GLOBAL POINT OF CARE: STRATEGIES FOR DISASTER, EMERGENCY, AND PUBLIC HEALTH RESILIENCE—USING “FAST POC” TO STOP EBOLA & MERS CoV OUTBREAKS

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Please email questions to Dr. Kost at gjkost@ucdavis.edu. Thank you.
Fanfare for a New Field of Medicine!

The Origin and Definition of Point-of-Careology

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EBOLA

Signs and Symptoms

If You Have Fever, Diarrhoea and Vomiting With or Without Bleeding
GO IMMEDIATELY TO THE NEAREST HEALTH FACILITY
For more information call 117 (Call free)
Fear is what you imagine. Danger is real. Courage to act is everything!

“Newdemics” Publication Set—2015
AMERICAN JOURNAL OF DISASTER MEDICINE
CLINICAL LABORATORY INTERNATIONAL
EXPERT REVIEWS IN MOLECULAR DIAGNOSTICS
WHITEHAT COMMUNICATIONS WEBINARS
Ebola virus’ typical path through a human being

**First symptoms**
- Day 7-9: Headache, fatigue, fever, muscle soreness
- Day 10: Sudden high fever, vomiting, bleeding from nose, mouth, eyes, anus
- Day 11: Bruising, brain damage, loss of consciousness, seizures, massive internal bleeding, death

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Source: U.S. Centers for Disease and Control, BBC
Graphic: Melina Yingling
NEEDS ASSESSMENT FOR RAPID DECISION MAKING IN PANDEMICS, COMPLEX EMERGENCIES, AND DISASTERS: A GLOBAL PERSPECTIVE

GERALD J. KOST, RICHARD F. LOUIE, ANH-THU TRUONG, AND CORBIN M. CURTIS

OVERVIEW

Clinical needs assessment defines unmet healthcare needs and determines how to fill them. The goal of this chapter is to describe the process of performing needs assessment in the context of translating needs into innovative point-of-care (POC) technologies. We performed need assessment surveys to identify diagnostic testing gaps in complex emergencies, disasters, and public health and used SurveyMonkey® to administer them. Literature searches also were conducted using the PubMed database and keywords, such as point of care, needs assessment, and POC disaster needs assessment. An emerging technology logic model summed up our approach. Original research by the University of California, Davis POC Technologies Center and publications by other investigators revealed insights about POC testing (POCT) needs for emergency and disaster response. Laboratory, POC coordinators, medical doctors, researchers, disaster responders, disaster experts, and others indicated the importance of (a) having specific POC tests in emergencies and disasters, (b) desired sampling methods that preserve integrity of the sample while minimizing biohazard risks, and (c) defined essential test clusters for bloodstream and respiratory infections. Evidence also revealed strong need for influenza testing and resistance markers useful in public health. Developers can reduce product development risks by conducting formal needs assessment that helps identify end-user product features and requirements early on. Needs assessment guides the product development pipeline of new technologies by helping (a) to identify and prioritize diagnostic testing needs, (b) to determine technological gaps and deficiencies that impact patient care, and (c) to design specifications for new POC technologies. Needs assessment has been successfully applied to identify POC diagnostic testing in complex emergencies, disasters, and public health as illustrated in this review and therefore can be used broadly in the point of care field to accelerate progress.

Based on a 2012 World Health Organization Health Statistics report, a median of 61% of the world health expenditure was paid by the government in 2009 (1). Needs assessment can reduce global health care expenditures, improve healthcare resource, and enhance standards of care. Needs assessment, per se, represents a systematic process for determining and addressing what POC users want, as well as for discovering gaps and deficiencies in the current delivery and practice of diagnostic testing at the sites of decision making (2).

Fundamentally, POC grew out of satisfying clinical needs for bedside glucose testing, coagulation monitoring, and intensive care, where the advent of ionized calcium (Ca²⁺), free calcium; Figure 1–1) (3, 4) proved that whole-blood analysis (5) was necessary for the diagnosis and treatment of critically ill patients with rapid therapeutic turnaround time (3) that could not be accomplished with centrifuged samples processed distantly in the conventional clinical laboratory. Once speed was achieved within a comprehensive view proposition of convenience, impactful bedside information, and improved outcomes, the paradigm of testing shifted to the point-of-need where it is likely to remain.

Enhanced healthcare delivery in complex emergencies and disasters can improve crisis standards of care (6). The Southeast Asia Tsunami in 2004, Hurricane Katrina in 2006, Haiti Earthquake in 2010, and Sandy Superstorm in 2012 disrupted, flooded, and destroyed infrastructure, including hospital laboratories and microbiology testing services thereby prolonging patient treatment (7–9). Public health officials should understand the methods of needs assessment, its importance, and current healthcare delivery models in order to push developers to deliver appropriate POC technologies that will enhance standards of care (6).

Strategically integrated POC can provide rapid diagnostic data, facilitate triage, and improve management of victims during disasters (10). POC is testing performed at or near the site of the patient care (11). Recent disasters have demonstrated the feasibility of POC, but POC devices lack crucial test clusters and are vulnerable to harsh disaster environments (12–22). The goal of this chapter is to describe the process of performing needs assessment in the context of translating needs into innovative POC technologies.
LEARNING OBJECTIVES

- **To demonstrate how to determine needs:** Needs assessment helps define the role of POCT in pandemics, complex emergencies, and disasters. “FAST POC” will help stop outbreaks.

- **To understand environmental stresses:** Environmental stresses affect test results and must be avoided, so that POCT can be effective for decision-making in crises.

- **To illustrate the design of POCT caches:** Disaster caches should be designed, expanded, and harmonized for worldwide collaborative use, in part, to address new threats, such as Ebola & MERS CoV.

- **To describe Spatial Care Paths™ (SCP) and point of care culture:** The spatial care path™ starts with the patient, positions POCT optimally, and accelerates care—one “tunes” testing for cultural acceptance. National POCT policy and guidelines in limited-resource and other settings then enhance community resilience effectively.
Needs Assessment Results from AACC members

Top five pathogens selected for disaster settings

- MRSA
- Salmonella typhi
- Vibrio cholerae
- Escherichia coli
- Staphylococcus aureus

First Responders are the preferred group to perform POC testing in disasters.
Respondents preferred patient-side testing in the field over testing inside a vehicle or tent.

Respondents chose CBC, Lytes/Chemistry, Blood Bank, & O₂ Saturation as the highest priority diagnostic tests for a disaster.

How To: Monitor $O_2$ Saturation & Hemoglobin

Changing threats: Ebola & MERS CoV—moving targets need flexible POC devices & culturally sound solutions!

Respondents chose 3 physical challenges as the most important environmental factors to overcome in future POC device designs for extreme conditions.

Hurricane Katrina, 2005
Temp: 20 to 43.3°C

Haiti Earthquake, 2010
Temp: 20 to 35°C

Christchurch, New Zealand, 2011
Temp: 8 to 31°C

Japan Earthquake / Tsunami, 2011
Temp: -5 to 20°C
THE IMPACT OF ENVIRONMENTAL STRESS ON DIAGNOSTIC TESTING AND IMPLICATIONS FOR PATIENT CARE DURING CRISIS RESPONSE

RICHARD F. LOUIE, WILLIAM J. FERGUSON, CORBIN M. CURTIS, ANH-TU TRUONG, MANDY H. LAM, AND GERALD J. KOST

OVERVIEW

Strategic integration of point-of-care (POC) diagnostic tools during crisis response can accelerate triage and improve management of victims. Timely differential diagnosis is essential wherever care is provided to rule out or rule in disease, expedite life-saving treatment, and improve utilization of limited resources.

