LMICs (WHO, 2021), results generated by POCT allow space for on-site

TABLE 2 Proposed benefits of point-of-care testing (POCT) across various stakeholders

Stakeholder	Proposed benefits of POCT
Patient/participant	*Improving patient and participant engagement with their health*
	• Greater sense of health ownership and autonomy through proximity of results (e.g., Lilly et al., 2020; Shephard, 2017)
	• Creates opportunities for educational dialogue about etiology of disease states and modifiable behaviors that can ameliorate patient/participant health status
	• Offers visible, tangible connection to health results (Cambridge, 2020; Gildner et al., 2022)
	• Less traumatic testing from minimally invasive sampling (Khan al., 2019)
	• Improvement in adherence to medication and treatment in clinical settings (e.g., Gialamas et al., 2009)
	• Minimal wait time for results; avoidance of secondary visit for results (Shephard, 2006)
	• More convenient
	Improving health access imposed by spatial barriers
	• Reduces travel time to distant health facilities (e.g., Shephard, Causer, & Guy, 2017)
	• Ensures start of treatment in same clinical encounter (e.g., Shephard, 2013)
	• Increases likelihood of follow-up visits for disease monitoring (e.g., Motta et al., 2017)
	• Helps to identify at-risk patients and prioritize their transport to nearby health facilities
	Improving health access imposed by disaster situations
	• Offers essential lab tests and services where hospitals are encumbered by physical or non-physical barriers (Kost et al., 2009)
	• Facilitates rapid diagnosis at site of patient care (Kost et al., 2006)
	• Can curb transmission rates of infectious disease through immediate diagnosis and treatment (Kost et al., 2006)
Health researcher /professional	*Forges a more engaging physician/patient or researcher/participant interaction*
	• Improved physician/patient rapport can translate into improved clinical outcomes (Shephard, 2006)
	• Allows for ongoing participant engagement and local collaborations which can reinforce research agenda
	Enhances a sense of empowerment and responsibility among trained community members who contribute to the success of a research project (e.g., Shephard, 2013)
	Reduces equipment and travel infrastructure costs (Gildner et al., 2022; Shaw, 2016; Shephard, 2017)
Community	*Empowers communities with health information that can support and justify solicitations for resources from regional agencies*
	Fosters community collaboration by training qualified locals on POCT (Gurven et al., 2017; Shephard, Causer, & Guy, 2017)
	Facilitates health screenings to hard-to-reach, vulnerable populations (e.g., Dona et al., 2019; McClure et al., 2015)
Trainees	*Forges a culturally competent research agenda by training qualified locals* (e.g., Shephard et al., 2020; Shephard, Causer, & Guy, 2017)
	Augments trainee learning of health processes
	Creates experiential learning opportunities (Dona et al., 2019)

discussion of modifiable lifestyle/behavioral factors that are connected to disease risk (e.g., diet or physical activity), as exemplified by the Shuar example above. By engaging in a dialogue about results and, by extension, individual participant health concerns, POCT has potential within community-based participatory research (CBPR) models; such models aim to forge a relational engagement whereby researchers and participants are one step closer to becoming partners with equitable stake in the research project (Sandoval, 2017). Within the context of recent disciplinary movements that call for necessary reevaluation and reimagining of the researcher-participant relationship across all facets of research, anthropological and beyond (e.g., Broesch et al., 2020;

Sidik, 2022; Tsosie et al., 2021), this may be among the most salient benefits of point-of-care testing.

Proximity to the one's own health data may also facilitate a greater sense of ownership in the testing process and control over one's own health information (Shephard, 2017). This may be obvious for patients who are self-managing their health and wellness using at-home devices such as blood pressure monitors and glucometers (Lilly et al., 2020). Yet, even when POCT devices are operated by others outside of the home setting, the visual connection to one's own sample being processed and the generation of results on the device screen have direct clinical value, contributing to increased levels of patient self-motivation and improve compliance with treatment (Gialamas et al., 2009). Among diabetic Indigenous Australians, POCT was effective in improving clinical outcomes with 93% of patients noting that regular POCT encouraged them to be both compliant and self-motivated to improve their health (Shephard, 2006). Moreover, these patients indicated that the immediacy and simplicity of POCT results contributed positively to their experience and improved the relationship between patient and doctor. Improved patient satisfaction can also come from testing that is less traumatic (e.g., due to minimal amount of blood collected) and minimally invasive (e.g., finger prick) (Khan et al., 2019).

Some of these benefits can extend to participants in health-based research as well, including enhanced participant experience and satisfaction in the research process. More importantly, however, is that basic health information provided by POCT results can arm participants with an understanding of how various chronic and infectious diseases emerge and may be prevented; this is especially valuable in regions undergoing rapid epidemiological shifts. Health information may also motivate/support an at-risk person to seek medical attention when they may otherwise be hesitant to do so because of financial, time, or travel restrictions. This latter point is most beneficial for participants in RIR contexts where health centers may be typically located far from the one's home.

4.1.2 | POCT for improving health access: Constraints by geographic distance

Unsurprisingly, geographical barriers, travel distance and time, and the opportunity costs they incur are critical obstacles to health service access. The greater the distance or travel time to health facilities, the less likely people are to access health resources and engage with health practitioners or return for follow-up treatment (Peters et al., 2008). In one meta-analysis of HIV/AIDS studies focused on sub-Saharan Africa, researchers found that 40% of HIV-positive patients do not provide a blood sample for testing or return to a central lab for their CD4 count (an indicator of immune function in HIV patients) results because of the long distances they must travel to attain healthcare (Rosen & Fox, 2011). This distance has severe implications for HIV-infected individuals in this region, contributing to a reduction in life expectancy.

Bringing POCT to a population/region constrained by geographic distance can therefore have immense benefits. Shephard et al. (2017) highlighted how employing three POCT models of health service delivery in rural and remote Indigenous communities led to a reduction in pre-diabetic patients through regular monitoring, allowed acutely ill patients to be diagnosed and treated in their community (i.e., avoiding medical evacuation), and improved the management and treatment of sexually transmitted infections. Researchers note that participant satisfaction was significantly higher after POCT implementation with participants reporting greater convenience with this mode of health delivery (Shephard, 2013). Notably, active training and collaboration with Indigenous health care providers at the front lines of POCT facilitated culturally competent dissemination and explanation of results, serving as an integral feature of the success of these POCT testing programs.

Enhancing access to health services has benefits even in peri-urban regions with limited public and health infrastructure. Project HOPE, a program established on the outskirts of Johannesburg, South Africa, aims to improve access to patient services for hypertension and diabetes using a POCT model. With global diabetes prevalence expected to increase by 25% by 2030 (Saeedi et al., 2019), and in Africa specifically, 110% by 2035 (Peer et al., 2014), initial data from Project HOPE are especially promising. Within two years of introducing POCT devices for hemoglobin A1c levels (HbA1c, glycated hemoglobin; reflects mean blood glucose across prior 3–4 months), HbA1c lowered significantly across at-risk participants with 48% showing improved glycemic control, results attributed to accessible POCT monitoring and treatment in the same clinical visit (Motta et al., 2017). Project HOPE demonstrates how bridging more proximate access to testing and immediate treatment translates into improved health delivery for at-risk patients in disadvantaged settings including increased likelihood of follow-up visits for diabetes monitoring.

Other research employing a global health lens, such as in human biology, may have fewer resources available to support long-term health care delivery models in RIR contexts, and can therefore enhance health-care access in conjunction with POCT use by minimizing the geographic distance between at-risk participants and available health services. The Bolivian-based Tsimane Health and Life History Project (THLHP), which employs POCT and other technologies to address questions related to aging, health, and sociality among Indigenous Tsimane, enables the transport of participants to nearby urban centers with more robust health services (Gurven et al., 2017). Here, participants who present with primary (e.g., bacterial and fungal infections; minor trauma; parasites) and urgent care needs (e.g., hernia surgeries; head trauma; brain tumors) in their remote villages are treated by qualified local professionals in urban centers and follow-up treatment is facilitated whenever necessary (Gurven et al., 2017).

Similar strategies are employed in our own fieldwork in remote Amazonia; the Ecuadorian-based Shuar Health and Life History Project (SHLHP) works in concert with local health workers (e.g., Indigenous nurses) to provide basic health information to interested participants and communities. For participants with POCT results outside the device-specific cutoffs (e.g., such as for hemoglobin, glucose, triglycerides), and/or who report concerning symptoms, SHLHP provides travel and financial support. Assistance may include coordinating transport to the nearest health centers (*puestos de salud*), covering costs of travel and treatment, accompanying a participant to facilitate communication with health workers, and in extreme cases, arranging a medical evacuation from a governmental or mission service (using two-way radio or satellite phone).

