

Principles of point of care culture, the spatial care path™, and enabling community and global resilience

Gerald J. Kost, MD, PhD, MS, FACB^{a,b,c}; William J. Ferguson, BS^a;
Laurie E. Kost, BS, MS^d

^a Point-of-Care Center for Teaching and Research (POCT•CTR), School of Medicine, UC Davis, CA

^b Knowledge Optimization®, Davis, CA

^c Affiliate Faculty, College of Population Studies, Chulalongkorn University, Bangkok, Thailand

^d Harvard School of Public Health, Harvard University, Boston, MA

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Corresponding author

Gerald J. Kost, MD, PhD, MS, FACB
Point-of-Care Testing Center for
Teaching and Research (POCT•CTR)
School of Medicine, University of California
3455 Tupper Hall, Davis, CA 95616

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ABSTRACT

Goals: This article a) defines point of care (POC) culture; b) presents seven underlying fundamental principles; c) describes the importance of needs assessment; d) introduces a new innovation, the spatial care path™; and e) illustrates how POC testing that properly fulfills needs and spatial care paths™ enable community and global resilience.

Observations: Often, POC testing supplants the conventional clinical laboratory, which may be too distant, prohibitively expensive, or simply not available in limited-resource settings. New POC technologies “fit” future medical problem solving. Screening and testing directly in the home or primary care facilitate rapid diagnosis, monitoring, and treatment. In contrast to the past where attention has been placed on emergency departments, hospitals, and referral centers, the spatial care path™ starts with the patient and guides him or her through an efficient strategy of care in small-world networks (SWNs) defined by local geography and topology, long-standing customs, public health jurisdictions, and geographic information systems (GIS).

Conclusions: POC testing needs in limited-resource settings are striking. Fulfillment is best guided by thorough understanding of POC culture. Quick feedback and fast decision-making

by patients and physicians alike yield significant value that motivates changes in patient lifestyles and physician interactions. Culturally sensitive technology assimilation addresses leadership challenges in nations adapting to increasing populations of young and old, despite scarcity of resources. The spatial care path™ facilitates an essential balance of prevention and intervention in public health and shifts future focus to the patient, empowerment, and primary care within the context of POC culture.

INTRODUCTION—TERMS AND SCOPE

Broadly interpreted, *culture*, per se, has several practical definitions, including the beliefs, customs, and arts of a particular society, group, place, or time; a society that has its own ways of life; and a way of thinking, behaving, or working that exists in a place or organization.

We define *point of care culture* as medical empowerment of the individual and family nucleus integrated with norms, behaviors, beliefs, attitudes, expectations, POC technology, and outcomes (1,2). POC culture crosses the standard definitional dimensions of culture, because health is at the core of human existence, and people expect society to assure their good health. *Expectations* are strong beliefs that something will happen in the future. New technologies weigh heavily on expectations, and therefore, expectations should be assessed through needs assessment designed to improve health with POC testing.

POC testing is medical testing at or near the site of care (3). It includes *in vitro* testing with handheld, portable, and transportable instruments, as well as self-monitoring and noninvasive scanning. A *small-world network (SWN)* is a loosely tied and well, but not necessarily evenly, connected set of nodes in a scale-free network with a topology neither completely regular nor entirely random, such as roadmaps, extended

families, and the spread of infectious diseases (4). A *geographic information system (GIS)* is a computerized approach that systematically helps organize point of need data in an electronic cloud for facile access, remote computations, and in the context here, decision-making in a medical GIS (5).

Skin autofluorescence (SAF), in the context of one of the instruments referenced here (Scout DS, Miraculins, Canada), is the measurement of light in the range of 360 to 660 nm from volar forearm skin excited with low-intensity multiple near-ultraviolet and visible wavelengths by light emitting diodes (LED) centered at 375, 405, 417, 435 and 456 nm (6).

FUNDAMENTAL PRINCIPLES—PREMISE AND HYPOTHESIS

First introduced by Kost et al. (1,2), the concept of POC culture is likely to become a focal point of future medical endeavors, in view of the monumental challenges of taking care of over 7.2 billion people in the world with the global population increasing at a rate of several persons per second. Technologies will be replaced perpetually with new inventions and innovations, but once arrived, and it is in the process of doing that, POC culture will forever stay as the new practice of medicine, actuated collaboratively by patients and physicians together.

Therefore, our fundamental premise is that POC testing will empower individuals to care for themselves in their own cultural context, despite burgeoning populations, diminishing resources, limited hospital access, and nations growing old before rich. In fact, patient self-management already exists. Patients with diabetes are taught to integrate self-monitoring and self-administration of therapy as part of their daily lives.

We hypothesize that increasingly, as people learn more about conditions that they can

prevent, they will prefer self-management of their own health. Thus, understanding POC culture means understanding the future of POC testing and how it can benefit people optimally. This article strives to outline several of the key principles of POC culture.

PRINCIPLE I—UNDERSTANDING HISTORICAL ROOTS

Table 1 (7-32) summarizes cultural principles related to medical care described by investigators through 2014. Additionally, Small et al. (33) argue that a study of poverty should be concerned with culture for scholarly and policy reasons. We devised an original demographic scoring system that showed the combination of a) poverty, b) insufficient health resources, and c) short supply of personnel who can perform diagnostic tests (e.g., medical technologists) identifies locations severely in need of POC testing (34). Once these settings have been defined, structured analysis can be set up to identify which POC tests to implement within the SWN (4). In these settings of significant deprivation of both materials and manpower, one must understand local culture well in order to alleviate POC medical poverty, which is one of the most important goals of cultural adaptation of POC technologies.

As we hit this milestone in history, that is, full recognition of the importance of POC culture, we will look back and realize that the world population was outstripping available health resources except in situations where foresight brought medical decision-making directly to points of need, wherever they might be—during birthing, in the home, for an emergency, or at a disaster. For example, The Point-of-Care Foundation, London, United Kingdom, focuses on the points of need for both patients and staff in terms of improving patients' experience of care and increasing support for the staff

working with them (35). Similarly, the most recent papers in Table 1 illustrate further how medical professionals in several disciplines are recognizing the importance and impact of cultural expectations.

PRINCIPLE II—RECOGNIZING A DISRUPTIVE TRANSFORMATION

People everywhere must learn to take care of themselves, detect their own medical risks, and solve problems using new emerging POC technologies appropriately matched to therapies, including improvements in lifestyle and diet. Hence, mankind is evolving a worldwide transformative principle of enabling people with POC tools for personalized medicine at the individual level and in the communities where they live. These stronger communities will mean more resilient ones.