POC testing (POCT) needs to be accurate in any environment in which it is used. Devices are exposed to potentially adverse storage and operating conditions, such as high and low temperature and humidity during emergencies and field rescues. Therefore, characterizing environmental conditions allows technology developers, operators, and responders to understand the broad operational requirements of test reagents, instruments, and equipment in order to improve the quality and delivery of care in complex emergencies, disasters, and austere environmental settings.

This chapter aims (a) to describe the effects of environmental stress on POCT performance and its impact on decision making; (b) to describe how to study the effects; and (c) to summarize approaches to minimize or nullify the effects of environmental stressors through good laboratory practice, development of robust reagents, and producing novel thermal packaging solutions.

ENVIRONMENTAL STRESSORS AND POC TESTING

In crisis response, strategic integration of POC diagnostic tools, such as portable multiplex cardiac biomarker testing, at alternate care facilities can accelerate triaging and improve management of victims (1). Timely differential diagnosis is essential wherever care is provided to rule out or rule in disease, expedite appropriate life-saving treatment, and improve utilization of limited resources (1).
Dynamic Temperature and Humidity Environmental Profiles: Impact for Future Emergency and Disaster Preparedness and Response

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Abstract

Introduction: During disasters and complex emergencies, environmental conditions can adversely affect the performance of point-of-care (POC) testing. Knowledge of these conditions can help device developers and operators understand the significance of temperature and humidity limits necessary for use of POC devices. First responders will benefit from improved performance for on-site decision making.

Objective: To create dynamic temperature and humidity profiles that can be used to assess the environmental robustness of POC devices, reagents, and other resources (eg, drugs), and thereby, to improve preparedness.

Methods: Surface temperature and humidity data from the National Climatic Data Center (Asheville, North Carolina USA) was obtained, median hourly temperature and humidity were calculated, and then mathematically stretched profiles were created to include extreme highs and lows. Profiles were created for: (1) Banda Aceh, Indonesia at the time of the 2004 Tsunami; (2) New Orleans, Louisiana USA just before and after Hurricane Katrina made landfall in 2005; (3) Springfield, Massachusetts USA for an ambulance call during the month of January 2009; (4) Port-au-Prince, Haiti following the 2010 earthquake; (5) Sendai, Japan for the March 2011 earthquake and tsunami with comparison to the colder month of January 2011; (6) New York, New York USA after Hurricane Sandy made landfall in 2012; and (7) a 24-hour rescue from Hawaii USA to the Marshall Islands. Profiles were validated by randomly selecting 10 days and determining if (1) temperature and humidity points fell inside and (2) daily variations were encompassed. Mean kinetic temperatures (MKT) were also assessed for each profile.

Results: Profiles accurately modeled conditions during emergency and disaster events and enclosed 100% of maximum and minimum temperature and humidity points. Daily variations also were represented well with 88.6% (62/70) of temperature readings and 71.1% (54/70) of relative humidity readings falling within diurnal patterns. Days not represented well primarily had continuously high humidity. Mean kinetic temperature was useful for severity ranking.

Conclusions: Simulating temperature and humidity conditions clearly reveals operational challenges encountered during disasters and emergencies. Understanding of environmental stresses and MKT leads to insights regarding operational robustness necessary for safe and accurate use of POC devices and reagents. Rescue personnel should understand these principles before performing POC testing in adverse environments.


PO2: partial pressure of oxygen
POC: point of care
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Environmental Stress Testing Workflow

POC Reagent
Test Strips & Cartridges

Environmental Stress
Testing Chamber & Profile

Test Stressed
Strips & Cartridges

- Facilitate Device Design
- Enhance Guidelines Development for POCT in Emergency and Disaster Settings

Effects of Dynamic Temperature and Humidity Stresses on Point-of-Care Glucose Testing for Disaster Care

Richard F. Louie, PhD; William J. Ferguson, Stephanie L. Sumner; Jimmy N. Yu; Corbin M. Curtis; Gerald J. Kost, MD, PhD, MS

ABSTRACT

Objective: To characterize the performance of glucose meter test strips using simulated dynamic temperature and humidity disaster conditions.

Methods: Glucose oxidase- and glucose dehydrogenase-based test strips were dynamically stressed for up to 680 hours using an environmental chamber to simulate conditions during Hurricane Katrina. Paired measurements vs control were obtained using 3 aqueous reagent levels for GMS1 and 2 for GMS2.

Results: Stress affected the performance of GMS1 at level 1 (P<.01); and GMS2 at both levels (P<.001), lowering GMS1 results but elevating GMS2 results. Glucose median-paired differences were elevated at both levels on GMS2 after 72 hours. Median-paired differences (stress minus control) were as much as −10 mg/dL (range, −65 to 33) at level 3 with GMS1, with errors as large as 21.9%. Glucose median-paired differences were as high as 5 mg/dL (range, −1 to 10) for level 1 on GMS2, with absolute errors up to 24.4%.

Conclusions: The duration of dynamic stress affected the performance of both GMS1 and GMS2 glucose test strips. Therefore, proper monitoring, handling, and storage of point-of-care (POC) reagents are needed to ensure their integrity and quality of actionable results, thereby minimizing treatment errors in emergency and disaster settings.

Key Words: disaster preparedness, Hurricane Katrina, medical errors, austere environments, quality assurance

During emergencies and disasters, point-of-care testing (POCT) facilitates patient triage with rapid screening and monitoring tests at the site of care, such as the field, an alternate care facility, or an emergency department.1 Emergency responders need to be prepared to manage acute diseases and injuries, such as infections and trauma, and provide care for displaced victims with chronic ailments, such as diabetes.

POCT devices, such as glucose meter systems (GMS), are found in caches of disaster response teams. During Hurricane Katrina, shortages of diabetes supplies (eg, medicine, glucose test strips and meters) have been reported.2 Emergency responders are deployed to a variety of environments where conditions often may exceed the agent and device storage and operating tolerance limits.

We hypothesize that dynamic temperature and humidity stresses affect the performance of glucose meter test strips. Therefore, the objective of this report is to characterize the performance of two commercial glucose test strips using a dynamic stress profile that models conditions in New Orleans during Hurricane Katrina.

METHODS

Point-of-Care Systems and Reagents

GMS1 is a glucose oxidase-based electrochemical meter system, and GMS2 is a glucose dehydrogenase-based meter system. Glucose meters and aqueous quality control solutions (QC) were stored and operated within manufacturer’s specifications, at room temperature (19.7 ± 0.6°C, range 18.8 to 23.0°C) and at relative humidity (46.4 ± 12.8%, range 21% to 77%). A subset of single-use disposable reagent test strips from each GMS was stressed with an environmental testing chamber (Tennyson T2RC, Thermal Products Solution) that was programmed to simulate conditions during Hurricane Katrina. Stressed strips were tested immediately after removal from the chamber in pairs with control (unstressed) strips. Control strips were stored at room temperature.