4.1.3 | POCT for improving health access: Constraints imposed by disaster scenarios

POCT may also have value for disaster relief efforts in communities where life-saving resources are hindered by physical (e.g., floods, inclement weather) or non-physical (e.g., power outages, lack of potable water, and war-related) barriers. Hospitals, for example, that are threatened by seasonal hurricanes, may experience significant disruption in laboratory operations. The health conditions of refugees and migrants in refugee camps may not be easily monitored because of a lack of clinics and hospitals (Bernardini et al., 2021); in these cases, POCT can support some essential laboratory tests and services (including testing for infectious pathogens often found at disaster sites [e.g., hepatitis, typhoid, dengue, yellow fever] or commonly detected among vulnerable refugees [such as *mycobacterium tuberculosis*]) (Bernardini et al., 2021). Limited availability of adequate diagnostic instruments and a sudden overload of critical victims and transportation failures has caused excessive morbidity and mortality in many of these disaster scenarios (Kost et al., 2006). Kost et al. (2009) argued that global efforts must be made to improve POCT to rapidly diagnose and treat patients to help avoid the worst consequences of disasters on the horizon, a plea made over a decade and a half before the current COVID-19 pandemic and the recent rise in politico-economic and climate change-related disasters. Integration and global use of POCT in emergencies can facilitate rapid evidence-based diagnosis at the site of patient care, in RIR and non-RIR contexts alike, and can potentially help prevent the spread of emerging and re-emerging pathogenic threats.

4.2 | Benefits to health researchers and professionals

From a clinical standpoint, the objective of POCT is to generate an immediate result to inform treatment options, while forging a more effective physician/patient interaction, thereby leading to improved public health or economic outcomes (Shephard et al., 2020). Shephard (2006), for example, found that among doctors working with POCT for diabetes management in remote Australia, 80% stated that POCT contributed positively to their rapport and relationship with their patients; additionally, >60% believed patients were more likely to return for a follow-up visit specifically because of immediacy of results. From a clinical outcome perspective, the percentage of patients who achieved optimal or improved glycemic control in this assessment increased by 12–19% since POCT introduction.

For health-based researchers in human biology and related disciplines, especially those who may not be medical doctors or practitioners and therefore not qualified to make clinical decisions or provide direct medical care, POCT offers an opportunity to gather data on population-level health to address practical or theoretical questions ideally studied in RIR settings, while also providing robust health information immediately to individual participants and creating a space for researcher-participant dialogue and feedback. In this way, POCT can help researchers forge strong, meaningful relationships with participants and promote participation, an essential component to the growth of a research project (e.g., Shephard, 2006, 2013; Shephard, Causer, & Guy, 2017). Importantly, strong participant-researcher relationships are also achieved while forging connections with local collaborators and/or Indigenous representatives and health care providers to ensure that the research is not extractive, but rather is beneficial to the community and their interests, and that results are disseminated in a responsible, culturally appropriate, and collaborative manner (Broesch et al., 2020; Sidik, 2022; Tsosie et al., 2021).

POCT may also facilitate local collaborations on another level, through the active training of qualified community members (e.g., health workers, nurses, and educators) as POCT operators. Notably, the extent to which a sustainable community workforce can be built is context-specific, as different field sites vary in the levels of participant engagement and collaborations possible. Moreover, the degree to which knowledge transfer is feasible may be limited by numerous factors including funding (which varies widely across disciplines and global regions). One of Australia's longest-standing POCT programs has attributed its success to empowering Indigenous health workers to train and work as POCT operators, training that has been facilitated by two decades of continuous funding from the Australian Government (Shephard et al., 2017). Indigenous operators, who share cultural and/or linguistic background with the patients, provide a crucial communication bridge between management staff, the community and non-Indigenous health staff; the operators themselves also report a strong sense of empowerment, responsibility, and commitment to the project (Shephard, 2013). Moreover, this position has become highly respected by the Indigenous patients they serve and proven crucial to the acceptance of the program within the community.

The Indigenous Siberian Health and Adaptation Project, which has incorporated a range of POCT devices across two decades of research, also collaborates extensively with local physicians and nurses, many of whom are Indigenous Yakut (Sakha) (Levy et al., 2016; Snodgrass et al., 2010). The simplicity of POCT use permits training opportunities for local collaborators, thereby enhancing their direct involvement in data collection and interpretation. Yakut collaborators perform POCT, disseminate health information to participants, conduct follow-up examinations, and are often co-authors on publications (e.g., Wilson et al., 2015). Similarly, the THLHP has trained over 45 Indigenous Tsimane as project personnel to date, many of whom have a primary role in collecting data, including using POCT (Gurven et al., 2017). This capacity building and training is an integral component to the success of THLHP and its ongoing collaborations with local hospitals and other institutions (Gurven et al., 2017).

4.3 | Applications for community engagement

Community collaboration is essential for the implementation, execution, and sustainability of any health-focused research agenda, including studies using POCT. At the outset, engagement with the community is critical to solicit feedback about local health concerns, to establish how research goals may address those concerns, why POCT may be introduced, what benefits POCT offers at the individual participant and broader community levels, and to ensure locally appropriate implementation of research design and methods (Sidik, 2022; Tsosie et al., 2021). If the community does not understand or accept what POCT involves and its potential benefits, then utilization of testing is likely to be poor and an invitation to work in the community improbable (Shephard et al., 2020).

POCT has potential to augment community-based participatory research approaches (CBPR) by helping build local health workforce capacity (described earlier) and direct and active engagement of communities in the research process (from inception to dissemination of results) (McCloskey et al., 2011). A fundamental principle of CBPR involves integrating knowledge and action, whereby knowledge itself is important, though not enough; it must be coupled with action for social change (Olshansky & Zender, 2016). Here we see the role of human biologists as contributing to knowledge and harnessing the strengths of the community to collaborate on developing and implementing means to alleviate health problems identified (i.e., action). For example, using POCT, communities may be empowered by greater awareness and knowledge about local-level health issues (Shephard et al., 2015). Coupled with an understanding of local cultural values and realities, researchers can convey POCT results to the community that may indicate the emergence of disease states in the population and/or reduce stress about issues that are not an immediate cause for concern. These insights may drive, help prioritize, and support decisions that community members themselves make when identifying local needs and appealing to regional organizations/agencies to provide health resources and outreach in RIR settings.

Such approaches are exemplified by work of the Tsimane project. Across two decades of research, THLHP researchers have employed a range of POCT including ultrasounds, accelerometers, and hematology systems (for measuring various blood parameters) as well as other methodologies integrated into community clinics (e.g., echocardiograms, CT scans, flow cytometry) (Gurven et al., 2017). Through extensive collaborations with Bolivian institutions, national laboratories, and non-governmental aid organizations, systematic baseline data (including biomarkers related to health and aging, infection, and inflammation) have been collected for thousands of Tsimane participants. In addition to organizing culturally salient educational workshops on disease states and prevention, health data generated by the THLHP are integrated into biannual reports that are submitted to the

Tsimane political council (*Gran Consejo Tsimane*) and local authorities to help solicit government resources to meet the health-care needs of the Tsimane (Gurven et al., 2017).

4.3.1 | POCT use in health initiatives targeting underserved populations in high-income regions

Access to health information is not uniformly and universally available around the globe, even in high-income nations such as the US. Among undocumented immigrants, for example, who comprise roughly 4% of the US population (~12 million individuals), a robust set of interconnected barriers limits access to health services including legal status, geographic proximity, language proficiency, health insurance eligibility, and financial means (Beck et al., 2019; Hill et al., 2021). Because of their portability, on-site testing features, and relative cost-effectiveness, POCT are easily integrated into health initiatives (such as health and wellness fairs) targeting underserved communities in high-income regions who experience many of these barriers to health care delivery (e.g., McClure et al., 2015).

An example that illustrates the successful application of POCT in community-wide health outreach comes from the collaborative effort, "Día de Salud," organized by the University of Oregon's (UO) Global Health Biomarker Laboratory, the community-based organization *Huerto de la Familia* ("The Family Garden"), local volunteer health providers, and undergraduate students (Dona et al., 2019). This annual free health fair targets the underserved Latinx community living in Oregon and offers general health information generated through POCT diagnostics including glucose, lipid, and hemoglobin biomarker testing (Dona et al., 2019). Although not a replacement for comprehensive primary healthcare, 50–100 participants are typically served at each event, highlighting the efficacy of screening facilitated by rapid, onsite POCT diagnostics. This type of holistic approach to delivering health information creates a social environment that facilitates networking and community engagement across participants, while providing a unique opportunity for direct contact with health care workers.

4.4 | Student/trainee impact

From a student/trainee standpoint, health fairs such as those described above can offer on-the-ground health services and interpreting experience specifically with POCT devices. With UO's *Día de Salud*, approximately 85 undergraduate students have participated in health fairs over the past decade, all of whom received training in POCT methods and cultural competency in health care (Dona et al., 2019).

POCT may indeed foster student/trainee engagement in research through heuristic approaches, particularly among individuals from underserved communities themselves. The experiential learning aspect of POCT allows for trainees to learn about health processes through generating their own measurements (e.g., Chamane & Mashamba-Thomspon, 2019). For example, POCT devices that measure lipid levels to assess cardiovascular risk can be an easy way to demonstrate the link between health markers and disease risk. Trainees can also engage with POCT to measure their own body's response to stimuli, such as with glucose. Introducing a dose of sugars to the body (as is done with a glucose tolerance test) can allow trainees to see the insulin response in action through their own physiology. In this way, trainees can make connections between behaviors, such as diet in this case, and health measures; as with research participants, this visual connection has benefits for the trainee's ability to communicate health information with study participants.