The key to this disruptive transformation is “point of care culture,” that is, actual implementation of *medical empowerment of the individual and family nucleus integrated with norms, behaviors, beliefs, attitudes, expectations, POC technology, and outcomes*. Enlightened point of care tuned to local culture will enable a resilient future and help keep larger numbers of people healthy worldwide, despite disparities of disease, income, demography, and opportunity.

PRINCIPLE III—ASSESSING NEEDS

Expectations can be established through formal and informal needs assessment surveys which are addressed in detail in Kost et al. (36). See Kost et al. (37) for an example of a POC culture survey questionnaire. The overall cognitive process is summarized here in Figure 1. Subjects go through a series of cognitive stages when responding to surveys. After the interviewer presents the survey, subjects first interpret the questions and response options, retrieve relevant information from memory, and make

Table 1 Point of care culture—sociology, insight, and solutions

Sociological phenomena	Cultural insight	Point of care solutions and suggestions
Mindset that POC test results will have no effect on health outcomes & no future benefits	Religious belief that life outcomes are predetermined as well as lack of knowledge to improve health behaviors & lifestyle	Medical professionals can highlight how evidence improves health outcomes & connect with healthy eating habits & the importance of exercise
Some patients doubtful they can acquire necessary skills to utilize POC testing	Reliance on medical experts to handle all medical needs, significant level of illiteracy in older populations, & a belief that a high level of education is needed for device use	Medical experts should highlight the ease of using POC devices & use step-by-step free video teaching tools (e.g., YouTube) to instill confidence in patients
Fear that devices can cause physical discomfort	Belief that needles or injections given by oneself will lead to serious conflict	Reinforcement from others with similar backgrounds will dispel fear & mollify false beliefs
Conviction that devices are only for middle & upper class	Philosophical tenant that those with money are not similar to those with modest means	Highlight success stories of successful POC testing usage by poor people in rural areas
Inertia when faced with problems operating POC technologies, so patients drop long-term	Norms encourage not worrying about potential troubles & maintaining a relaxed mindset	Encourage medical volunteers to conduct home visits to prevent & mitigate POC technical problems in a timely manner
POC devices are inconsistently beneficial if medical professionals are unaware patients are using them	Medical professionals see numerous patients in a day, coupled with the fact that patients tend to play the role of spectator during physician visits	Tests, results, & trends in evidence should be integrated into the patient’s medical record so the health team is aware of benefits for diagnosis, monitoring, & guided therapy at the point of need
Hesitancy to seek care for chest pain with delays in getting to the ER (7), plus language barriers	Stoic philosophy of the “poor” derived from engrained modest expectations & a life experience of suffering	Move screening for elevated cardiac biomarkers, such as cardiac troponin I or T, closer to the patient’s home & into the hands of familiar people

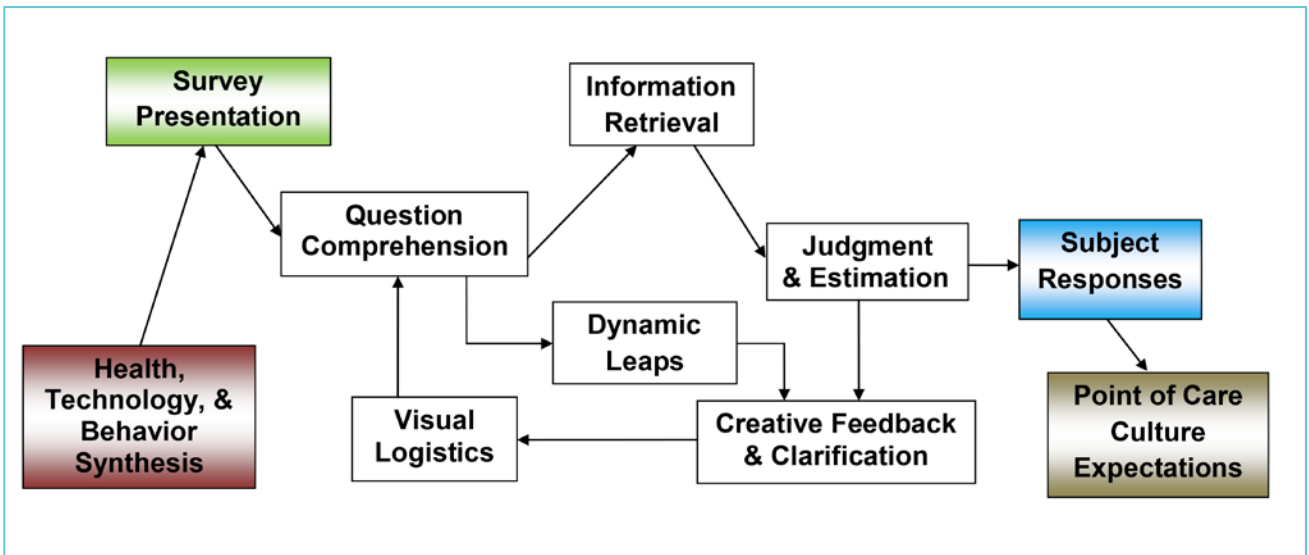
Sociological phenomena	Cultural insight	Point of care solutions and suggestions
Isolation experienced during the Great Bangkok Flood of 2011 (8)	High level of stress from lack of needed support by family & friends, & no acute care	Place POC devices on trucks carrying mobile labs above the water line, or in boats, & screen & rescue
HIV risk in border provinces due to human trafficking & lack of continuity of care among transient workers	Health screening is moving “private,” whereby there is the potential for “hiding” diseases from public health scrutiny (9)	Provide POC tests to clinics, screen birthing mothers & newborns, use algorithmic testing routines, monitor viral load, treat more effectively, & prevent childhood morbidity & mortality
Dengue fever, malaria, & TB outbreaks & endemic areas where people must work outdoors	Public health problems may not receive adequate funding before the advent of resistant strains, when treatment becomes more difficult & risks higher	Invest in the future, invent new POC assays, focus on drug resistance, design platforms for novel approaches, & target therapy better
Broad teaching of healthy lifestyle habits may be ineffective for rural patients who are obese	Rural citizens may lack the creative ability to adapt teachings to their own life—they prefer a “how to” approach	Knowledge sessions (e.g., diabetes) must be specific & teach about glycemic index, portion control, & the effects of carbohydrates on glucose levels
POC devices can be less beneficial in certain patients over the long term	Needs assessment will reveal what each patient expects, why failures may occur, & how the care team can address them	Baseline data must be obtained for each patient (e.g., pre- & postprandial glucose) & individual trends in HbA1c followed quarterly (10)
Relationship between patient complexity, practice-level performance, & quality of rural care (11)	Proportions in diabetes control were lower for patients with greatest difficulty self-testing & keeping appointments—disjointedness	Reporting & resource allocation based on quality assessment must account for patient characteristics in vulnerable populations doing SMBG
Massive self-screening program (12) & urine alb:cr ratio testing (13)	Awareness of renal disease improved, & can assess risk & manage blood pressure better	Tab proteinuria overdiagnosis to be corrected with better color resolution, ACR better in community