We used aqueous QC solutions supplied by the manufacturers to test performance. QC solutions are proprietary reagents manufactured by each company to allow the operator to check if the test strips and meter are working properly. The QC solutions typically are composed of glucose, buffer, dyes, salts, preservatives, and viscosity-adjusting agents. Three levels of QC were used for testing GMS1, and two levels of QC were used for testing GMS2.

Environmental Profile

We modeled the dynamic thermal and humidity conditions of New Orleans, Louisiana, during Hurricane Katrina (Figure 1) with data collected over a 31-day period from the National Climatic Data Center (NCDC). Data were compiled from two weather stations, New Orleans/Moissant and Baton Rouge Metro. The Baton Rouge station supplied 1.5 days of missing values for the...
Dynamic Temperature and Humidity Stress

- **Goal**—To characterize the effects of dynamic thermal and humidity stress on the performance of glucose meter measurements.

- **Methods**—Glucose test strips were exposed to conditions simulating the temperature and humidity experienced in New Orleans following the Hurricane Katrina disaster for a duration of ~4 weeks.

- **Statistical Model**—Paired measurements were obtained from stressed and unstressed glucose reagent strips at defined time points. Strips were tested with aqueous quality control solutions.

- **Results**—The duration of stress affected the performance of the glucose meter systems. One system provided lower measurements and the other elevated when stressed. As demonstrated on one system, the stress effects on test performance is cumulative with pronounce effect after 32 hours of exposure.
Maximum Absolute Paired Differences Between Stress & Control Glucose Test Strips

- For GMS1, errors as large as 27.6% (16 mg/dL / 57.9 mg/dL) was observed when tested at mean glucose concentration of 57.9 mg/dL, 21.9% (24/109.6) at 109.6 mg/dL, and 22.4% (65/290.5) at 290.5 mg/dL.

- For GMS2, errors as large as 24.4% (10/41) was observed when tested at mean glucose concentration of 41.0 mg/dL, and 11.1% (34/305.3) at 305.3 mg/dL.

Short-Term Thermal-Humidity Shock Affects Point-of-Care Glucose Testing: Implications for Health Professionals and Patients

Mandy Lam¹, Richard F. Louie, PhD, FACB¹, Corbin M. Curtis, BS¹, William J. Ferguson, BS¹, John H. Vy, BS¹, Anh-Thu Truong¹, Stephanie L. Sumner, BS¹, and Gerald J. Kost, MD, PhD, MS, FACB¹

Abstract
The objective was to assess the effects of short-term (≤ 1 hour) static high temperature and humidity stresses on the performance of point-of-care (POC) glucose test strips and meters. Glucose meters are used by medical responders and patients in a variety of settings including hospitals, clinics, homes, and the field. Reagent test strips and instruments are potentially exposed to austere environmental conditions. Glucose test strips and meters were exposed to a mean relative humidity of 83.0% (SD = 8.0%) and temperature of 42°C (107.6°F, SD = 3.2) in a Tenney BTRC environmental chamber. Stressed and unstressed glucose reagent strips and meters were tested with spiked blood samples (n = 40 measurements per time point for each of 4 trials) after 15, 30, 45, and 60 minutes of exposure. Wilcoxon’s signed rank test was applied to compare measurements test strip and meter measurements to isolate and characterize the magnitude of meter versus test strip effects individually. Stressed POC meters and test strips produced elevated glucose results, with stressed meter bias as high as 20 mg/dL (17.7% error), and stressed test strip bias as high as 13 mg/dL (12.2% error). The aggregate stress effect on meter and test strips yielded a positive bias as high as 33 mg/dL (30.1% error) after 15 minutes of exposure. Short-term exposure (15 minutes) to high temperature and humidity can significantly affect the performance of POC glucose test strips and meters, with measurement biases that potentially affect clinical decision making and patient safety.

Keywords
clinical decision making, environmental stress, glucose test strip and meter performance, measurement error, patient safety, quality assurance

Glucose meter systems aid responders in triaging, screening, monitoring, and the diagnosis of victims and patients at the site of crisis care. Temperature and humidity conditions at the site of patient care, whether inside or outside the victims’ home or hospital, may exceed manufacturer specifications for storage and operation. Operation of devices outside of product specifications could produce inaccurate results.

Point-of-care (POC) devices deployed with disaster response teams are recommended to be housed in climate controlled settings.¹ However, these devices may be exposed to austere conditions when mobilized for field testing. Temperature extremes can be found in a variety of settings including the patient’s home, distinct geographic locations, and with the settings.

This study aims to simulate realistic operation of POC glucose devices in austere environments, to compare measurements obtained from unstressed devices and test reagents, and to characterize how short-term stress affects meter and test strip performance. We discuss the potential implications of these effects on clinical decision making.

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Effects of environmental conditions on point-of-care cardiac biomarker test performance during a simulated rescue: Implications for emergency and disaster response

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Abstract

Objective: To characterize the effects of environmental stress on point-of-care (POC) cardiac biomarker testing during a simulated rescue.

Design: Multiplex test cassettes for cardiac troponin I (cTnI), brain natriuretic peptide (BNP), CK-MB, myoglobin, and D-dimer were exposed to environmental stresses simulating a 24-hour rescue from Hawaii to the Marshall Islands and back. We used Tenera environmental chambers (T2RC and BT1RC) to simulate flight conditions (20°C, 10 percent relative humidity) and ground conditions (22.3-33.9°C, 73-77 percent). We obtained paired measurements using stressed versus control (room temperature) cassettes at seven time points (T1, with T1,2,6,7 during flight and T3-5, on ground). We analyzed paired differences (stressed minus control) with Wilcoxon signed rank test. We assessed the impact on decision-making at clinical thresholds.

Results: cTnI results from stressed test cassettes (n = 10) at T3 (p < 0.05), T5 (p < 0.01), and T7 (p < 0.05) differed significantly from control, when testing samples with median cTnI concentration of 80 ng/L. During the ground rescue, 36.7 percent (11/30) of cTnI measurements from stressed cassettes generated significantly lowered results. At T7, 20 percent (2/10) of cTnI results were highly discrepant—stressed cassettes reported normal results, when control results were >100 ng/L. With sample median concentration of 108 pg/mL, BNP results from stressed test cassettes differed significantly from controls (p < 0.05).

Conclusion: Despite modest, short-term temperature elevation, environmental stresses led to erroneous results. False negative cTnI and BNP results potentially could miss acute myocardial infarction and congestive heart failure, confounded treatment, and increased mortality and morbidity. Therefore, rescuers should protect POC reagents from temperature extremes.

Key words: austere environments, disaster preparedness, medical errors, Pacific Islands, and quality assurance

Introduction

Emergency medical responders are deployed with limited point-of-care (POC) tests during crises, which restricts triaging in the field. Quantitative measurement of cardiac troponin I (cTnI), brain natriuretic peptide (BNP), CK-MB, myoglobin, and D-dimer in whole blood and plasma specimens can aid in the diagnosis of myocardial infarction, heart failure, pulmonary embolism, and deep vein thrombosis. Environmental conditions present during rescue operations may exceed storage and operating specifications of POC devices and test reagents. The objective of this study was to characterize the performance of POC cardiac biomarker tests in a simulated rescue between the Hawaiian Islands and Marshall Islands.
Effects of Stress on cTn I Test Results

• During ground rescue 36.7% (11/30) of stressed test cards reported falsely low cTnI results interpreted as “normal”

• At T₅, 20% (2/10) results were highly discrepant: stress <0.05, control ≥0.10 ng/mL

• Median stressed cTnI at T₅ was <0.05 ng/mL

• During the return flight, stressed cards reported falsely elevated cTnI >0.1 ng/mL at T₇, which in our emergency department “alerts” possible AMI.