Ultimately, the ease of use of most POCT enables rapid training of individuals as device operators, while the simplicity of the test performance and interpretation allows individuals with different backgrounds and skills to achieve comparable results (i.e., low inter-observer variability in output) (Wiencek & Nichols, 2016). Moreover, training qualified people to perform POCT in their own communities is an effective means of forging a culturally competent research agenda, bridging local culture with scientific culture (Shephard, 2013; Shephard et al., 2020; Sidik, 2022).

5 | POCT: THE CHALLENGES

While the application of POCT can be an innovative solution for improving health care research in underserved groups and settings, the implementation and sustainability of such tools face several challenges in these contexts ranging from the practical (e.g., quality assurance concerns, hidden costs) to the ethical (e.g., the provision of long-term care for chronic conditions identified through POCT).

5.1 | Practical challenges

5.1.1 | Development challenges

One major challenge involves where POCT devices are typically developed (in high-income countries), establishing a fundamental disconnect and disengagement between device developers and end-users, and thereby inhibiting the full potential of these devices. For example, most POCT devices are designed for primary care facilities in high-income nations that are typically temperature-regulated. POCT devices require certain temperature ranges and will produce error messages when temperatures are out of range (Malcolm et al., 2019). Severe environmental conditions—including heat, humidity, sand, and dust—may also interfere with the functioning of POCT devices and reagents (Wiencek & Nichols, 2016). Thus, the onus is on the developer to not only create a testing format that is feasible, but also one that performs adequately within the constraints imposed by the available infrastructure and variable ecological conditions (Urdea et al., 2006).

Relatedly, device development is funded and managed largely by the private sector and is consequently driven by what device features and health targets are deemed most marketable and profitable (Gildner et al., 2022; Peeling & Mabey, 2010). Because of a perceived lack of return on investment, there is little incentive to target diseases with low impact in affluent regions. For instance, developers in resource-rich settings typically focus attention on chronic diseases or highest-burden infectious diseases (e.g., influenza, COVID-19) while disregarding neglected tropical diseases (NTDs; e.g., dengue fever, helminth infection, and schistosomiasis), which primarily affect the world's poorest populations (Furuse, 2019). With more than a billion people worldwide affected by NTDs, technical improvements of POCT are vital for the early diagnosis necessary for management and linkage to treatment (Bharadwaj et al., 2021). Yet, NTDs continue to be of little commercial research interest because of a lack of financial motivation for the development of relevant POCT devices.

5.1.2 | Infrastructure and resource challenges

Adding to ecological and market constraints, limited laboratory infrastructure imposes the greatest technical challenges for test developers (Urdea et al., 2006). The design approach to developing POCT for moderate- to high-resource regions generally involves the initial selection of the most suitable biomarker for a particular condition, and then technology design to target that biomarker without significant consideration of the infrastructure or resources needed to collect and analyze outside of clinical settings. Performing venipuncture, for example, is rarely an issue in high-income countries and so POCT developed for these regions generally have no strong restrictions for blood sample quantities (Heidt et al., 2020). Conversely, in RIR settings without a trained phlebotomist, a test must be able to work with samples that are easily acquired (such as saliva or urine) or much smaller blood sample sizes (via finger prick or heel stick). As such, rather than selecting for the most suitable biomarker for a given illness, the approach for designing POCT in RIR settings should be based on the likely available infrastructure and other constraints (Heidt et al., 2020); this may require identification of novel biomarkers and sampling techniques, an undertaking with its own set of hurdles (see Urdea et al., 2006).

Immediate and long-term personnel and financial costs of POCT may impose additional challenges, although this is not without nuance. Central laboratory (i.e., non-POCT) testing costs often include the salaries of nursing and ancillary staff, which may be relatively higher in rural settings and, even then, trained personnel may not even be available; on the other hand, POCT also requires qualified operators who demonstrate proficient POCT use before performing tests on patients/participants. An even greater challenge is high staff turnover, a pervasive problem in any research group or healthcare setting, but especially in RIR contexts. In a study from India, Kabra and Kanungo (2012) emphasize that high staff turnover is the single greatest challenge in maintaining a quality POCT program in this region. Despite the simplicity of some POCT devices, training is required and in settings where personnel are unfamiliar with laboratory procedures and practices, quality control and proficiency testing programs can be difficult to implement and sustain.

Extra costs for POCT include the regular purchase of quality control materials and reagents, as POCT instruments must be validated periodically (Malcolm et al., 2019); additionally, for field researchers, depending on the field-specific factors (e.g., climate) and extent of use, POCT instruments may also have limited lifespan, and in our experience, some POCT instruments require replacement after several years.

5.1.3 | Inter- and intra-methodological limitations

Barriers to implementing POCT in RIR settings are not only limited to infrastructure or resources; ascertaining quality assurance can be difficult for many POCT devices. For instance, there is a demonstrated lack of consistency between some POCT devices and test results derived from central laboratory instruments, as well as variability across different models of POCT devices (Wiencek & Nichols, 2016).

An important example involves blood, the most employed biosample type in medical tests and health research. In contrast to central laboratory testing where serum or plasma samples are typically used, POCT requiring finger prick blood is generally conducted using whole blood samples. Whole blood obtained by finger prick reflects blood from capillaries, venules, and arterioles in the finger compared to venous sampling which yields blood coursing through veins (Yang et al., 2001). For this reason, POCT devices that measure hemoglobin or hematocrit (volume measurement of red blood cells in blood as a percentage) using finger prick blood can generate slightly different values from venipuncture measures (Patel et al., 2013). Additional factors including idiosyncrasies of the patient/participant (e.g., participant sex, iron stores, etc.) can also translate into slight discrepancies between results generated by POCT and central laboratory testing (e.g., Cable et al., 2012).

Different models of POCT devices may likewise generate disparate results; this is best exemplified by glucose testing, one of the most measured analytes in POCT. In fact, the American Diabetes Association does not endorse the use of POCT glucometers for the *diagnosis* of diabetes because of concerns about sensitivity to external variables and accuracy of these tests (Shaw, 2016). This is because POCT glucometer measures may be influenced by hematocrit levels (Montagnana et al., 2009), drugs (e.g., acetaminophen) (Eastham et al., 2009), miscellaneous environmental factors (e.g., temperature and altitude) (Fink et al., 2002), and a slew of other factors (Rebel et al., 2012).

Approaches to mitigating some, albeit not all, concerns related to POCT accuracy and consistency include properly training operators who interpret device-specific cutoff values to diagnose or monitor disease, who regularly perform quality control procedures, and who adhere to appropriate storage and handling instructions. Certainly, advances in POCT stability and harmonization across testing devices by manufacturers are also paramount as are more strategic research targeting these methodological concerns across POCT technologies (Wiencek & Nichols, 2016).

5.1.4 | Supply chain limitations

Once POCT is introduced into an RIR context, long-term research or initiatives may be challenged by supply chain issues. Since POCT reagents are only manufactured in specific regions of the globe, manufacturer-imposed restrictions can limit where POCT materials can be shipped; different countries may impose significant import tariffs as well. Even when shipping is not a problem, delays in delivery may occur, thereby shortening the shelf life of reagents. Test kits and quality control materials can sit in shipping containers exposed to sun, heat, and humidity for days (Wiencek & Nichols, 2016); in colder climates, materials may undergo multiple freeze and thaw cycles affecting POCT performance (Louie et al., 2012). One inventive solution to within country supply chain issues is exemplified by Zipline, a commercial drone delivery service, that uses drone technology to bring vital medical supplies to remote hospitals throughout Rwanda. Time-sensitive blood products are dropped from drones via parachute, slashing delivery time of life-saving red blood cells and platelets to minutes compared to hours by motorbike (Baker, 2017). Zipline drones were also used to transport COVID-19 test samples to large hospitals while distributing COVID-19 supplies to hospitals in need (Kretchmer, 2020). Such creative approaches should increasingly help to counteract infrastructure and/or supply chain issues including those specific to POCT, but other barriers in RIR settings (such as economic ones) are likely to persist for the foreseeable future.

5.1.5 | Additional considerations and recommendations

Although not an exhaustive description of challenges (see Gildner et al., 2022 for additional challenges), it is important to be aware of the limitations of POCT when considering their use in RIR contexts. POCT reagents and instruments are vulnerable to exogenous elements which may limit their use in some field-based settings, or at minimum, requires thoughtful consideration about how to reduce potential environmental influences on POCT quality. Researchers must also be cognizant of issues related to consistency of results across methodologies, POCT or otherwise, and acknowledge these limitations when making comparisons across datasets using different techniques.