Sociological phenomena	Cultural insight	Point of care solutions and suggestions
<p>Roles for health care from the South-Isaan local wisdom in Khamer-Kui's Women (14)</p>	<p>Beliefs in local knowledge with traditional health care & treatment, holistic views based on epistemology, plus language & culture barriers leading to inaccessibility to governmental development</p>	<p>Position modern laboratory medicine, particularly POC testing & devices, to enhance health care delivery in the SWN & reassure the health status of people living there in terms of evidence-based medicine</p>
<p>Health beliefs & health care lifestyle of Thai-Song-Dam, one of the ethnic groups in Phitsanulok Province, in the present differ from the past (15)</p>	<p>Most of the Thai-Song-Dam people now access health facilities, such as sanitariums, clinics, & hospitals, compared to less use in the past, but many still have serious problems, such as diabetes & hypertension</p>	<p>Care paths should take into account not only acute & chronic diseases, but also the needs of different generations & changes with aging, so as to make continuous the POC culture of the future & to enlighten self-care</p>
<p>Self-testing for HIV, STDs, & cancer in different settings (16-18)</p>	<p>Cultural match varies resulting in successes & failures, & impact on population screening</p>	<p>Care paths must be culturally tuned & piloted before launching formal self-care POC programs</p>
<p>Neglected remote rural high prevalence population (19)</p>	<p>"Building Healthy Communities" proven with the introduction of convenient & rapid POC "one-stop" multidisciplinary services</p>	<p>Targeted POC tests provided multidimensional benefits in outcomes for patients with diabetes, "one-stop" multidisciplinary services raised awareness, enhanced community ownership, contributed to compliance, & helped doctor-patient relationships</p>
<p>Type 2 diabetes patients were more concerned about their personal perceptions of the outcomes they experienced related to complementary & alternative medicine use than to the opinions of health professionals (20)</p>	<p>Belief in their own experiences are stronger than the influence of external opinions</p>	<p>Medical professionals should provide POC test results to instill confidence in patients</p>

Sociological phenomena	Cultural insight	Point of care solutions and suggestions
<p>Rural elderly people have unsafe sociodemographic conditions & potential for low health care seeking (21)</p>	<p>Low economic status is one of the barriers in seeking medical care for morbidity</p>	<p>Place POC devices on mobile units that visit the elderly periodically, perform relevant testing, then counsel the elderly gently so that they believe in the evidence presented & will return for follow-up</p>
<p>Physicians & policy makers/regulators had inadequate knowledge & negative attitudes concerning the proper use of opioids for cancer pain management in Thailand (22)</p>	<p>View that inadequate knowledge & negative attitudes represent real barriers</p>	<p>Provide sufficiently relevant training & give examples of modern POC devices accepted in hospitals worldwide for toxicology screening & detection of substance abuse</p>
<p>Caregiver dependent factors were more strongly associated with high burden than patient characteristics(23)</p>	<p>Age of caregiver, self-reported health status, self-reported income, & duration of care are associated with chronic diseases</p>	<p>Necessary, but easy to use POC devices (e.g., oxymeter & glucose meter) should be offered to caregivers to help reduce their burden</p>
<p>Thai Buddhist families' perspectives on a peaceful death in the ICUs (24)</p>	<p>The thought that "knowing death is impending" is important to families who prepare for & manage a peaceful death in ICUs</p>	<p>All related persons must arrive at a consensus regarding families' perspectives & POC trend monitoring may allay anxiety as families come to accept demise</p>
<p>Women's attitudes towards heavy menstrual bleeding & their impact on the quality of life (25)</p>	<p>Beliefs that heavy menstrual bleeding is problematic to social life, relationships, & work</p>	<p>Medical professionals should seek a proper way of mitigating heavy menstrual bleeding in women while also checking POC Hgb/Hct to avoid Fe-deficiency anemia</p>
<p>Community satisfaction with POC testing was validated using qualitative surveys of device operators in the Northern Territory, Australia (26)</p>	<p>Intangible qualities of POC testing can be as important to people as the underlying science</p>	<p>Analytical quality for POC testing met professional-based analytical goals & laboratory performance thresholds for most tests; >80% of respondents cited convenience & stated it assisted in the stabilization of patients with acute illness</p>

Sociological phenomena	Cultural insight	Point of care solutions and suggestions
Delivering exemplary neurosurgical care in the future (27)	“Our profession is battling a relentless assault as numerous sectors implement change that impacts us & our community every day.”	Consider adopting POC early detection technologies. “Innovation & diversity are crucial to encourage & reward when trying to effect meaningful cultural change, while appreciating the power of a ‘Tipping Point’ strategy will also reap significant benefits.”
A jealous “widow ghost” (pii mae mai or lai tai) kills men in Surin, Thailand (28)	Superstitious evil spirit thwarted by “red shirt” postings outside houses thought to protect dwellers inside	POC EKG mobile monitoring to detect arrhythmia in Brugada Syndrome & avoid sudden death when asleep or ambulatory by continuous recording or telemetry
Education in cultural competency of radiologists in Japan (29)	Adapt practice specifically for Japanese behavior	Implement POC tests, such as rapid creatinine, to screen for renal compromise & reduce risks of contrast media
Ethical issues regarding information disclosure for consents in Saudi Arabia (30)	Male, post-procedure, & older patients are in favor of more information disclosure, while educated patients are particularly dissatisfied with current communications	Adopt point-of-need technologies, such as iPads with ample visual logistics, to communicate more effectively, & also perform bedside tests with immediate feedback enabling “physician capture” & fast feedback on status
Practice-based perspective on technology acceptance (31)	Innovation characteristics are reflected through the events of existing practices in the context of power-related concerns, resistance to change, & conflicts between professions in the creation of a new practice, namely, POC testing	The acceptance of an innovation is closely connected with the acceptance of existing & emerging practices, & key characteristics include reliability, speed, cost efficiency, usability, & ecology for POC testing approaches
Terror management theory & mortality reminders (32)	Examined if various mortality reminders would elicit more avoidant responses toward a novel device that indicates cardiovascular disease risk, the “CVD Risk Biochip”	Performance of initial qualitative investigations of the cultural worldviews of a particular cohort must come first, & the POC Biochip may have a beneficial effect on the potential uptake of screening behaviors, because it furnishes individuals with a risk status for developing a condition rather than indicating the presence or absence of a condition