WBC & 5-PART DIFFERENTIAL—ENVIRONMENTAL STRESS VALIDATION IN PROGRESS

1. Fill microcuvette.
2. Place microcuvette into analyzer.
3. View results.

The microcuvette cavity is analyzed in separate layers to enable detection of cells at different depths.

Cavity depth 140 μm

The camera lens moves in small steps taking several images through the cavity of the microcuvette.

All cells in all images will be cut out.

Identification when each cell is in focus

Mount the focused cells into one image

Total WBC and differential counting as final step

Neutrophils
Lymphocytes
Monocytes

Transferring characteristics into mathematical algorithms. WBC DIFF uses over 30 features and state-of-the-art image analysis technology.
Global Point of Care Strategies for Disasters, Emergencies, and Public Health Resilience

Edited by
Gerald J. Kost & Corbin M. Curtis

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THE CURRENT AND FUTURE DESIGN OF POINT OF CARE IN NATIONAL DISASTER CACHES

CORBIN M. CURTIS, RICHARD F. LOUIE, AND GERALD J. KOST

OVERVIEW

The objective of this chapter is to describe, innovate, recommend, and foster the implementation of point-of-care testing (POCT) in disaster caches in order to enhance crisis standards of care and improve triage, diagnosis, monitoring, treatment, and management of victims and volunteers in complex emergencies and disasters. The authors compared point-of-care (POC) technologies in US disaster caches to commercially available POC technologies to enhance the caches and reflect current state-of-the-art diagnostic capabilities. We also provided recommendations based on literature review and knowledge from newly developed POC technologies from the University of California, Davis Point-of-Care Technologies Center on designing POC caches applicable to meet global needs. US POC testing requires chemistry/electrolytes, pregnancy, hemoglobin, cardiac biomarkers, hematology, fecal occult blood, drug of abuse, liver function, blood gases, and limited infectious disease tests. Deficiencies with existing POCTs for cardiac biomarkers, hematology, and infectious diseases should be eliminated. POC resources can be customized for pandemics, complex emergencies, or disasters based on geographic location and the potential for pandemics. Additionally, new thermally stabilized containers can help alleviate environmental stresses that reduce test quality. Innovations in POC technologies can improve response preparedness with enhanced diagnostic capabilities. Several innovations, such as the i-STAT® Wireless (Abbott Point of Care, Princeton, NJ, USA), OraQuick ADVANCE® HIV-1/2 (OraSure Technologies, Bethlehem, PA, USA), VeriChip™ Lab-on-a-Chip (Veredus Laboratories, Singapore), and new compact hematology analyzers will improve test clusters that facilitate evidence-based decision making and crisis standards of care during national disaster responses. Additionally, strategic resources and operator training should be globally harmonized to improve the efficiency of international responses.

Our goal is to describe, innovate, recommend, and accelerate the implementation of POCT in disaster caches in order to (a) enhance crisis standards of care; (b) improve diagnosis, triage, and monitoring in complex emergencies and disasters; and (c) harmonize evidence-based decision making during responses globally. The Office of the Assistant Secretary for Preparedness and Response (ASPR) under the US Department of Health and Human Services (DHHS) maintains three Mission Support Centers (MSCs) located in the western, central, and eastern United States. The eastern region and largest cache warehouse (200,000 ft²) serves as a training facility, home base for cache management, and national headquarters. Disaster response supplies deploy by trucks from any one of the three locations to reach a disaster site in the contiguous United States or by airplane to sites outside the landlocked states such as Hawaii, Alaska, and the Republic of the Marshall Islands, within 12 h.

The caches within each facility hold supplies that Disaster Medical Assistance Teams (DMATs) use to triage, diagnose, and monitor victims following catastrophic events. Each facility has an inventory of pharmaceuticals, DMAT response packages, Basic Load Resupply packages to replenish 3 days of supplies for 175 patients per day, temporary portable housing, electricity generators, communication supplies, and vehicles to deliver resources to disaster sites where they converge with DMATs. The packages load straight onto trucks or airplanes without needing further organization. POC devices

*1 ft² = xxx m².
Locations of US National Caches

- AK: 1 DMAT, 1 LAB BASIC
- HI: 1 DMAT, 1 LAB BASIC
- PR: 2 DMAT, 2 LAB BASIC
- CA: 6 DMAT, 9 LAB BASIC, 4 LAB PLUS, 1 IMSURT
- TX: 9 DMAT, 2 CCC, 9 LAB BASIC, 8 LAB PLUS
- NCR: 19 DMAT, 11 LAB BASIC, 6 LAB PLUS, 1 IMSURT, 2 CCC
- GA: 2 DMAT
- Mission Support Center
- Warehouse
Lab Basic Kit
Lab Plus Kit
Coming:
Orasure Ebola POC Test
Drawing Kalasin and Maha Sarakham Province SWN ambulance routes

Critical paths (bold) of Kalasin Province SWN extracted from the ER RN's highlights (orange)

Kalasin: above to her right
Maha Sarakham: below to her left
**Prehospital Spatial Care Path™ for Acute Myocardial Infarction**

**Step 1.** The patient alerts emergency services while at home or about.

**Step 2.** An ECG is recorded and a cardiac troponin T (or I) test is performed if there is suspicion of AMI.

**Step 3.** The ECG and cTnT test results are transmitted wirelessly to the cardiologist on call.

**Step 4.** The ambulance is directed to the invasive center or nearest coronary care unit, depending on the diagnosis.

**Conclusion:** “POCT performed by paramedics, nurses, or doctors can improve diagnostic accuracy where the ECG does not provide decisive information. This enables optimal triage and early aggressive treatment of patients who currently experience a very high mortality. Prehospital biomarkers provide strong prognostic information early on, allowing the ER to prepare optimally for patient arrival.”

From Sorensen JT and Stengaard C. Prehospital application of cardiac biomarkers for decision support in patients with suspected AMI. In: Kost GJ, Ed., *Global Point of Care*, 2015.
Transforming the Physical Domain to the Temporal Domain in Small-World Network Spatial Care Paths™

Shortcut to Heart Center if cTn is Elevated

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

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\textbf{Running title}
Enabling Community and Global Resilience

\textbf{Key words}
Care path, customs, decision-making, empowerment, geographic information systems (GIS), geography, intervention, lifestyle, medical poverty, needs assessment, point-of-care (POC) technologies, POC testing, prevention, public health jurisdictions, small-world network, survey, and value

\section*{ABSTRACT}

\textbf{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.

\textbf{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).

\textbf{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 are essential in delivering care in small-world networks.
THE SPATIAL CARE PATH™

• **Definition:** The most effective route taken by the patient when receiving definitive care in a small-world network.

• **Hypothesis:** Integrates prevention and intervention to shift the focus upstream to the patient site early on, in order to save resources, time, and lives, and to stop outbreaks.

• **Features:** Starts with the patient rather than the institution, empowers primary care, establishes critical access using geographic information systems, positions POCT, and optimizes decision-making with “FAST POC.”

• **Status:** Exploratory research—Thailand, Brazil, & others.