In the dynamic and rapidly changing field of POCT, researchers in human biology and related disciplines are well-positioned to bring insights from the field to the lab bench while highlighting the primary concerns of study participants, whose needs, values, and concerns may be outside the purview of POCT device developers who are often motivated by testing demands in high-income regions. For example, a multiplex POCT device that could screen pregnant women for HIV infection, syphilis, malaria, and anemia as part of prenatal treatment would make dramatic strides in reducing poorer birth outcomes in many of the regions where human biologists often work. One suggestion is that we, as researchers, might explicitly describe in our manuscripts how specific POCT devices perform in our field sites and emphasize the need for a broader array of devices designed for such contexts. Currently, these insights are primarily spread by word of mouth among interested stakeholders, but publications on device performance would expand the reach of this information to scholars considering POCT use in their own research; these details would additionally serve to highlight device limitations for POCT developers. Gildner et al. (2022) begin this discussion, but a larger, cross-disciplinary dialogue is necessary. Finally, working within patient/participant-centered approaches, we might also incorporate qualitative methods that survey research participants, a kind of "exit" interview, regarding their experiences with POCT to assess methodological efficacy in engaging participants in RIR contexts.

5.2 | Ethical challenges

In addition to these practical issues, complicated ethical challenges are also presented by POCT in RIR settings. Firstly, within these contexts, there exists an imbalance between the need for disease prevention/treatment and the ability to meet these needs in both the short and long-term (Nuffield Council on Bioethics, 2004). Improving global health requires a continual commitment to learn from the results of carefully designed and executed research studies, while facilitating care for participants if disease risk is identified. For this reason, some researchers have argued for reframing of the ASSURED criteria to explicitly articulate that the goal of POCT is not simply the communication of test results, but rather the linkage to treatment and sustainable long-term care when necessary (Pai et al., 2015).

One specific challenge to this end is related to the burden of NCDs in RIR contexts where people are increasingly and disproportionately affected, yet access to needed treatment is generally limited. This is often the case in regions, such as LMICs, where already-constrained resources are primarily allocated toward combating infectious disease, despite the increasing prevalence of NCDs. In cases where elevated risk for a chronic health condition is identified, modifiable behaviors might be discussed to reduce the possibility of the condition worsening. However, certain chronic conditions, such as diabetes risk, can be difficult to monitor and manage if the participant does not have access to ongoing treatment and care. Community and regional-level factors such as limited health education, poor regulation (e.g., of POCT diagnostics), and economic barriers (e.g., high cost of implementing POCT in some settings), can further hamper long-term access to treatment (Heidt et al., 2020). Thoughtful consideration about how local resources may be augmented (e.g., through targeted allocation of research funds) to facilitate pathways for tracking health information and accessing long-term health services is paramount in these cases.

Relatedly, the dearth of NCD diagnostics being used in RIR contexts poses a unique set of challenges. For one, compared to infectious disease, the high burden of NCDs is a relatively recent phenomenon in many RIR settings. This is in part due to recent and accelerated diet change as sources of nutrition have become increasingly delocalized (i.e., produced and processed elsewhere, such as within broader market systems) (e.g., Cantor et al., 2018; Liebert et al., 2013; Lu, 2007) and increasing sedentism (e.g., Booth et al., 2017; Gurven & Lieberman, 2020; Park et al., 2020; Urlacher et al., 2021). Moreover, an unprecedented number of individuals are surviving into advanced ages in many countries (UN, 2017). Cumulatively, these nutritional and demographic shifts all contribute to the heightened prevalence of NCDs in RIR contexts. These changes impose additional pressure on already constrained health care systems, exacerbating problems for testing and treatment of chronic NCDs.

Further, health research in human biology and related disciplines is usually funded through grants, and studies are therefore challenging to sustain once the funded project is completed. Certainly, this is not only a concern for POCT, but also for health research employing traditional lab-based methods. Yet, the implementation of POCT at the local level, within the community and within the constraints of local capacities, means that long-term implementation of such health-based projects are uniquely challenged. In the absence of permanent health clinics, enhancing sustainability of health research may be achieved through other means including knowledge transfer, such as by training and development of expertise among local people, technology transfer, including donating POCT equipment and supplies to communities to strengthen local monitoring capabilities, and contributing more broadly toward local infrastructural development whenever possible (Gurven et al., 2017; Nuffield Council on Bioethics, 2004; Sidik, 2022).

6 | CONCLUSIONS

Point-of-care testing (POCT) offers numerous opportunities for expanding the reach of health services into often underserved, rural/remote and/or Indigenous populations in resource-limited settings, with whom and where many human biologists and global health researchers work. Many scholars have demonstrated the utility of POCT for generating health insights that were not previously possible without POCT. This includes work addressing core questions about health and disease, and of evolutionary and biocultural theoretical importance. At the same time, POCT allows researchers to immediately return robust health information to study participants while allowing ample opportunity to communicate, discuss, and educate participants about health issues through direct researcher-participant and researcher-community engagement. Specifically, POCT has potential within participant-centered and community-based research approaches to usher in improved, engaged, mutualistic, and synergistic dialogue between researchers and participants about their health conditions, needs, and goals while also reinforcing this dialog in culturally competent and appropriate ways, such as through ongoing local collaborations. Through such interactions, researchers may be able to help inform and link patients to treatment when necessary while facilitating public health interventions more effectively at the community-level in ways that can be sustained long-term.

Practical and ethical barriers to POCT application persist, and this is especially the case within RIR contexts; it is evident that the full potential of POCT cannot be realized until such limitations and challenges are addressed and resolved. Researchers in human biology and related disciplines working in global health are well-situated to call attention to these challenges through more intentional methodological reflections (e.g., such as highlighting the strengths and weaknesses of POCT use in RIR contexts in publications), so that POCT researchers and developers are made aware of both on-the-ground needs and pragmatic barriers to their use. The continued development and use of effective POCT in RIR contexts have immense promise for fostering collaborative research and enhancing global access to much needed health information and services. In this way, POCT tools designed at the lab bench and integrated into the field have great potential to help mitigate persistent global health disparities and inequities.

AUTHOR CONTRIBUTIONS

Felicia C. Madimenos conceived and drafted this manuscript. James J. Snodgrass helped in the conception of this manuscript and provided feedback during manuscript drafting. Theresa E. Gildner and Geeta N. Eick provided valuable feedback during the drafting of this manuscript. Lawrence S. Sugiyama provided insight on key themes and concepts throughout the manuscript editing processing.

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CONFLICT OF INTEREST

All authors have indicated no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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ENDNOTE

[i] A "patient" is typically defined as a person who receives or is registered to receive medical treatment; the term "participant" is generally reserved for individuals who voluntarily take part in a research study. In this article, we refer to a patient as someone being treated by a health-care clinician as authorized in a particular setting (e.g., locale, country, province), and a participant as an individual in a research study. These roles can and often do overlap such as when a patient is a participant in clinical studies, or when a person may be a participant in a research study on metabolic syndrome, for instance, but is also a patient separately being monitored/treated for diabetes by clinicians who are not associated with the research study. In other cases throughout the article, the terms *patient* or *participant* are employed based on the original term used in the article cited.

[2]While no single authoritative definition exists for "Indigenous," there are a few criteria that help to broadly define Indigenous peoples, as outlined by the UN Permanent Forum on Indigenous Peoples (2013). In the current article, the term "Indigenous" is used to refer to international, transnational, and global peoples who have a long settlement and strong affiliation with specific lands and who have been adversely affected by displacement and settlement on their traditional territories by settlers, colonizers, or other populations who have sought to threaten Indigenous autonomy. Here, "Indigenous" is a broad reference that is used to emphasize a common challenge, in this case, health outcomes, shared by communities adversely affected by colonialism, displacement, and exploitation.

REFERENCES

Baker, A. (2017, November 27). The American drones saving lives in Rwanda. *Time*. https://time.com/rwanda-drones-zipline/

Bateman, L. B., Schoenberger, Y. M., Hansen, B., Osborne, T. N., Okoro, G. C., Speights, K. M., & Fouad, M. N. (2021). Confronting COVID-19 in under-resourced, African American neighborhoods: A qualitative study examining community member and stakeholders' perceptions. *Ethnic Health*, *26*(1), 49–67. https://doi.org/10.1080/13557858.2021.1873250

Beck, T. L., Le, T. K., Henry-Okafor, Q., & Shah, M. K. (2019). Medical Care for Undocumented Immigrants: National and international issues. *Physician Assistant Clinics*, *4*(1), 33–45. https://doi.org/10.1016/j.cpha.2018.08.002

Bernabé-Ortiz, A., Zafra-Tanaka, J. H., Moscoso-Porras, M., Sampath, R., Vetter, B., Miranda, J. J., & Beran, D. (2021). Diagnostics and monitoring tools for noncommunicable diseases: A missing component in the global response. *Globalization and Health*, *17*, 26. https://doi.org/10.1186/s12992-021-00676-6

Bernardini, S., Pieri, M., & Ciotti, M. (2021). How could POCT be a useful tool for migrant and refugee health? *EJIFCC*, *32*(2), 200–208.