Figure 1 Cognitive processes, flow, and stages experienced by subjects while being interviewed



After the interviewer presents the survey, first the subjects interpret the survey questions and the response options, then retrieve relevant information from their memories. Subjects then make judgments about the relevance and accuracy of their answers to the question and eventually report their response. Clarification by means of visual logistics assists the interview process and helps alleviate the “recency effect” by pointing, without biasing, subjects toward future decision-making.

a judgment about the relevance and accuracy of answers, then eventually report a response (38). Errors and biases can occur at each of the stages as a result of both internal and external factors.

It is worth noting that psychological theories and methods evolve rapidly and are constantly under debate. Nonetheless, Table 2 highlights key topics and valuable concepts for high quality surveys. Our POC culture survey, which is divided into POC testing, POC culture, and post-evaluation assessment, and can be found as Appendix 3 in *Global Point of Care: Strategies for Disasters, Emergencies, and Public Health Resilience* (37), aims to reveal underlying expectations, perspectives, beliefs, and acceptance of emerging technology, some of which is not yet available in the United States. Current knowledge of point of care and its technical and cultural attributes strives to integrate a logic web of future community and global resilience (39).

PRINCIPLE IV—CHARACTERIZING POINT OF CARE CULTURE

We investigated POC culture in rural Thailand by employing the principles above and composing questions for a 1-1.5 hour 1-on-1 survey (2,37). The survey was translated into the Thai language and approved by the Ethics Committee of Chulalongkorn University in Bangkok. Questioning of individual subjects was conducted by a native Thai-speaking interviewer familiar with laboratory medicine. When facing unexpected medical problems, subjects called for medical services mostly delivered at hospitals close to their home, reflecting confidence in and familiarity with local medical care, such as Primary Care Units, which are distributed near villages throughout Thailand, in contrast to services provided by university medical centers, which are quite distant and were least desirable. Interestingly, subjects were fairly receptive to services in homes, which bodes well for the use of POC testing and self-monitoring.

Table 2 Survey characteristics that produce objectivity, quality, and impact

Neutral survey presentation	Elimination of false inferences that result from biased survey delivery. If the respondent's perceived intent of the survey is different from the researcher's actual purpose, the respondents are likely to only provide information that they believe the interviewer is seeking, which could be inconsistent with the actual purpose of survey.
Question comprehension	Avoidance of comprehension errors that affect data quality. Sources of comprehension errors include ambiguity, low-frequency words, vague quantifiers, and excessive complexity.
Memory retrieval	<p>Reducing retrieval failure. Different forms of retrieval failure include memory decay, interference, and distortion. Researchers should avoid asking overly detailed questions, allow subjects to review past records, increase respondent time on tasks, and provide retrieval cues.</p> <p>Minimizing the possibility of availability heuristic. Availability heuristic is a mental shortcut used when one estimates frequency or probability of events by the ease with which instances could be brought to mind rather than examining other alternatives. The result may not reflect the actual probability of the events happening.</p> <p>Elimination of the priming effect. Exposure to certain stimuli may trigger activation of related thoughts later. For example, when exposed to the notion of diabetes, concepts like disease, blood glucose, and insulin are activated as well, making them easier to be retrieved than other concepts. Careful ordering of questions can help reduce priming effect.</p>
Judgment and estimation	<p>Avoidance of satisficing. Difficult tasks, lack of motivation, and limited capability tend to make the respondent only search for a satisfactory choice rather than the best alternative. Simplifying the tasks so that respondents are capable of executing the task and gaining cooperation from respondents are effective solutions.</p> <p>Elimination of acquiescence bias. Acquiescence bias refers to the tendency for respondents to agree with a statement, which usually happens with agree/disagree questions. One solution is to use item-specific response options.</p>
The recency effect	Balancing recent and past events. There is a tendency when making decisions to give recent events more weight than things further in the past. Visual logistics can point the subject forward, rather than backward, and encourage responses in synch with future decision-making.
Subject response	Elimination of social desirability bias. Respondents tend to deliberately misreport their behaviors in order to be viewed in a positive light. Researchers can control the interview mode and survey wording to minimize social desirability bias.

When questioned about preferences for medical care, subjects preferred quick diagnosis and treatment, friendly staff, availability of technology, and short time to reach help, in that order. Oddly, quality came in last. The survey tool includes several questions and “visual logistics.” These illustrations help simulate actual interfacing with diagnostic testing, which is not performed during the questioning period. The subjects thought that capillary blood sampling would be the most uncomfortable procedure, followed by venipuncture, while innocuous collection of urine samples and noninvasive scanning were not deemed uncomfortable. Since capillary blood sampling is common to POC testing and “nanotainer” microassays (40), we will investigate subject past experiences further to determine if lancets were selected inappropriately, fingertips were pierced several times, or collection methods were performed incorrectly in the absence of adequate training, which one author (GK) has observed several times in the field. Nonetheless, subjects recognized the merit of noninvasive scanning.

Subjects felt that the fear of the procedures, views in their community, and potential personal risks from procedures influenced their choice of medical care. Religious beliefs, government policy, family opinions, and superstition occupied the middle ground, while the costs of care were not deemed that important, possibly because they had so-called 30 Baht (~1 USD) “gold cards” that gateway inexpensive access to care. Other responses revealed attitudes toward and knowledge of diabetes (see below). In short, the survey tool provided an efficient approach for exploring the basic characteristics of local POC culture, namely, norms, behaviors, beliefs, attitudes, expectations, POC technology, and outcomes, and we intend to continue this discovery process in order to integrate effective therapy, which may be as straightforward as

lifestyle and diet changes that will reduce risk of diabetes.