Reference: Kost GJ, Ferguson WJ, Kost LE. Principles of point of care culture, the spatial care path™, and enabling community and global resilience. e-JIFCC. 2014;25(2):4-23.
Developing a Spatial Care Path™ for Ebola

Enzootic Cycle
New evidence strongly implicates bats as the reservoir hosts for ebolaviruses, though the means of local enzootic maintenance and transmission of the virus within bat populations remain unknown.

Ebola Viruses:
- Ebola virus (formerly Zaire virus)
- Sudan virus
- Taï Forest virus
- Bundibugyo virus
- Reston virus (non-human)

Epizootic Cycle
Epizootics caused by ebolaviruses appear sporadically, producing high mortality among non-human primates and duikers and may precede human outbreaks. Epidemics caused by ebolaviruses produce acute disease among humans, with the exception of Reston virus which does not produce detectable disease in humans. Little is known about how the virus first passes to humans, triggering waves of human-to-human transmission, and an epidemic.

Human-to-human transmission is a predominant feature of epidemics.

Following initial human infection through contact with an infected bat or other wild animal, human-to-human transmission often occurs.
Ebola is a viral illness which infects through direct contact with blood or bodily fluids of a sick person or animal, or with contaminated objects. It leads to haemorrhage and organ failure and kills up to 90% of victims.

**INFECTION:** Ebola genome contains four genes which together prevent dendritic cells - in skin, nose, lungs and digestive system - from sending messages to trigger immune system.

**UNCHECKED VIRAL GROWTH:** Virus spreads to cell types throughout body by binding glycoprotein to receptors on cell surfaces.

**1. SYMPTOMS:** Onset of illness is abrupt and is characterized by fever, headache, joint and muscle aches, sore throat, red eyes, and weakness.

**2. CYTOKINE STORM:** Immune cells get caught in endless loop, releasing extreme levels of cytokines - proteins within cells which cause inflammation - and attracting yet more immune cells.

**3. SEPTIC SHOCK:** Infected cells detach from blood vessels, causing massive haemorrhage. Loss of blood leads to kidney and liver failure.
<table>
<thead>
<tr>
<th>TIMELINE OF INFECTION</th>
<th>DIAGNOSTIC TESTS AVAILABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within a few days after symptoms begin</td>
<td>Antigen-capture enzyme-linked immunosorbent assay (ELISA) test</td>
</tr>
<tr>
<td>Later in disease course or after recovery</td>
<td>IgM ELISA</td>
</tr>
<tr>
<td>Retrospectively in deceased patients</td>
<td>Polymerase chain reaction (PCR)</td>
</tr>
<tr>
<td></td>
<td>Virus isolation</td>
</tr>
<tr>
<td></td>
<td>IgM and IgG antibodies</td>
</tr>
<tr>
<td></td>
<td>Immunohistochemistry test</td>
</tr>
<tr>
<td></td>
<td>PCR</td>
</tr>
<tr>
<td></td>
<td>Virus isolation</td>
</tr>
</tbody>
</table>

Doctors Without Borders/Médecins Sans Frontières (MSF) Ebola Clinic
MSF has set up a specialized Ebola clinic in a hospital in Conakry, Guinea. The virus is contagious and so dangerous that patients must be quarantined. Access to the isolation area is thus strictly controlled.

Inside an MSF Ebola treatment centre

1. Low-risk infected
   Patients are kept apart from the high-risk group while they wait for their blood test results.

2. High-risk of infection
   Those showing symptoms are kept apart from zone 1. Sent to zone 3 if they test positive.

3. Infected patients
   There is no cure for Ebola, but good supportive care increases chances of survival.

4. Visiting area
   No direct contact between patients and visitors to eliminate the risk of infection.

Source: Médecins Sans Frontières (Doctors Without Borders)
Ebola Containment

Top (A)
High Risk Zone

Bottom (B)
A Complete Center

From Chertow DS et al.
Ebola Virus disease in West Africa—Clinical Manifestations and Management.
2014; November 5.
Source: Preparing for Ebola: What U.S. Hospitals Can Learn From Emory Healthcare and Nebraska Medical Center. Planning to Treat Patients with Ebola Virus Infection by Dr. Ribner. Emory Serious Communicable Disease Unit. CDC Webinar. 2014.
Move POC testing upstream in the spatial care path.™ Detect the disease before the patient spreads it!

World Health Organization

“Target Product Profile for Zaire Ebola virus rapid, simple test to be used in the control of the Ebola outbreak in West Africa”

Source: http://www.who.int/medicines/publications/target-product-profile.pdf?ua=1

### Key Features

<table>
<thead>
<tr>
<th>Priority Features</th>
<th>Desired</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target population</td>
<td>Patients presenting with fever to health care facilities for assessment.</td>
<td><img src="http://" alt="" /> Decentralized health care facilities with minimum laboratory infrastructures available.</td>
</tr>
<tr>
<td>Target use setting</td>
<td>Decentralized health care facilities with no laboratories infrastructure available.</td>
<td><img src="http://" alt="" /></td>
</tr>
<tr>
<td>Intended Use</td>
<td>In Ebola outbreak setting, distinguish between symptomatic patients with acute Ebola virus infection and non-Ebola virus infection without the need for confirmatory testing.</td>
<td><img src="http://" alt="" /> In Ebola outbreak setting, distinguish between symptomatic patients with acute Ebola virus infection and non-Ebola virus infection with the need for confirmatory testing.</td>
</tr>
<tr>
<td>Clinical sensitivity</td>
<td>&gt; 98%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>Analytical specificity</td>
<td>&gt;99%</td>
<td>&gt;99%</td>
</tr>
<tr>
<td>Type of analysis</td>
<td>Qualitative or Quantitative</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Sample type</td>
<td>Capillary whole blood from finger stick once/if the use of this type of samples has been validated. Other less invasive sample types (e.g., saliva, buccal) once/if their use has also been validated.</td>
<td>Whole blood from phlebotomy, in particular if collection is simple and automated to reduce biosafety requirements.</td>
</tr>
</tbody>
</table>

### Test Procedure

<table>
<thead>
<tr>
<th>Number of steps to be performed by operator (use of different reagents/incubation steps)</th>
<th>&lt; 3 0 timed steps</th>
<th>&lt;10 1 timed step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biosafety</td>
<td>No additional biosafety in addition to Personal Protective Equipment</td>
<td>No additional biosafety in addition to Personal Protective Equipment</td>
</tr>
<tr>
<td>Need for operator to transfer a precise volume of sample</td>
<td>No</td>
<td>Acceptable if adequate disposable blood transfer device is provided</td>
</tr>
<tr>
<td>Time to result</td>
<td>&lt; 30 minutes</td>
<td>&lt; 3 hours</td>
</tr>
<tr>
<td>Internal control</td>
<td>included</td>
<td>included</td>
</tr>
</tbody>
</table>
Spring 2014: Corgenix received a $2.9 million grant from the NIH. Disposable test administered at a clinic, in the home, or during airport arrival. Pinprick of blood from the finger of a patient. Positive result indicated by a dark red line on the test strip. Can only identify Ebola at symptom onset 8-10 days following exposure. Costs $2-8 per test, 100 of which fit in a portable cooler.

Spring 2015: Oraasure received a $10 million grant from HHS for POC Ebola test.