Bharadwaj, M., Bengtson, M., Golverdingen, M., Waling, L., & Dekker, C. (2021). Diagnosing point-of-care diagnostics for neglected tropical diseases. *PLoS Neglect Trop D*, *15*(6), e0009405. https://doi.org/10.1371/journal.pntd.0009405

Blackwell, A. D., Gurven, M. D., Sugiyama, L. S., Madimenos, F. C., Liebert, M. A., Martin, M. A., Kaplan, H. S., & Snodgrass, J. J. (2011). Evidence for a peak shift in a humoral response to helminths: Age profiles of IgE in the Shuar of Ecuador, the Tsimane of Bolivia, and the U.S. NHANES. *PLoS Neglect Trop D*, *5*(6), e1218. https://doi.org/10.1371/journal.pntd.0001218

Blackwell, A. D., Snodgrass, J. J., Madimenos, F. C., & Sugiyama, L. S. (2010). Life history, immune function, and intestinal helminths: Trade-offs among immunoglobulin E, C-reactive protein, and growth in an Amazonian population. *American Journal of Human Biology*, *22*(6), 836–848. https://doi.org/10.1002/ajhb.21092

Boahen, O., Owusu-Agyei, S., Febir, L. G., Tawiah, C., Tawiah, T., Afari, S., & Newton, S. (2013). Community perception and beliefs about blood draw for clinical research in Ghana. *Tropical Royal Society of Tropical Medicine and Hygiene*, *107*(4), 261–265. https://doi.org/10.1093/trstmh/trt012

Booth, F. W., Roberts, C. K., Thyfault, J. P., Ruegsegger, G. N., & Toedebusch, R. G. (2017). Role of inactivity in chronic diseases: Evolutionary insight and pathophysiological mechanisms. *Physiological Reviews*, *97*(4), 1351–1402. https://doi.org/10.1152/physrev.00019.2016

Bright, T., Felix, L., Kuper, H., & Polack, S. (2017). A systematic review of strategies to increase access to health services among children in low- and middle-income countries. *BMC Health Services Research*, *17*(1), 252. https://doi.org/10.1186/s12913-017-2180-9

Broesch, T., Crittenden, A. N., Beheim, B., Blackwell, A. D., Bunce, J. A., Colleran, H., Hagel, K., Kline, M. A., McElreath, R., Nelson, R., Pisor, A., Prall, S., Pretelli, I., Purzycki, B. G., Quinn, E. A., Ross, C. T., Scelza, B., Starkweather, K., Stieglitz, J., & Borgerhoff Mulder, M. (2020). Navigating cross-cultural research: Methodological and ethical considerations. *Proceedings of the Royal Society B*, *287*, 20201245. https://doi.org/10.1098/rspb.2020.1245

Cable, R. G., Steele, W. R., Melmed, R. S., Johnson, B., Mast, A. E., Carey, P. M., Kiss, J. E., Kleinman, S. H., Wright, D. J., & NHLBI Retrovirus Epidemiology Donor Study-II (REDS-II). (2012). The difference between fingerstick and venous hemoglobin and hematocrit varies by sex and iron stores. *Transfusion*, *52*(5), 1031–1040. https://doi.org/10.1111/j.1537-2995.2011.03389.x

Cambridge, T. (2020, November 5). Patient-Centred care: Decentralized testing and diagnostics. *The Biomedical Scientist*, 14–18. https://thebiomedicalscientist.net/science/patient-centred-care-decentralised-testing-and-diagnostics

Cantor, A. R., Chan, I., & Baines, K. (2018). From the chacra to the tienda: Dietary delocalization in the Peruvian Andes. *Food and Foodways*, *26*(3), 198–222. https://doi.org/10.1080/07409710.2018.1490376

Centers for Disease Control and Prevention (CDC). (2019, September 17). *Community health workers (promotores)*. Centers for Disease Control and Prevention. https://www.cdc.gov/minorityhealth/promotores/index.html

Chamane, N., & Mashamba-Thompson, T. P. (2019). Experiential learning curriculum delivery approach for quality improvement in resource-limited settings: Mobile learning for point-of-care technologies. *Global Journal of Health Science*, *11*(13), 158–166.

Chen, H., Liu, K., Li, Z., & Wang, P. (2019). Point of care testing for infectious diseases. *Clinica Chimica Acta*, *493*, 138–147. https://doi.org/10.1016/j.cca.2019.03.008

Conching, A. K., & Thayer, Z. (2019). Biological pathways for historical trauma to affect health: A conceptual model focusing on epigenetic modifications. *Social Science & Medicine*, *230*, 74–82. https://doi.org/10.1016/j.socscimed.2019.04.001

DeLouize, A. M., Liebert, M. A., Madimenos, F. C., Urlacher, S. S., Schrock, J. M., Cepon-Robins, T. J., Gildner, T. E., Blackwell, A. D., Harrington, C. J., Amir, D., Bribiescas, R. G., Snodgrass, J. J., & Sugiyama, L. S. (2022). Low prevalence of anemia among Shuar communities of Amazonian Ecuador. *American Journal of Human Biology*, *34*(1), e23590. https://doi.org/10.1002/ajhb.23590

Dijkstra, L., & Poelma, H. (2008). Remote Rural Regions. Regional Focus No 1. https://ec.europa.eu/regional_policy/sources/docgener/focus/2008_01_rural.pdf

Dona, A. C., Eick, G., Huynh, A., & Snodgrass, J. J. (2019). Día de Salud: A model for community-based outreach to improve health care access for low-income families. *American Journal of Physical Anthropology*, *68*, 61.

Drain, P. K., Hyle, E. P., Noubary, F., Freedberg, K. A., Wilson, D., Bishai, W. R., Rodriguez, W., & Bassett, I. V. (2014). Diagnostic point-of-care tests in resource-limited settings. *The Lancet Infectious Diseases*, *14*(3), 239–249. https://doi.org/10.1016/s1473-3099(13)70250-0

Eastham, J. H., Mason, D., Barnes, D. L., & Kollins, J. (2009). Prevalence of interfering substances with point-of-care glucose testing in a community hospital. *American Journal of Health-System Pharmacy*, *66*(2), 167–170. https://doi.org/10.2146/ajhp070512

Egeland, G., & Harrison, G. (2013). Health disparities: Promoting indigenous Peoples' health through traditional food systems and self-determination. In H. Kuhnlein, B. Erasmus, D.

Spigelski, & B. Burlingame (Eds.), *Indigenous Peoples' food systems & well-being interventions and policies for healthy communities*. Food and Agriculture Organization (FAO) of the United Nations.

Epstein, R. M., & Street, R. L., Jr. (2011). The values and value of patient-centered care. *Annals of Family Medicine*, *9*, 100–103. https://doi.org/10.1370/afm.1239

Farmer, P. (2003). *Pathologies of power: Health, human rights, and the new war on the poor*. University of California Press.

Farmer, P. (2020). *Fevers, feuds, and diamonds: Ebola and the ravages of history* (First ed.). Farrar, Straus and Giroux.

Fink, K. S., Christensen, D. B., & Ellsworth, A. (2002). Effect of high altitude on blood glucose meter performance. *Diabetes Technology & Therapeutics*, *4*(5), 627–635. https://doi.org/10.1089/152091502320798259

Furuse, Y. (2019). Analysis of research intensity on infectious disease by disease burden reveals which infectious diseases are neglected by researchers. *PNAS*, *116*(2), 478–483. https://doi.org/10.1073/pnas.1814484116

Gee, G. C., & Ford, C. L. (2011). Structural racism and health inequities: Old issues, new directions. *Du Bois Review: Social Science Research on Race*, *8*(1), 115–132. https://doi.org/10.1017/S1742058X11000130

Geiling, J., Burkle, F. M., Jr., Amundson, D., Dominguez-Cherit, G., Gomersall, C. D., Lim, M. L., Luyckx, V., Sarani, B., Uyeki, T. M., West, T. E., Christian, M. D., Devereaux, A. V., Dichter, J. R., Kissoon, N., & Task Force for Mass Critical Care. (2014). Resource-poor settings: Infrastructure and capacity building: Care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. *Chest*, *146*(4 Suppl), e156S–e167S. https://doi.org/10.1378/chest.14-0744

Gialamas, A., Yelland, L. N., Ryan, P., Willson, K., Laurence, C. O., Bubner, T. K., Tideman, P., & Beilby, J. J. (2009). Does point-of-care testing lead to the same or better adherence to medication? A randomised controlled trial: The POCT in general practice trial. *Medical Journal of Australia*, *191*(9), 487–491. https://doi.org/10.5694/j.1326-5377.2009.tb02910.x

Gildner, T. E., Eick, G. N., Schneider, A. L., Madimenos, F. C., & Snodgrass, J. J. (2022). After Theranos: Using point-of-care testing to advance measures of health biomarkers in human biology research. *American Journal of Human Biology*, 1–28. https://doi.org/10.1002/ajhb.23689

Gravlee, C. C. (2020). Systemic racism, chronic health inequities, and COVID-19: A syndemic in the making? *American Journal of Human Biology*, *32*(5), e23482. https://doi.org/10.1002/ajhb.23482

Gurven, M., Stieglitz, J., Trumble, B., Blackwell, A. D., Beheim, B., Davis, H., Hooper, P., & Kaplan, H. (2017). The Tsimane health and life history project: Integrating anthropology and biomedicine. *Evolutionary Anthropology*, *26*(2), 54–73. https://doi.org/10.1002/evan.21515

Gurven, M. D., Jaeggi, A. V., Kaplan, H., & Cummings, D. (2013). Physical activity and modernization among Bolivian Amerindians. *PLoS One*, *8*(1), e55679. https://doi.org/10.1371/journal.pone.0055679