PRINCIPLE V—REACHING OUT AND EDUCATING

Common diseases, such as prediabetes and diabetes, must be addressed by modifying beliefs, habits, lifestyles, diets, and knowledge, while implementing novel instruments that redefine medical self-sufficiency at the point of need, and do it meticulously, individually, and socially within communities on a global scale. While POC culture is strikingly multifactorial (1,2), it is the element of *expectation*, per se, that has changed medical transactions and confronts physicians, nurses, and care teams every day, since POC testing is virtually ubiquitous throughout the world, and people expect immediate knowledge, diagnosis, problem solving, and treatment, despite circumstances that may be beyond the ability of the healthcare system to control (e.g., newdemics), while still delivering high quality care at points of need.

As POC information becomes organized into collective SWN knowledge in the accessible GIS, the future impact of POC culture will become apparent to public health practitioners, strategists, and importantly, businesses, the practical providers of the new and emerging technologies. Culturally, with a philosophy of promoting self-care for both personal and public health, one must know how patient behavior affects POC results and vice versa. For example, some POC results, such as evidence of HIV-1/2 and Hepatitis B (or C) infection, may have devastating immediate impact on patients and their families.

Therefore, test results should be presaged by outreach and education, a theme we encourage. In rural limited-resource communities, major challenges arise when linking self-testing with treatment in a manner whereby the

patient, the primary care nurse, the physician, and the pharmacologist all agree long-term and then see to it that there is persistence, continuity, oversight, and correction of non-compliance. Thus, development of care paths in local languages will facilitate cost-effectiveness, improvements in outcomes, and future cultural acceptance. We call this the *final frontier* of POC testing (1,2)!

PRINCIPLE VI—CREATING COMMON PURPOSE IN PUBLIC HEALTH

While technology plays an important role in disease management at the point of care, thorough understanding (the compass) of local culture is just as crucial. Both a map (needs assessment results) and compass are necessary to arrive at medical destinations successfully, both literally and figuratively. Effective utilization of needs assessment surveys, which requires sufficient understanding of survey psychology (2, 37), can provide healthcare professionals with invaluable information about local customs, values, and lifestyles to build a strong foundation for a targeted, interactive, and meaningful POC program.

Particularly important cultural aspects worth exploring include dietary habits and preferences, religious beliefs, individualism/collectivism, degree of long-term orientation, power distance index (the extent to which patients, as less powerful participants in the healthcare organizations, accept and expect that power is distributed unequally), and attitudes and preferences regarding different POC technologies before deciding which to implement. As more and more handheld and portable devices are implemented, they will become second nature, possibly to the extent where the “point of care” concept, per se, is nearly forgotten, and personal diagnosis and monitoring become routine,

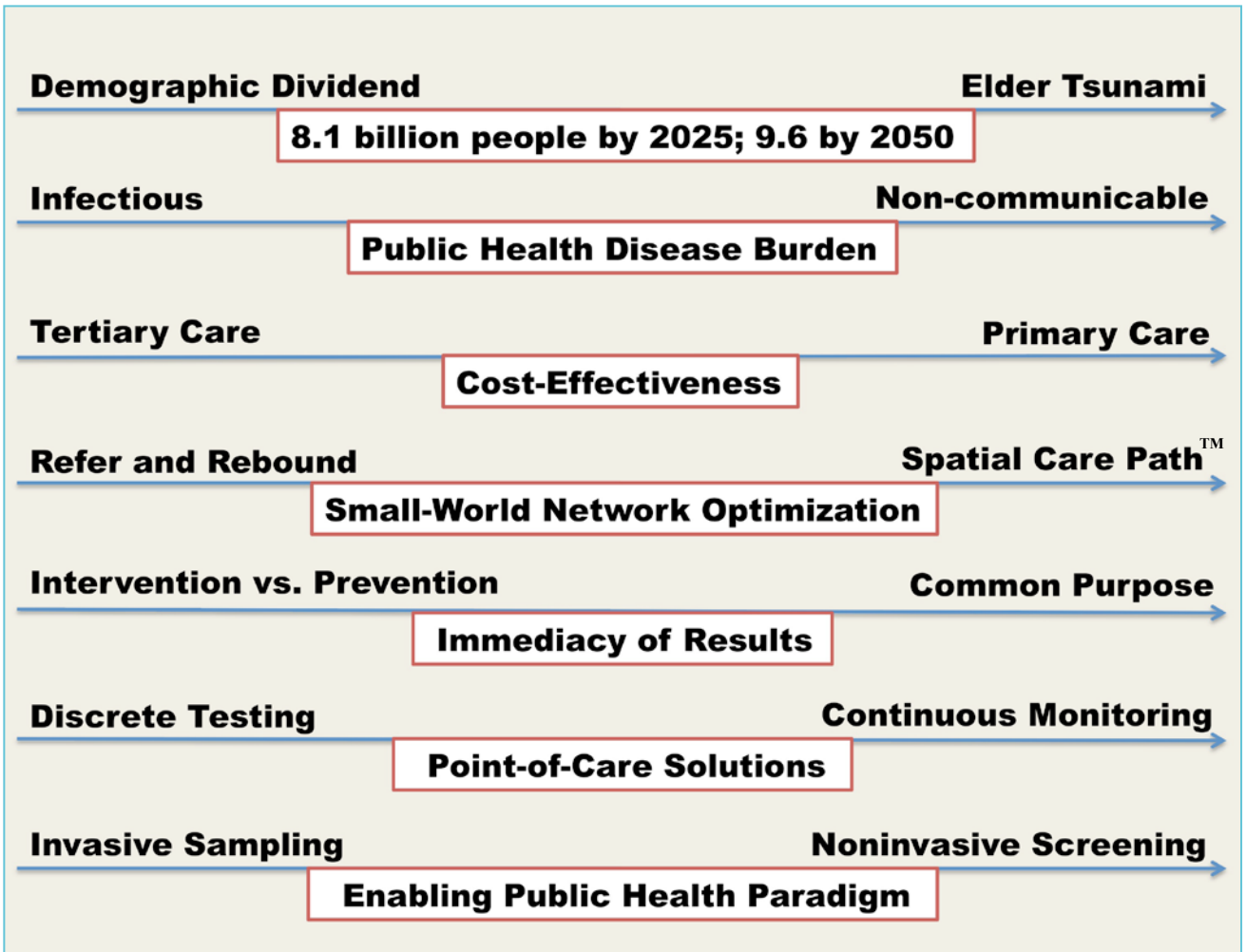
commonplace, and because of economies of scale, inexpensive.