Before: US DOD considering Liberia request for 3 more diagnostic labs (total 8) in country. Sierra Leone has 4, and Guinea, 3. 100 tests per day now, but expect 10,000 new cases per week by December, according to the WHO. Need to get 70% of population with Ebola into isolation and care. Now: new outbreaks.

“With enough tests, we can shut it down. Without them, Ebola may be here to stay.”

<table>
<thead>
<tr>
<th>Instrument(s) &amp;/or Assay/Kit Manufacturer</th>
<th>Principle</th>
<th>Sample(s)</th>
<th>Time to Results</th>
<th>FDA Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xpert Ebola Assay Cepheid</td>
<td>rRT-PCR Cartridge-based</td>
<td>Blood</td>
<td>2 h</td>
<td>EUA 3/23/15</td>
</tr>
<tr>
<td>Corgenix ReEBOV &amp; Fio Corp†</td>
<td>Lateral flow Ag immunoassay, Deki reader, smartphone data capture, &amp; case tracking</td>
<td>Blood or plasma</td>
<td>15 min</td>
<td>EUA 3/16/15 [eligible for WHO procurement]</td>
</tr>
<tr>
<td>LightMix Roche cobas z480</td>
<td>rRT-PCR</td>
<td>Blood</td>
<td>Over 3 h</td>
<td>EUA 12/23/14</td>
</tr>
<tr>
<td>QIAamp Viral Kit RealStar Filovirus: ABI Prism 7500 SDS LightCycler 480 II CFX96/Dx RT Sys</td>
<td>rRT-PCR (Kit 1.0)</td>
<td>Blood, plasma</td>
<td>Varies with instrument</td>
<td>EUA 11/26/14 [eligible for WHO procurement]</td>
</tr>
<tr>
<td>BioFire Defense Biothreat-ENGDS bioMérieux® [in 300 hospitals]</td>
<td>Film Array EZV Auto’d. rRT-PCR</td>
<td>Blood, urine (if matched to blood)</td>
<td>1 h</td>
<td>EUA 10/25/14 3/2/15 (RI)</td>
</tr>
<tr>
<td>MagMax Pathogen Kit, Dynal Bead Re. ABI 7500 BioRad CFX96</td>
<td>CDC NP rRT-PCR VP40 rRT-PCR</td>
<td>Blood, plasma, serum, urine (if matched)</td>
<td>NS</td>
<td>EUA 10/10/14 3/2/15 (RI)</td>
</tr>
<tr>
<td>ABI 7500 LightCycler 480 JBAIDS</td>
<td>DOD EZ1 rRT-PCR TaqMan Assay</td>
<td>Inactivated whole blood &amp; plasma</td>
<td>Varies with instrument</td>
<td>EUA 10/10/14</td>
</tr>
<tr>
<td>Nanomix [Corgenix &amp; Tulane University]</td>
<td>Carbon nanotube biosensor† Handheld multiplex cartridge-based</td>
<td>Pinprick capillary blood</td>
<td>10 min</td>
<td>No EUA* (see above)</td>
</tr>
<tr>
<td>Lucigen AmpliFire [Douglas Sci., UTMB, CDC]</td>
<td>LAMP (isothermal) 1-step, battery-operated, portable††</td>
<td>RNA extract [plan 50 μL POC fingerstick capillary blood]</td>
<td>40 min</td>
<td>No EUA*</td>
</tr>
<tr>
<td>Biomarkers USAMRIID/ECBC/TFS</td>
<td>Mass spectrometry</td>
<td>In development</td>
<td>NS</td>
<td>No EUA*</td>
</tr>
<tr>
<td>OraQuick** Orasure</td>
<td>CLF Ag assay [EZV, SEV, &amp; BEV not differentiated]</td>
<td>In development: saliva sample</td>
<td>Est. 20 min</td>
<td>EUA* 7/31/15 [venous WB &amp; fingerstick WB; not for screening, e.g., in airports; not for contact tracing]</td>
</tr>
</tbody>
</table>
Watertight Primary Plastic Receptacle

*If multiple fragile primary receptacles are placed in a single secondary packaging, they must be either individually wrapped or separated so as to prevent contact between them.

Watertight Secondary Packaging

List of Contents

Itemized List of Contents:

Infectious Substance

Absorbent Packing Material (for liquids)

Cross Section of Closed Package

Closure requires positive means of ensuring leakproof seal

Infectious Substance

Absorbent Packing Material

Rigid Outer Packaging

Infectious Substance Label

Proper Shipping Name and UN Number

UN Package Certification Mark

Shipper or Consignee Identification
Ebola National Headlines Composite

Liberia-awaiting child’s test results

Phil wants zero Ebola toll

Japan-Haneda

Ebola precautions taken in Guangdong

Guangdong, a front-line region in preventing Ebola from spreading in the Chinese mainland, is going all out to stop an outbreak of the deadly virus in the southern province. According to the Guangdong Provincial Center for Disease Control and Prevention, the province, which has a large number of foreign visitors, has been taking strict precautions against the virus.

Inspection and quarantine authorities across China have recently intensified efforts to prevent the Ebola virus from entering the country, and no confirmed infections have been found. China's top inspection and quarantine authority said on Wednesday that measures taken include requesting governments in affected West African countries to intensify inspections and quarantines of outbound travelers, and requiring travelers to declare health status to the authorities.

NO INFECTIONS FOUND
Alternate Care Facility for Ebola Triage and Care
SPATIAL CARE PATH™

SYMPTOMATIC PATIENT

RAPID MOLECULAR TESTING → TN, FN(t)

EXPOSED PATIENT

CLINICAL EVALUATION & DIAGNOSTIC TESTING
POC WBC, DIFFERENTIAL & PLATELET COUNT
INR, aPTT, Bleeding Time, ALT, & AST

LIMITED QUARANTINE VACCINATION

HIGHLY INFECTIOUS DISEASE BEDS WITH ANTEROOM

BLOOD SAMPLE PROCESSED IN ISOLATION UNIT &/OR TRANSPORTED TO REFERRAL LAB:
- CDC
- PUBLIC HEALTH

SLOWER RESPONSE GREATER EXPENSE

INTEGRATED PLANNING

SWN

ALTERNATE CARE FACILITY
- Dynamic Segregation
- POC Coordinator
- Fully Equipped POCT
- Telehealth

HIGHER EFFICIENCY LOWER RISK

OPTIMIZED POC SOLUTION

COMMUNITY RESILIENCE

HYBRID SOLUTION
### Point-of-Care Tests Established in Ebola Isolation Areas

#### A. Emory University Hospital Specialized Isolation Area

<table>
<thead>
<tr>
<th>Manufacturer Website</th>
<th>Instrument</th>
<th>Test(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abaxis</td>
<td>Piccolo Express</td>
<td>Chemistry profiles, Magnesium, Phosphate, liver enzyme assays, others available&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Instrumentation Laboratory</td>
<td>GEM Premier 4000</td>
<td>pH, pCO₂, pO₂, Na⁺, K⁺, Ca⁺⁺, Cl⁻, Glu, Lac, Hct, THb, CO-Oximetry, TBil</td>
</tr>
<tr>
<td>Siemens</td>
<td>CLINITEK Status automated urinalysis</td>
<td>Albumin, Bilirubin, Cr, Glu, Ketone, Leukocytes, Nitrite, pH, Protein, Specific Gravity, Urobilinogen, others available&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hoffman-La Roche</td>
<td>CoaguChek</td>
<td>PT/INR&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sysmex</td>
<td>pocH-100i</td>
<td>CBC: WBC (3-part differential), RBC, Hb, Hct, MCV, MCH, MCHC, Platelets&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Alere</td>
<td>BinaxNOW</td>
<td>Malaria</td>
</tr>
<tr>
<td>BioFire Diagnostics</td>
<td>FilmArray</td>
<td>Infectious diseases including Ebola&lt;sup&gt;e&lt;/sup&gt; (see Table 1)</td>
</tr>
</tbody>
</table>
## Point-of-Care Tests Established in Ebola Isolation Areas