Gurven, M. D., Kaplan, H., Trumble, B., & Stieglitz, J. (2021). The biodemography of human health in contemporary non-industrial populations: Insights from the Tsimane health and life history project. In R. Sear, O. Burger, & R. Lee (Eds.), *Human evolutionary demography*. Open Book Publishers. https://doi.org/10.11647/OBP.0251

Gurven, M. D., & Lieberman, D. E. (2020). Weird bodies: Mismatch, medicine and missing diversity. *Evolution and Human Behavior*, *41*(5), 330–340. https://doi.org/10.1016/j.evolhumbehav.2020.04.001

Heidt, B., Siqueira, W. F., Eersels, K., Dilien, H., van Grinsven, B., Fujiwara, R. T., & Cleij, T. J. (2020). Point-of-care diagnostics in resource-limited settings: A review of the present and future of POC in its most needed environment. *Biosensors*, *10*(10), 113. https://doi.org/10.3390/bios10100133

Hengel, B., Causer, L., Matthews, S., Smith, K., Andrewartha, K., Badman, S., Spaeth, B., Tangey, A., Cunningham, P., Saha, A., Phillips, E., Ward, J., Watts, C., King, J., Applegate, T., Shephard, M., & Guy, R. (2021). A decentralised point-of-care testing model to address inequities in the COVID-19 response. *The Lancet Infectious Disease*, *21*(7), e183–e190. https://doi.org/10.1016/S1473-3099(20)30859-8

Hill, J., Rodriguez, D. X., & McDaniel, P. N. (2021). Immigration status as a health care barrier in the USA during COVID-19. *Journal of Migration and Health*, *4*, 100036. https://doi.org/10.1016/j.jmh.2021.100036

Hologic. (2014). Sahara Bone Sonometer FAQs. http://www.hologic.ca/sites/default/files/product-files/Sahara%20FAQs.pdf

James, C. V., Moonesinghe, R., Wilson-Frederick, S. M., Hall, J. E., Penman-Aguilar, A., & Bouye, K. (2017). Racial/ethnic health disparities among rural adults — United States, 2012–2015. *MMWR. Surveillance Summaries*, *66*(23), 1–9. https://doi.org/10.15585/mmwr.ss6623a1

Ji, R., & Cheng, Y. (2021). Thinking global health from the perspective of anthropology. *Global Health Research and Policy*, *6*, 47. https://doi.org/10.1186/s41256-021-00233

Kabra, S., & Kanungo, R. (2012). Monitoring quality of HIV testing at point of care facilities in India. *Indian Journal of Medical Microbiology*, *30*(2), 129–130. https://doi.org/10.4103/0255-0857.96635

Katoba, J., Kuupiel, D., & Mashamba-Thompson, T. P. (2019). Toward improving accessibility of point-of-care diagnostic services for maternal and child health in low- and middle-income countries. *Point of Care*, *18*(1), 17–25. https://doi.org/10.1097/poc.0000000000000180

Kelly, K., & Dade-Smith, J. (2007). What and where is rural and remote Australia? In J. Dade-Smith (Ed.), *Australia's rural and remote health: A social justice perspective* (2nd ed., pp. 86–106). Tertiary Press.

Khan, A. H., Shakeel, S., Hooda, K., Siddiqui, K., & Jafri, L. (2019). Best practices in the implementation of a point of care testing program: Experience from a tertiary care hospital in a developing country. *EJIFCC*, *30*(3), 288–302.

Kieny, M. P., Evans, T. G., Scarpetta, S., Kelley, E. T., Klazinga, N., Forde, I., & Donaldson, L. (2018). *Delivering quality health services: A global imperative for universal health coverage*. World Bank Group.

Kim, S., Nhem, S., Dourng, D., & Ménard, D. (2015). Malaria rapid diagnostic test as point-of-care test: Study protocol for evaluating the VIKIA® malaria AG PF/pan. *Malaria Journal*, *14*, 114. https://doi.org/10.1186/s12936-015-0633-3

Kost, G. J., Hale, K. N., Brock, T. K., Louie, R. F., Gentile, N. L., Kitano, T. K., & Tran, N. K. (2009). Point-of-care testing for disasters: Needs assessment, strategic planning, and future design. *Clinics in Laoratory Medicine*, *29*(3), 583–605. https://doi.org/10.1016/j.cll.2009.07.014

Kost, G. J., Tran, N. K., Tuntideelert, M., Kulrattanamaneeporn, S., & Peungposop, N. (2006). Katrina, the tsunami, and point-of-care testing: Optimizing rapid response diagnosis in disasters. *American Journal of Clinical Pathology*, *126*(4), 513–520. https://doi.org/10.1309/NWU5E6T0L4PFCBD9

Kozhimannil, K. B. (2020). Indigenous maternal health—A crisis demanding attention. *JAMA Health Forum*, *1*(5), e200517. https://doi.org/10.1001/jamahealthforum.2020.0517

Kretchmer, H. (2020). How drones are helping to battle COVID-19 in Africa – and beyond. World Economic Forum. https://www.weforum.org/agenda/2020/05/medical-delivery-drones-coronavirus-africa-us/

Lagranja, E. S., Phojanakong, P., Navarro, A., & Valeggia, C. R. (2015). Indigenous populations in transition: An evaluation of metabolic syndrome and its associated factors among the Toba of northern Argentina. *Annals of Human Biology*, *42*(1), 84–90. https://doi.org/10.3109/03014460.2014.932008p

Land, K. J., Boeras, D. I., Chen, X. S., Ramsay, A. R., & Peeling, R. W. (2019). REASSURED diagnostics to inform disease control strategies, strengthen health systems and improve patient outcomes. *Nature Microbiology*, *4*(1), 46–54. https://doi.org/10.1038/s41564-018-0295-3

Levy, S. B., Leonard, W. R., Tarskaia, L. A., Klimova, T. M., Fedorova, V. I., Baltakhinova, M. E., & Josh Snodgrass, J. (2016). Lifestyle mediates seasonal changes in metabolic health among the Yakut (Sakha) of northeastern Siberia. *American Journal of Human Biology*, *28*(6), 868–878. https://doi.org/10.1002/ajhb.22879

Liebert, M. A., Snodgrass, J. J., Blackwell, A. D., Madimenos, F. C., & Sugiyama, L. S. (2013). The effects of market integration on blood pressure, glucose, cholesterol, and triglyceride levels in an indigenous lowland Ecuadorian population. *Annals of Human Biology*, *40*, 228–242. https://doi.org/10.3109/03014460.2012.759621

Lilly, C. M., Ensom, E., Teebagy, S., DiMezza, D., Dunlap, D., Hafer, N., Buchholz, B., & McManus, D. (2020). Patient preferences for point-of-care testing: Survey validation and results. *Point of Care*, *19*(4), 112–115. https://doi.org/10.1097/poc.0000000000000214

Lindgärde, F., Widén, I., Gebb, M., & Ahrén, B. (2004). Traditional versus agricultural lifestyle among Shuar women of the Ecuadorian Amazon: Effects on leptin levels. *Metabolis*, *53*(10), 1355–1358. https://doi.org/10.1016/j.metabol.2004.04.012

Louie, R. F., Ferguson, W. J., Sumner, S. L., Yu, J. N., Curtis, C. M., & Kost, G. J. (2012). Effects of dynamic temperature and humidity stresses on point-of-care glucose testing for disaster care. *Disaster Medicine and Public Health Preparation*, *6*(3), 232–240. https://doi.org/10.1001/dmp.2012.42

Lu, F. (2007). Integration in the market among indigenous peoples: A cross-cultural perspective from the Ecuadorian Amazon. *Current Anthropology*, *48*(4), 593–602. https://doi.org/10.1086/519806

Lucero, A. A., Lambrick, D. M., Faulkner, J. A., Fryer, S., Tarrant, M. A., Poudevigne, M., Williams, M. A., & Stoner, L. (2014). Modifiable cardiovascular disease risk factors among indigenous populations. *Advances in Preventive Medicine*, *2014*, 1–13. https://doi.org/10.1155/2014/547018

Mabey, D., Peeling, R. W., & Perkins, M. D. (2001). Rapid and simple point-of-care diagnostics for STIs. *Sexually Transmitted Infections*, *77*, 397–398.

Madimenos, F. C. (2015). An evolutionary and life history perspective on osteoporosis. *Annual Review of Anthropology*, *44*(1), 189–206.

Madimenos, F. C., Liebert, M. A., Cepon, T. J., Snodgrass, J. J., & Sugiyama, L. S. (2015). Determining osteoporosis risk in older Colono adults from rural Amazonian Ecuador using calcaneal ultrasonometry. *American Journal of Human Biology*, *27*, 139–142.