Professionals should strive for continuous collaboration between laboratory medicine and other fields, such as psychology and public health in order to develop successful culturally tuned POC paradigms for the future. As medicine moves progressively to points of need, as it must in order to be cost-effective in overly crowded societies, people increasingly will make their own decisions about which devices and modalities to select for self-care. Therefore the power index will shift in favor of the patient, who becomes, for all practical purposes, a public health practitioner.

Just like it is almost unreasonable not to be able to contact anyone anywhere on a cell (mobile) phone nowadays, POC will do the same, but with simultaneous risk assessment and diagnostic information, which will be distributed and assessable on site. Marketplace competition will speed that process, both for patients and physicians. Business entrepreneurs will see to it, in part because this new approach will improve the health of their employees. Ideally, the evolving strategies, decision-making, and value propositions will be informed, guided, and seasoned.

Kost LK et al. (41) devised such a scheme for risk assessment and diagnosis of prediabetes in India. The approach, which integrates prevention and intervention to create common purpose in public health, is summarized briefly here. Current global perspective suggests that there is convergence to a single common purpose in the public health field as non-communicable diseases displace infectious diseases in terms of the vast numbers of people afflicted, and ageing of world populations increases the prevalence of non-communicable diseases while disproportionately adding chronically ill elderly to societal burden (Figure 2).

Figure 2 The vectors of future public health

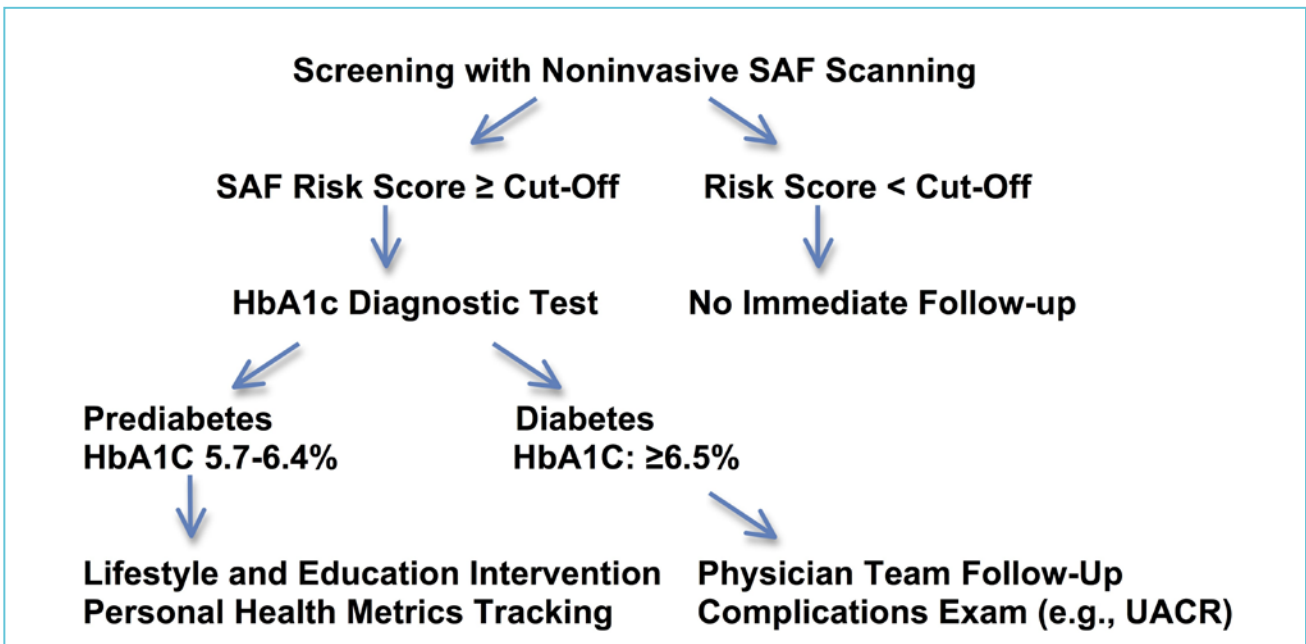


Seven vectors will strongly influence the future destiny of public health. They reflect inevitable changes transforming current professional practice to a paradigm that better fits ageing societies burdened with non-communicable diseases. To achieve cost-effectiveness, innovative POC solutions are necessary at the primary site of care. Patients follow spatial care paths™ in optimized small-world networks without inefficient hospital referrals and rebounds after discharge because of lack of personal ownership of solutions that facilitate preventative health measures, such as improvements in lifestyle, diet, and physical activity. POC screening, testing, and monitoring provide immediate evidence-based results for simultaneous prevention and intervention. The program plan for prediabetes uses noninvasive screening and POC HbA1c testing of capillary fingerstick blood samples, an innovation that is enabling to the new public health paradigm.

The program plan comprises evidence-based metrics [body mass index (BMI), skin autofluorescence (SAF) score, POC HbA1c, sugar-sweetened beverage (SSB) consumption, questionnaire follow-up, physical activity (steps walked determined by pedometer), and an optional POC lipid panel for the assessment of metabolic syndrome] of patients with prediabetes discovered during an initial subject encounter

that occurs at the place of employment or other convenient location for the individual being screened. Then, the test cluster of risk, diagnostic, and potentially therapeutic data are gathered rapidly and on site. Figure 3 shows the decision tree. Thus, we anticipate that public health will be transformed to blend prevention and intervention in one common purpose (Table 3).

Figure 3 Prediabetes program flowchart



One of the primary advantages of the program plan designed as a community approach is that large numbers of subjects can be screened quickly, painlessly, and cost-effectively to discover those with prediabetes who merit further evaluation, entry into the education branch of intervention, and follow-up with personal health ownership and outcomes metrics that track successful personal management and a return to healthy living. [UACR is urine albumin to creatinine ratio.]