### B. University of Nebraska Medical Center Biocontainment BSL-3 Laboratory

<table>
<thead>
<tr>
<th>Manufacturer Website</th>
<th>Instrument/Method</th>
<th>Test(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott</td>
<td>i-Stat</td>
<td>G3+ cartridge (pH, pCO$_2$, pO$_2$) &amp; Chem8+ cartridge (Na$^+$, K$^+$, Cl$^-$, TCO$_2$, Ca$^{++}$, Glu, UN, Cr, Hct)</td>
</tr>
<tr>
<td>International Technidyne Corp.</td>
<td>Hemochron Signature Elite</td>
<td>Citrate prothrombin time (PT), citrate-activated partial thromboplastin time (aPTT)</td>
</tr>
<tr>
<td>Slide Agglutination</td>
<td>Manual</td>
<td>Blood &amp; serum antibody typing (for transfusion)</td>
</tr>
<tr>
<td>Slide Preparation</td>
<td>Manual</td>
<td>Malaria—modified for the slide to be fixed in methanol 15 min before delivering to Core Lab for staining &amp; interpretation</td>
</tr>
<tr>
<td>NS</td>
<td>Rapid manual assay</td>
<td>HIV Ab/Ag</td>
</tr>
<tr>
<td>Urine Dipstick</td>
<td>Manual dipstick</td>
<td>For tests not on strip, specimen transferred with precautions to Core Lab for non-decapped Dxl800 &amp; DXC800i$^f$ analysis</td>
</tr>
<tr>
<td>NS</td>
<td>RPR</td>
<td>Syphilis (card assay)</td>
</tr>
</tbody>
</table>
### Ebola Holding Units (4) in Sierra Leone, West Africa

<table>
<thead>
<tr>
<th>Developer Website</th>
<th>Method</th>
<th>Performance</th>
</tr>
</thead>
</table>
| United Kingdom’s Defense Science & Technology Laboratory  
https://www.gov.uk/government/organisations/defence-science-and-technology-laboratory | Rapid diagnostic antigen test | Sensitivity 100%, 95% CI: 78.2–100. Specificity: 96.6%, 95% CI: 91.3–99.1. +/- predictive values: 79.0% (95% CI: 54.4–93.8)/100% (95% CI: 96.7–100). |

### Suite Environment, ARUP Institute for Clinical and Experimental Pathology

<table>
<thead>
<tr>
<th>Manufacturer Website</th>
<th>Instrument/Method</th>
<th>Tests, Evaluation Study Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abaxis</td>
<td>Piccolo Express</td>
<td>Liver Panel Plus&lt;sup&gt;g&lt;/sup&gt; using disposable exact volume transfer pipettes and BSL-2 cabinet in BSL-3 suite environment for Ebola patient workup. Checked device air flow characteristics are suitable.</td>
</tr>
</tbody>
</table>
CDC REQUIREMENTS FOR EBOLA CENTERS

- Accept patients within eight hours of being notified,
- Have the capacity to treat at least two Ebola patients at the same time,
- Have respiratory infectious disease isolation capacity or negative pressure rooms for at least 10 patients,
- Conduct quarterly trainings and exercises,
- Receive an annual readiness assessment from the soon-to-be-established National Ebola Training and Education Center, composed of experts from health care facilities that have safely and successfully cared for patients with Ebola in the U.S., and funded by ASPR and the Centers for Disease Control and Prevention, to ensure clinical staff is adequately prepared and trained to safely treat patients with Ebola and other infectious diseases,
- Be able to treat pediatric patients with Ebola or other infectious diseases or partner with a neighboring facility to do so, and,
- Be able to safely handle Ebola-contaminated or other highly contaminated infectious waste.

Does not require POC resources or strategies. No harmonized POC testing, molecular diagnostics, or early detection. Neglects integrated community resilience and optimized geospatial care (no SCP).

Source: ASPR Press Office. HHS selects nine regional Ebola and other special pathogen treatment centers. June 12, 2015. HSS.gov or http://www.hhs.gov/news
9 CENTERS, 5 YEARS—$29(10^6), ~3.25 ea, $339.5 pkg

- New York City Department of Health and Mental Hygiene in partnership with New York City Health and Hospitals Corporation/HHC Bellevue Hospital Center in New York City
- Maryland Department of Health and Mental Hygiene in partnership with Johns Hopkins Hospital in Baltimore, Maryland
- Georgia Department of Public Health in partnership with Emory University Hospital and Children’s Healthcare of Atlanta/Egleston Children’s Hospital in Atlanta, Georgia
- Minnesota Department of Health in partnership with the University of Minnesota Medical Center in Minneapolis, Minnesota
- Texas Department of State Health Services in partnership with the University of Texas Medical Branch at Galveston in Galveston, Texas
- Nebraska Department of Health and Human Services in partnership with Nebraska Medicine
  - Nebraska Medical Center in Omaha, Nebraska
- Colorado Department of Public Health and Environment in partnership with Denver Health Medical Center in Denver, Colorado
- Washington State Department of Health in partnership with Providence Sacred Heart Medical Center and Children’s Hospital in Spokane, Washington
Camels vs. Humans

How a zoonotic MERS-CoV infection may be indirectly acquired from a primary or secondary animal host.

- Insects
  - Attract bats
- Bats
  - Excreta
  - Saliva
  - Parturition
- Palms
  - Dates
  - Sap/Drinks
  - Shade
  - Contact (climbing)
- Dust/dirt
  - Contaminated
- Wind
  - Stirs up dust
- Baboons
  - Excreta
- Camels
  - Excreta
  - Meat preparation
  - Milking
  - Close contact
- Humans
  - Aerosol
  - Inhalation
  - Ingestion?
  - Self-inoculation
  - Eye rubbing
  - Nose picking

Structures/Caves
- Bat roosts
- Baboon contact
HOW MERS GOT TO SOUTH KOREA
One business trip led to an outbreak that now has dozens sick and thousands in quarantine

Rising numbers: 122 Confirmed cases 10 Dead 4 Recovered 3,439 Quarantined

Update late June, 2015
16+ Dead
172 Infected
4,035 being monitored
New case in Thailand

Patient Zero
male, 68

Arrived in South Korea from Qatar on May 4
Developed symptoms on May 11
Confirmed May 20 that he had MERS

Samsung Medical Center, Seoul: May 17-20
Chonho 365 Open hospital, Seoul: May 17
St. Mary’s, Pyeongtaek: May 15-17
Dunpo Seoul hospital, Asan: May 12-14

SOURCE: South Korean government, June 11, 2015
Reverse Transcription Recombinase Polymerase Amplification Assay for the Detection of Middle East Respiratory Syndrome Coronavirus

Ahmed Abd El Wahed, Pranav Patel, Doris Heidenreich, Frank T. Hufert, and Manfred Weidmann

Ahmed Abd El Wahed, Department of Virology, University Medical Centre, Goettingen, Germany; Department of Virology, Faculty of Veterinary Medicine, Mansoura University, Mansoura, Egypt;

Contributor Information.