Madimenos, F. C., Liebert, M. A., Cepon-Robins, T. J., Urlacher, S. S., Snodgrass, J. J., Sugiyama, L. S., & Stieglitz, J. (2020). Disparities in bone density among contemporary Amazonian forager-horticulturalists: Cross-population comparison of the Tsimane and Shuar. *American Journal of Physical Anthropology*, *171*(1), 50–64. https://doi.org/10.1002/ajpa.23949

Madimenos, F. C., Snodgrass, J. J., Blackwell, A. B., Liebert, M. A., & Sugiyama, L. S. (2011). Physical activity in an indigenous Ecuadorian forager-horticulturalist population as measured using accelerometry. *American Journal of Human Biology*, *23*(4), 488–497.

Madimenos, F. C., Snodgrass, J. J., Liebert, M. A., Cepon, T. J., & Sugiyama, L. S. (2012). Reproductive effects on skeletal health in Shuar women of Amazonian Ecuador: A life history perspective. *American Journal of Human Biology*, *24*(6), 841–852.

Malcolm, S., Cadet, J., Crompton, L., & DeGennaro, V., Jr. (2019). A model for point of care testing for non-communicable disease diagnosis in resource-limited countries. *Global Health, Epidemiology and Genomics*, *4*, e7. https://doi.org/10.1017/gheg.2019.6

Marks, M., & Mabey, D. C. (2017). The introduction of syphilis point of care tests in resource-limited settings. *Expert Review of Molecular Diagnostics*, *17*(4), 321–325. https://doi.org/10.1080/14737159.2017.1303379

Marrone, S. (2007). Understanding barriers to health care: A review of disparities in health care services among indigenous populations. *International Journal of Circumpolar Health*, *66*(3), 188–198. https://doi.org/10.3402/ijch.v66i3.18254

Mayberry, R. M., Mili, F., & Ofili, E. (2000). Racial and ethnic differences in access to medical care. *Medical Care Research and Review*, *57*(4), 108–145. https://doi.org/10.1177/107755800773743628

McCloskey, D. J., McDonald, M. A., Cook, J., Heurtin-Roberts, S., Updegrove, S., Sampson, D., Gutter, S., & Eder, M. (2011). Community engagement. In M. Silberberg, J. Cook, C. Drescher, D. J. McCloskey, S. Weaver, & L. Ziegahn. (Eds.), *Principles of community engagement* (2nd ed., pp. 3–41). National Institutes of Health. https://www.atsdr.cdc.gov/communityengagement/pdf/PCE_Report_Chapter_1_SHEF.pdf

McClure, H. H., Josh Snodgrass, J., Martinez, C. R., Jr., Squires, E. C., Jiménez, R. A., Isiordia, L. E., Eddy, J. M., McDade, T. W., & Small, J. (2015). Stress, place, and allostatic load among Mexican immigrant farmworkers in Oregon. *Journal of Immigrant and Minority Health*, *17*(5), 1518–1525. https://doi.org/10.1007/s10903-014-0066-z

Montagnana, M., Caputo, M., Giavarina, D., & Lippi, G. (2009). Overview on self-monitoring of blood glucose. *Clinica Chimica Acta*, *402*(1–2), 7–13. https://doi.org/10.1016/j.cca.2009.01.002

Motta, L. A., Shephard, M., Brink, J., Lawson, S., & Rheeder, P. (2017). Point-of-care testing improves diabetes management in a primary care clinic in South Africa. *Primary Care Diabetes*, *11*(3), 248–253. https://doi.org/10.1016/j.pcd.2016.09.008

Murray, C. J., Kulkarni, S. C., Michaud, C., Tomijima, N., Bulzacchelli, M. T., Iandiorio, T. J., & Ezzati, M. (2006). Eight Americas: Investigating mortality disparities across races, counties, and race-counties in the United States. *PLoS Medicine*, *3*(12), e545. https://doi.org/10.1371/journal.pmed.0030260

Nuffield Council on Bioethics. (2004). Annual Report. Nuffield Council on Bioethics. https://www.nuffieldbioethics.org/assets/pdfs/NCOB-Annual-report-2004.pdf

Olshansky, E., & Zender, R. (2016). The use of community-based participatory research to understand and work with vulnerable populations. In M. Chesnay & B. A. Anderson (Eds.), *Caring for the vulnerable* (4th ed., pp. 243–252). Jones and Bartlett Learning.

Pai, M., Ghiasi, M., & Pai, N. P. (2015). Point-of-care diagnostic testing in global health: What is the point? *Microbe*, *10*(3), 103–107.

Pai, N. P., Vadnais, C., Denkinger, C., Engel, N., & Pai, M. (2012). Point-of-care testing for infectious diseases: Diversity, complexity, and barriers in low- and middle-income countries. *PLoS Medicine*, *9*(9), e1001306. https://doi.org/10.1371/journal.pmed.1001306

Park, J. H., Moon, J. H., Kim, H. J., Kong, M. H., & Oh, Y. H. (2020). Sedentary lifestyle: Overview of updated evidence of potential health risks. *Korean Journal of Family Medicine*, *41*(6), 365–373. https://doi.org/10.4082/kjfm.20.0165

Patel, A. J., Wesley, R., Leitman, S. F., & Bryant, B. J. (2013). Capillary versus venous haemoglobin determination in the assessment of healthy blood donors. *Vox Sanguinis*, *104*(4), 317–323. https://doi.org/10.1111/vox.12006

Peeling, R. W., & Mabey, D. (2010). Point-of-care tests for diagnosing infections in the developing world. *Clinical Microbiology and Infection*, *16*(8), 1062–1069. https://doi.org/10.1111/j.1469-0691.2010.03279.x

Peer, N., Kengne, A. P., Motala, A. A., & Mbanya, J. C. (2014). Diabetes in the Africa region: An update. *Diabetes Research and Clinical Practice*, *103*, 197–205.

Peters, D. H., Garg, A., Bloom, G., Walker, D. G., Brieger, W. R., & Rahman, M. H. (2008). Poverty and access to health care in developing countries. *Annals of the New York Academy of Sciences*, *1136*, 161–171. https://doi.org/10.1196/annals.1425.011

Phelan, J. C., & Link, B. G. (2015). Is racism a fundamental cause of inequalities in health. *Annual Review of Sociology*, *41*, 311–330. https://doi.org/10.1146/annurev-soc-073014-112305

Pollard, T. M. (2008). *Western diseases: An evolutionary perspective*. Cambridge University Press.

Pontzer, H., Wood, B. M., & Raichlen, D. A. (2018). Hunter-gatherers as models in public health. *Obesity Reviews*, *19*, 24–35. https://doi.org/10.1111/obr.12785

Power, T., Wilson, D., Best, O., Brockie, T., Bourque Bearskin, L., Millender, E., & Lowe, J. (2020). COVID-19 and indigenous peoples: An imperative for action. *Journal of Clinical Nursing*, *29*(15–16), 2737–2741. https://doi.org/10.1111/jocn.15320

Raichlen, D. A., Pontzer, H., Zderic, T. W., Harris, J. A., Mabulla, A. Z. P., Hamilton, M. T., & Wood, B. M. (2020). Sitting, squatting, and the evolutionary biology of human inactivity. *PNAS*, *117*(13), 7115–7121. https://doi.org/10.1073/pnas.1911868117

Rebel, A., Rice, M. A., & Fahy, B. G. (2012). Accuracy of point-of-care glucose measurements. *Journal of Diabetes Science and Technology*, *6*(2), 396–411. https://doi.org/10.1177/193229681200600228

Reyes-García, V., Paneque-Gálvez, J., Luz, A. C., Gueze, M., Macía, M. J., Orta-Martínez, M., & Pino, J. (2014). Cultural change and traditional ecological knowledge. An empirical analysis from the Tsimane in the Bolivian Amazon. *Human Organ*, *73*(2), 162–173. https://doi.org/10.17730/humo.73.2.31nl363qgr30n017

Rivero, G. S. (2012). Características de la Diabetes Mellitus tipo 2 en pacientes de la etnia shuar atendidos en el Hospital General de Macas. *Revista de la Facultdad de Ciencias Medicas*, *30*(3), 36–43.