Table 3 Factors transforming public health:
 Point of care will merge intervention and prevention

Decreasing birth rates and increasing longevity are reshaping disease patterns from infectious and acute to non-communicable and chronic

Internationalization of medical science, globalization of the healthcare workforce, and convergence of common purpose are transforming standards of care

Globalized economies bring hazards, set-backs in lifestyles, and need for international disease control in the local context

Local patient encounters take place in the context of worldwide information access and influence, so likewise, access to public health must be reengineered for the point of care

Outcomes measured by objective metrics will increasingly depend on assimilation of appropriate POC technologies at dynamic points of need

Spatial care paths™, that is optimized treks through small-world networks, are facilitated by POC screening, monitoring, and testing, which simultaneously merge intervention and prevention to create common purpose in public health

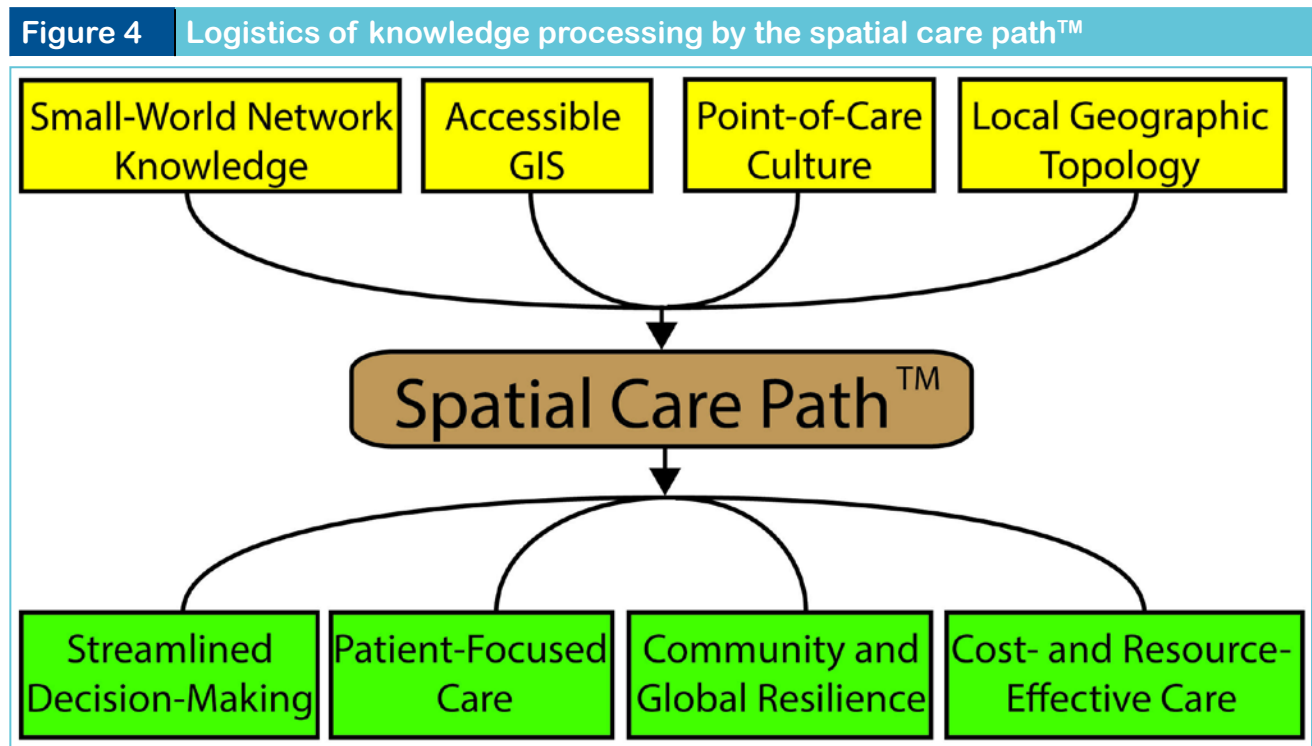
PRINCIPLE VII—INNOVATING THE SPATIAL CARE PATH™

Definition and utility

We define the spatial care path™ as the most efficient route taken by the patient when receiving definitive care in a small-world network (SWN). While being introduced formally here and also recently for the first time at a national meeting in the United States (42), the spatial care path™ concept eventually will dominate the delivery of healthcare as populations expand, the elderly increase in numbers, and common sense, not to mention financial necessity, dictates that care must shift upstream to the site of the patient in order to conserve resources, save time, and spare lives (Figure 2). In other words, just like POC testing, it will become commonplace in future POC culture for the patient to increasingly take possession of his or her own medical destiny (read: screening, diagnosis, monitoring,

and therapeutic adjustments) and by doing so, the collective community will benefit from enhanced resilience.

The inputs and outputs for a spatial care path™ (Figure 4) are self-evident—local geographic topology builds the physical relationships between the community and their health resources; SWN knowledge helps define how these communities relate to and utilize these physical connections, and identifies inefficiencies; POC culture helps distinguish gaps in knowledge or cultural barriers inhibiting technology adoption; and a GIS ensures that this information is accessible at the point-of-need. The end result of this analysis is that POC testing will be implemented at relevant locations that streamline decision-making, enable patient-focused care, improve overall community global resilience, and reduce costs and resource utilization providing more effective and efficient care.



A spatial care path™ models existing infrastructure and suggests improvements that result in streamlined, patient-focused, cost- and resource-effective, and resilient care.

Key features

Key features of a spatial care path™ include but are not limited to the following: a) it starts with the patient wherever the patient is located, rather than at the other end of the spectrum, that is, at the medical institution; b) the patient progressively participates in decision-making by virtue of self-monitoring and POC tests available beginning in the home, primary care, and SWN hubs; c) it is highly facilitated by POC testing in that distributed diagnostics provide timely evidence-based decision-making along the way; d) it establishes access to the most critical elements and scarce specialists of the health-care delivery system in the SWN; e) it can be managed quantitatively by means of the real-time GIS, the POC test vector, V_{POC} , and the access vector, V_{ACCESS} ; and f) it is particularly useful in limited-resource settings because it optimizes the use of medical resources within the SWN, especially with the SWN becomes compromised or isolated by natural disasters, complex emergencies, or pandemics and necessary quarantine.

The role of the Geographic Information System (GIS)

A spatial care path™ relates populations and the resources that provide care. Since these relationships are linked to geography, it makes sense to evaluate them in that context. Geographic information systems allow one to view and analyze spatial relationships among populations, resources, road networks, and other attributes (6,43,44). Using a GIS to explore spatial care paths™ allows one additionally to visualize inefficiencies inherent within SWNs and model alternative POC placement schemes that will streamline access to care. The ability to visualize the SWN helps understanding of the advantages of POC technologies before implementing them in the real world, thereby saving resourc-

es, time, and money, and at the same time, establishing resilience within the SWN.