Copyright notice

Abstract

The emergence of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in the eastern Mediterranean and imported cases to Europe has alerted public health authorities. Currently, detection of MERS-CoV in patient samples is done by real-time RT-PCR. Samples collected from suspected cases are sent to highly-equipped centralized laboratories for screening. A rapid point-of-care test is needed to allow more widespread mobile detection of the virus directly from patient material. In this study, we describe the development of a reverse transcription isothermal Recombinase Polymerase Amplification (RT-RPA) assay for the identification of MERS-CoV. A partial nucleocapsid gene RNA molecular standard of MERS-coronavirus was used to determine the assay sensitivity. The isothermal (42°C) MERS-CoV RT-RPA was as sensitive as real-time RT-PCR (10 RNA molecules), rapid (3-7 minutes) and mobile (using tube scanner weighing 1kg). The MERS-CoV RT-RPA showed cross-detection neither of any of the RNAs of several coronaviruses and respiratory viruses affecting humans nor of the human genome. The developed isothermal real-time RT-RPA is ideal for rapid mobile molecular MERS-CoV monitoring in acute patients and may also facilitate the search for the animal reservoir of MERS-CoV.
On July 17, 2015, the FDA issued an Emergency Use Authorization (EUA) to authorize the emergency use of the RealStar® MERS-CoV RT-PCR Kit U.S. for the in vitro qualitative detection of RNA from the Middle East Respiratory Syndrome Coronavirus (MERS-CoV), formerly known as Novel Coronavirus 2012 or NCV-2012, in lower respiratory specimens (tracheal aspirate/tracheal secretions) from individuals with signs and symptoms of infection with MERS-CoV in conjunction with epidemiological risk factors for the presumptive detection of MERS-CoV, by laboratories certified under the Clinical Laboratory Improvement Amendments of 1988 (CLIA) and similarly qualified non-U.S. laboratories.
• Introduced at a National POC Testing Forum in Kuala Lumpur, **Malaysia**, July, 2012

• Uniquely combines policy *and* guidelines in one document

• Endorsed by the **Malaysia** Ministry of Health—entire country

• One of the world’s first nationally harmonized approaches to point-of-care testing, the new culture

• Needs extension based on “**Emergency and Disaster POC Testing**” (CLSI POCT16-coming!)

• **Thailand** MOPH national guidelines coming this year!

• **Philippines** in planning stage.
CONCEPT SOLUTION USING “FAST POC™” TO STOP OUTBREAKS!

Definition: Facilitated-access Self-testing Point of Care

The patient obtains his or her own (capillary blood, saliva, urine, or other) sample with an automatic retractable lancet or suitably simple sampling device built into a self-aspirating and self-contained microcassette, microcuvette, or cartridge, which then seals for automatic testing and automated processing by a POC instrument, while another person, the “facilitator,” instructs and guides hands off, so there is extremely limited or no exposure to infectious agents.
COMPACT PCR-BASED MOLECULAR DIAGNOSTICS

Influenza A & B
CLIA Waived

Sensitivity  A 99.3%  B 98.1%
Specificity  A 98.9%  B 99.6%
Molecular detection and point-of-care testing in Ebola virus disease and other threats: a new global public health framework to stop outbreaks

Gerald J Kost*, William Ferguson, Anh-Thu Truong, Jackie Hoe, Daisy Prom, Arirat Banpavichit and Surin Kongpila

Ultrahigh sensitivity and specificity assays that detect Ebola virus disease or other highly contagious and deadly diseases quickly and successfully upstream in Spatial Care Paths™ can stop outbreaks from escalating into devastating epidemics ravaging communities locally and countries globally. Even had the WHO and CDC responded more quickly and not misjudged the dissemination of Ebola in West Africa and other world regions, mobile rapid diagnostics were, and still are, not readily available for immediate and definitive diagnosis, a stunning strategic flaw that needs correcting worldwide. This article strategizes point-of-care testing for diagnosis, triage, monitoring, recovery and stopping outbreaks in the USA and other countries; reviews Ebola molecular diagnostics, summarizes USA. FDA emergency use authorizations and documents why they should not be stop-gaps; and reduces community risk from internal and external infectious disease threats by enabling public health at points of need.

FREE ACCESS FOR ONE WEEK! USE THIS LINK—

http://www.tandfonline.com/doi/full/10.1586/14737159.2015.1079776
Influenza A & B (not waived)
Sensitivity A 100%  B 100%
Specificity A 96.8% B 94.1%

Strep A
Sensitivity 98.3%
Specificity 94.2%
CLIA Waived

Sample
Scan
Start
The Ebola Spatial Care Path™: Accelerating point-of-care diagnosis, decision making, and community resilience in outbreaks.

Kost GJ¹, Ferguson WJ², Hoe J², Truong AT², Banpavichit A³, Kongpila S⁴.

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Abstract

OBJECTIVES:

To present a vision where point-of-care testing (POCT) accelerates an Ebola Spatial Care Path™ (SCP) and future molecular diagnostics enable facilitated-access self-testing (FAST POC); to design an alternate care facility (ACF) for the SCP; to innovate an Ebola diagnostic center (DC); and to propel rapid POCT to the frontline to create resilience that stops future outbreaks.

DESIGN:


OUTCOMES:

The authors designed an ACF and DC to integrate SCP principles for urgent Ebola care. FDA emergency use authorizations for Ebola molecular diagnostics were discovered, but no portable, handheld, or self-contained molecular POC instruments are yet available, although feasible. The WHO initiated design criteria and an acceptance protocol for testing. Financial investment in POCT will downsize Ebola outbreaks.

CONCLUSIONS:

POCT is facilitating global health. Now, global health problems are elevating POCT to new levels of importance for accelerating diagnosis and evidence-based decision making during disease outbreaks. Authorities concur that rapid diagnosis has potential to stop disease spread. With embedded POCT, strategic SCPs planned by communities fulfill CDC recommendations. POC devices should consolidate multiplex test clusters supporting patients with Ebola in isolation. The ultimate future solution is FAST POC. New technologies offer minimally significant risks. Diagnostic centers in ACFs and transportable formats also will optimize Ebola SCPs.

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Research in limited-resource and other settings. POC culture is medical empowerment of the individual and family nucleus integrated with norms, behaviors, beliefs, attitudes, expectations, POC technology, and outcomes—the final frontier!
WHAT WE HAVE LEARNED!

- Needs assessment defines the role of POCT in pandemics, complex emergencies, disasters, and outbreaks.

- Environmental stresses affect test results and must be avoided, so that POCT can be effective for decision-making in urgent care, emergencies, & crises (Ebola, MERS CoV).

- Disaster caches should be designed and harmonized for collaborative use throughout the world, and for pandemics.

- Spatial Care Paths™ start with the patient, position POCT optimally, and accelerate care, while ones “tunes” cultural acceptance. Then, national POCT policy and guidelines and fiscal planning will enhance and sustain community resilience, keys to stopping outbreaks.
DISCLOSURES (...WITH APPRECIATION!)

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