Rosen, S., & Fox, M. P. (2011). Retention in HIV care between testing and treatment in sub-Saharan Africa: A systematic review. *PLoS Medicine*, *8*(7), e1001056. https://doi.org/10.1371/journal.pmed.1001056

Rural Health Information Hub. (2019, April 22). Rural health disparities overview. https://www.ruralhealthinfo.org/topics/rural-health-disparities

Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., Colagiuri, S., Guariguata, L., Motala, A. A., Ogurtsova, K., Shaw, J. E., Bright, D., Williams, R., & IDF Diabetes Atlas Committee. (2019). Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the international diabetes federation diabetes atlas, 9th edition. *Diabetes Research and Clinical Practice*, *157*, 107843. https://doi.org/10.1016/j.diabres.2019.107843

Sandoval, J. (2017). Researcher–participant relationships. In M. Allen (Ed.), *The Sage encyclopedia of communication research methods* (Vol. 3, pp. 1466–1468). SAGE Publications. https://doi.org/10.4135/9781483381411.n511

Schell, L. M. (2014). Culture, urbanism and changing human biology. *Global Bioethics [Problemi di bioetica]*, *25*(2), 147–154. https://doi.org/10.1080/11287462.2014.897070

Schulz, L. O., Bennett, P. H., Ravussin, E., Kidd, J. R., Kidd, K. K., Esparza, J., & Valencia, M. E. (2006). Effects of traditional and western environments on prevalence of type 2 diabetes in Pima Indians in Mexico and the U.S. *Diabetes Care*, *29*(8), 1866–1871. https://doi.org/10.2337/dc06-0138

Shaw, J. L. V. (2016). Practical challenges related to point of care testing. *Practical Laboratory Medicine*, *4*, 22–29. https://doi.org/10.1016/j.plabm.2015.12.002

Shephard, M., Shephard, A., Matthews, S., & Andrewartha, K. (2020). The benefits and challenges of point-of-care testing in rural and remote primary care settings in Australia. *Archives of Pathology & Laboratory Medicine*, *144*(11), 1372–1380. https://doi.org/10.5858/arpa.2020-0105-RA

Shephard, M., Shephard, A., McAteer, B., Regnier, T., & Barancek, K. (2017). Results from 15 years of quality surveillance for a National Indigenous Point-of-Care Testing Program for diabetes. *Clinical Biochemistry*, *50*(18), 1159–1163. https://doi.org/10.1016/j.clinbiochem.2017.07.007

Shephard, M., Spaeth, B., Motta, L., & Shephard, A. (2015) Point-of-care testing in Australia: Practical advantages and benefits of community resiliency for improving outcomes. In: G. Kost, & C. Curtis, C. (Eds.), *Global point of care—Strategies for disasters, complex emergencies, and public health resilience*. (pp. 527–535). AACC Press.

Shephard, M. D. (2006). Cultural and clinical effectiveness of the 'QAAMS' point-of-care testing model for diabetes management in Australian aboriginal medical services. *Clinical Biochemist Reviews*, *27*(3), 161–170.

Shephard, M. D. (2013). Point-of-care testing in Australia: The status, practical advantages, and benefits of community resiliency. *Point of Care*, *12*(1), 41–45.

Shephard, M. D. (2017). *A practical guide to global point-of-care testing*. Csiro Publishing.

Shephard, M. D., Causer, L., & Guy, R. (2017). Point-of-care testing in rural, remote and indigenous settings. In M. Shephard (Ed.), *A practical guide to global point-of-care testing* (1st ed., pp. 343–354). Csiro Publishing.

Sidik, S. M. (2022). Weaving the lore of the land into the scientific method. *Nature*, *601*, 285–297.

Snodgrass, J. J. (2013). Health of indigenous circumpolar populations. *Annual Review of Sociology*, *42*, 69–87.

Snodgrass, J. J., Leonard, W. R., Tarskaia, L. A., Egorova, A. G., Maharova, N. V., Pinigina, I. A., Halyev, S. D., Matveeva, N. P., & Romanova, A. N. (2010). Impaired fasting glucose and the metabolic syndrome in an indigenous Siberian population. *International Journal of Circumpolar Health*, *69*(1), 87–98. https://doi.org/10.3402/ijch.v69i1.17430

Stieglitz, J., Beheim, B. A., Trumble, B. C., Madimenos, F. C., Kaplan, H., & Gurven, M. (2015). Low mineral density of a weight-bearing bone among adult women in a high fertility population. *American Journal of Physical Anthropology*, *156*, 637–648.

Stieglitz, J., Madimenos, F. C., Kaplan, H., & Gurven, M. (2016). Calcaneal quantitative ultrasound indicates reduced bone status among physically active adult forager-horticulturalists. *Journal of Bone and Mineral Research*, *31*(3), 663–671.

Strasser, R. (2003). Rural health around the world: Challenges and solutions. *Family Practice*, *20*(4), 457–463. https://doi.org/10.1093/fampra/cmg422

Tjepkema, M., Bushnik, T., & Bougie, E. (2019). Life expectancy of first nations, metis, and Inuit household populations in Canada. *Health Reports*, *30*(12), 3–10. https://doi.org/10.25318/82-003-x201901200001-eng

Trevathan, W., Smith, E. O., & McKenna, J. J. (2008). *Evolutionary medicine and health: New perspectives*. Oxford University Press.

Tsosie, K. S., Yracheta, J. M., Kolopenuk, J. A., & Geary, J. (2021). We have "gifted" enough: Indigenous genomic data sovereignty in precision medicine. *American Journal of Bioethics*, *21*(4), 72–75. https://doi.org/10.1080/15265161.2021.1891347

United Nations, Department of Economic and Social Affairs, Population Division. (2017). World Population Ageing 2017 – Highlights (ST/ESA/SER.A/397). https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf

Urdea, M., Penny, L. A., Olmsted, S. S., Giovanni, M. Y., Kaspar, P., Shepherd, A., Wilson, P., Dahl, C. A., Buchsbaum, S., Moeller, G., & Hay Burgess, D. C. (2006). Requirements for high impact diagnostics in the developing world. *Nature*, *444*-(Suppl 1), 73–79. https://doi.org/10.1038/nature05448

Urlacher, S. S., Liebert, M. A., Snodgrass, J., Blackwell, A. D., Cepon-Robins, T. J., Gildner, T. E., Madimenos, F. C., Amir, D., Bribiescas, R. G., & Sugiyama, L. S. (2016). Heterogeneous effects of market integration on sub-adult body size and nutritional status among the shuar of Amazonian Ecuador. *Annals of Human Biology*, *43*(4), 316–329. https://doi.org/10.1080/03014460.2016.1192219

Urlacher, S. S., Snodgrass, J. J., Dugas, L. R., Madimenos, F. C., Sugiyama, L. S., Liebert, M. A., Joyce, C. J., Terán, E., & Pontzer, H. (2021). Childhood daily energy expenditure does not decrease with market integration and is not related to adiposity in Amazonia. *The Journal of Nutrition*, *151*(3), 695–704. https://doi.org/10.1093/jn/nxaa361

Valeggia, C. R., Orlando, M. F., & Lagranja, E. S. (2015). Cambios en la prevalencia de sobrepeso y obesidad en asentamientos toba de la provincia de Formosa. In S. Hirsch, M. Lorenzetti, & O. D. Salomón (Eds.), *Procesos de investigación e intervención en salud en comunidades indígenas de la Argentina* (pp. 235–258). Ciudad Autonoma de Buenos Aires: Minist. Salud Nac.

Valeggia, C. R., & Snodgrass, J. J. (2015). Health of indigenous peoples. *Annual Review of Anthropology*, *44*(1), 117–135.

Valera, E., Jankelow, A., Lim, J., Kindratenko, V., Ganguli, A., White, K., Kumar, J., & Bashir, R. (2021). COVID-19 point-of-care diagnostics: Present and future. *ACS Nano*, *15*(5), 7899–7906. https://doi.org/10.1021/acsnano.1c02981

Vos, T., Barker, B., Begg, S., Stanley, L., & Lopez, A. D. (2008). Burden of disease and injury in aboriginal and Torres Strait islander peoples: The indigenous health gap. *International Journal of Epidemiology*, *38*(2), 470–477. https://doi.org/10.1093/ije/dyn240

Wakerman, J., Bourke, L., Humphreys, J., & Taylor, J. (2017). Is remote health different to rural health? *Rural and Remote Health*, *17*(2), 3832. https://doi.org/10.22605/rrh3832

Wiencek, J., & Nichols, J. (2016). Issues in the practical implementation of POCT: Overcoming challenges. *Expert Review of Molecular Diagnostics*, *16*(4), 415–422. https://doi.org/10.1586/14737159.2016.1141678

Wiley, A. S. (2021). Pearl lecture: Biological normalcy: A new framework for biocultural analysis of human population variation. *American Journal of Human Biology*, *33*(5), e23563. https://doi.org/10.1002/ajhb.23563

Williams, D. R., & Rucker, T. D. (2000). Understanding and addressing racial disparities in health care. *Health Care Financial Review*, *21*(4), 75–90.

Wilson, H. J., Leonard, W. R., Tarskaia, L. A., Klimova, T. M., Krivoshapkin, V. G., & Snodgrass, J. J. (2015). Do physical activity and sedentary behavior relate to cardio-metabolic risk factor clustering in indigenous Siberian adults? *American Journal of Human Biology*, *27*(2), 149–156. https://doi.org/10.1002/ajhb.22625

World Health Organization. (2021). Noncommunicable diseases. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

Wu, G., & Zaman, M. H. (2012). Low-cost tools for diagnosing and monitoring HIV infection in low-resource settings. *Bulletin of*

World Health Organ, *90*(12), 914–920. https://doi.org/10.2471/BLT.12.102780

Yang, Z. W., Yang, S. H., Chen, L., Qu, J., Zhu, J., & Tang, Z. (2001). Comparison of blood counts in venous, fingertip and arterial blood and their measurement variation. *Clinical and Laboratory Haematology*, *23*(3), 155–159. https://doi.org/10.1046/j.1365-2257.2001.00388.x

Zienczuk, N., Young, T. K., Cao, Z. R., & Egeland, G. M. (2012). Dietary correlates of an at-risk BMI among Inuit adults in the Canadian high arctic: Cross-sectional international polar year Inuit health survey, 2007-2008. *Nutrition Journal*, *11*, 73. https://doi.org/10.1186/1475-2891-11-73

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