Modeling population health access within a spatial care path™

Evaluating the spatial care path™ involves modeling population health access to diagnostic resources and then care. The spatial care path™ provides a structured analysis through a GIS of geographic entities (e.g., roads, hospitals, and population locations), SWN culture phenomena, and diagnostic resources to provide an objective analysis of appropriate changes to health resources. This spatial model provides a means to evaluate how to integrate POC to identify the critically ill and streamline their transportation to appropriate resources.

For example, exploring how integrating POC into different levels of the health system (e.g., primary care, community hospital hubs, and referral or tertiary care centers) or ensuring all population are within 60 minutes of a diagnosis, could set policy strategies for health officials. The GIS can then identify the most effective placement of POC technologies to prove evidence-based and streamlined care consistent with those policies.

Translating delivery systems into spatial care paths™

Care paths for specific diseases exist, or are being formulated to understand the best way to deal with adverse sequelae and downstream complications for which care by specialists is very expensive. For example, a diabetes care path was developed for rural Isaan in Thailand (45). The care path starts with primary care close to where patients live. Thus, in some cases the spatial care path™ can start with the diagnosis of preconditions, such as prediabetes by means of the strategy in Figure 3, and allow people to adopt changes in their lifestyle before prediabetes evolves into diabetes. These actions

improve health and decrease costs before more drastic complications appear. Disease-specific care paths serve as a good media to be translated into dynamic spatial care paths™. By understanding where patients are physically located through the GIS, inefficiencies can be observed upstream and alternatives can be modeled that will accelerate SWN operations downstream.

Spatial problem solving

A novel example of the dynamic spatial care path™ is provided by the efficacious approach to the acute rescue of Aboriginal Australians with acute coronary syndromes (ACS) (46). The Australian program was motivated by discrepancies in mortality rates of underserved peoples in rural areas of Australia who did not fare as well as their more affluent peers in metropolitan areas, and for whom “...distances to PCI (percutaneous coronary intervention) centres exceed 250 km...” The executive cardiac specialist on call for the integrated cardiovascular rescue network benefits from telemetry of raw data provided by the actuation elements of V_{POC} which is established with proper quality control and other proactive enhancements to include essentials, such as the ECG, cardiac troponin T, and electrolytes, obtained at the point of care. Risk stratification is achieved with POC cardiac troponin testing. Operationally, V_{POC} becomes a risk assessment vector.

In the Australian program, a pivotal decision occurs when the physician lead decides whether or not evidence is adequate to order fixed wing aircraft rescue (at a cost exceeding \$2,000 USD). Signs and symptoms of acute myocardial infarction (AMI) must be documented rapidly and adequately to warrant immediate coronary catheterization or other life-saving measures not available in the rural area. Program successes include relieving rural areas of unnecessarily high death rates from AMI, providing equity to Aboriginal Australians who previously did not

receive optimal interventional cardiac care, and other public health benefits such as improved quality-adjusted life years.

Specifically, “...availability of immediate cardiac support was associated with a 22% relative odds reduction in 30-day mortality...” and “...lower mortality (was) observed among transferred patients.” In this case, the primary diagnostic work-up of the patient at the point of need, access to POC cardiac biomarker testing in V_{POC} , the fixed-wing aircraft, and the case resolution in the hands of highly trained specialists at the referral hospital represent some of the key edges (process steps) in the real-time spatial care path™, which is optimized for each patient episode in the context of the geographic SWN, its topology, and net inaccessibility, which is overcome with the rescue flight. Therefore, this example of the spatial care path™ starts with the patient, evidence, and interpretation at the point of origin, and then moves the critically ill patient toward intervention, thereby optimizing strategy, sequence, and outcome.

CONCLUSIONS AND RECOMMENDATIONS: PROPELLING A FUTURE VISION

- Research findings generated by surveying POC culture motivate the sound practice of POC testing, thereby enhancing the efficacy and effectiveness of diagnostic tests and disease-specific care paths.
- Lifestyles, attitudes, expectations, and beliefs influence decisions on adopting current screening methods for prediabetes positively, and thus, noninvasive screening and associated POC testing might provide sufficient knowledge to forestall increases in prevalence.
- Integrative initiatives, such as an holistic approach recommended above for prediabetes discovery, management, treatment, and follow-up, conducted simultaneously with

- lifestyle changes and consumption of nutritious diets, represent vital building blocks for meeting future economic challenges in nations lacking adequate healthcare resources, yet at risk of growing old with the added burden of expensive disease complications before growing rich.
- Culturally aware POC solutions should be tuned to local societal norms and characteristics in order to optimize effectiveness, and readers can take advantage of the survey provided in Appendix 3 (37) of *Global Point of Care: Strategies for Disasters, Emergencies, and Public Health Resilience* as a starting point for investigation and exploration.
 - Metric value scales can be established from survey subject preferences, such that a POC test will support clinical decision-making within its operational context of local culture, and therefore, evaluation metrics will be more “organic” for emerging POC technologies than for conventional diagnostic tests performed in the hospital clinical laboratory.
 - Unmet needs assure a bright future for inventors, innovators, and entrepreneurs who develop these new POC solutions, that is, new elements of V_{POC} , such as SAF screening delivered reagent-free and inexpensively at the site of care for rapid detection of diabetes and cardiovascular risk, and therefore, government and private sectors should draw public attention to the high quality and cost-effectiveness of noninvasive screening and other promising newcomers.
 - As small, connected, and handheld POC devices and smartphone diagnostics become ubiquitous throughout society, a new way of living and thinking that embraces ownership of healthcare will become natural—part of everyday human existence that is highly informed.
 - Spatial care paths™ provide a structured analysis of health attributes in the SWN and model how to make it meet the demands and needs of the community.
 - Harmonizing diagnostic testing in SWNs will accelerate progress in the ASEAN member states, China, and other countries and their limited-resource rural areas by improving the accessibility, quality, usefulness, and impact of POC test results.
 - Practicing point of care in the context of local culture represents the *final frontier*, and if explored successfully, will become a notable achievement for the 21st Century!
 - Ultimately, POC culture will be recognized as one of the most important characteristics for reducing medical poverty, and its understanding will create impactful solutions and resilience at points of need worldwide.

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