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Strategic Point-of-Care Requirements of Hospitals and Public Health for Preparedness in Regions At Risk

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Abstract

Objectives—To study health resources and point-of-care (POC) testing requirements for urgent, emergency, and disaster care in Phang Nga Province, Thailand; to determine instrument design specifications through a direct needs assessment survey; to describe POC test menus useful in the small-world network; and to assess strategies for preparedness following the 2004 Tsunami.

Methods—We surveyed medical professionals in community hospitals, a regional hospital, and the Naval Base Hospital; and officials at the offices of Provincial Public Health and Disaster Prevention and Mitigation. Questions covered: a) demographics and test requirements, b) POC needs, c) device design specifications, and d) pathogen detection options. Respondents scored choices. Scores determined priorities.

Results—Respondents selected complete blood count, electrolytes/chemistry, blood type, oxygen saturation (by pulse oximeter), hematocrit, and microbiology as top priorities, and preferred direct blood sampling with cassettes. Cardiac biomarkers were important in alternate care facilities. *Staphylococcus aureus*, SARS, *Streptococcus pneumoniae*, and hepatitis B were top infectious disease problems. Temperature, vibration, humidity, and impact shock were four important environmental conditions during extreme conditions.

Conclusions—Point-of-care testing can be used on a daily basis for competency and efficiency. Familiarity improves preparedness. Instrument designs must anticipate user preferences and environment stresses. The results show how a region at risk can adapt its small-world network. Point-of-care testing has become an important risk-reducing modality for crises and works equally well in low-resource settings to speed the delivery of routine and urgent care.

Keywords

Community Hospital; device design; diagnostic testing; disaster; emergency; needs assessment; pathogens; Phang Nga; Primary Care Unit; Regional Hospital; survey

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INTRODUCTION

The goals of this research were: a) to study health resources and point-of-care (POC) testing requirements for urgent, emergency, and disaster care in Phang Nga Province, Thailand; b) to determine instrument design specifications through a direct needs assessment survey; c) to describe POC test menus useful in the small-world network; and d) to assess strategies for preparedness following the 2004 Tsunami.

Coastal Phang Nga Province lies in the seventh public health region of Thailand and has a population of 252,385.¹ The number of people per hospital bed, medical doctor, registered nurse, technical nurse, pharmacist, and medical technologist inclusive of seven community and two regional hospitals is 411, 4,428, 460, 4,428, 7,648, and 2,696, respectively.^{2,3}

Phang Nga Province was devastated by the Tsunami that hit shore following the Java earthquake on December 26, 2004, with 4,186 deaths, 5,597 injuries, and 1,935 missing.⁴ However, the province has recovered substantially. Enhanced awareness of the need for preparedness generated enthusiasm for this survey among health professionals.

METHODS

Survey Design and Sampling Distribution

Phang Nga Province participants (N = 24) were medical professionals related to critical, emergency, and disaster care services from different geographic regions and medical organizations, namely seven Community Hospitals, one Regional Hospital, and the Naval Base Hospital, and the Offices of Provincial Public Health and Disaster Prevention and Mitigation.

The study was conducted during 2011–2012 by distributing packages of survey forms including formal invitation letters, survey tools, participant information sheets, and informed consent forms to the directors of hospitals and other medical personnel in order to formally invite their participation. Then, survey responses and other key related documents were mailed back to the research team at Chulalongkorn University where the data were analyzed and collated. Later, follow-up surveys and additional data were obtained through telephone calls, email, and facsimile.

The survey was developed in the United States and approved by the Institutional Review Board of the University of California, Davis, then adapted and translated into the Thai language at the College of Population Studies, Chulalongkorn University in Bangkok. The survey instrument and this study were approved by the Ethics Committee of Chulalongkorn University.

Statistical analyses

Summary statistical analyses, including the mean, standard deviation (SD), range, medium, and maximum were calculated using Excel. Ranking questions were analyzed using Analysis of Variance (ANOVA) and Tukey's Multiple Comparison Test.

RESULTS

Small-World Network (Figure 1)

We determined locations of organizations surveyed (N = 11) and geographic relationships in the Phang Nga SWN. The distance [mean (SD), range, median, and maximum] from 53 Primary Care Units (PCUs) to 7 Community Hospitals was 19 (12), 3–60, 15, and 60 kms, and from 7 Community Hospitals to 2 Regional Hospitals, 39 (20), 7–65, 40, and 65 kms,

respectively, while the time needed for ambulances to travel from PCUs to Community Hospitals was 25 (22), 4–120, 20, and 120 mins, and from Community to Regional Hospitals, 43 (21), 20–80, 30, and 80.^{5–7}

Pathogen Detection

Survey results identified several pathogen test menus preferred by respondents (N = 24) by ranking weighted scores in cases of potential civil disaster infections, respiratory pandemics, blood stream infections (sepsis), and emergency blood donor screening (Table 1). For the civil disaster setting, *Staphylococcus aureus* had the highest weighted score (53); for respiratory pandemics, SARS (60); in blood stream infections, *Streptococcus pneumoniae* (95); and for emergency blood donor screening, hepatitis B virus (155).

Test Clusters and Environmental Conditions

Figure 2 illustrates weighted scores of the top 20 tests that respondents selected for emergencies and disasters. Complete blood count, electrolytes/chemistry, blood bank (blood group), oxygen saturation (by pulse oximeter), and hematocrit were selected as the top five POC tests to have in Phang Nga Province. Figure 3 illustrates eight environment conditions that respondents considered important. Temperature, vibration, humidity, and impact shock were the four most important ones when designing POC devices used during extreme conditions in local environments.

Device Design

Table 2 summarizes preferred sample collection methods during disasters by comparing a Vacutainer and hub sample draw using a butterfly needle versus a test cassette that connects by luer lock with also a butterfly needle. Table 2 also shows preferences regarding a test cassette that connects by luer lock with a standard butterfly needle for coupled sample collection versus a built-in retractable needle for direct sample collection.

Respondents evaluated four important criteria including lowest risks of contamination, operator error, and biohazard disposal, as well as lowest recurring cost. In their overall assessment, respondents (N = 23) preferred a test cassette sample (score 62) over a Vacutainer and hub (53) for disaster settings. For the comparison of coupled and direct sample collection, respondents (N = 21) selected direct (70) over coupled samplings (35) in disasters.

Near-patient and Bedside Testing within an Alternate Care Facility

Survey respondents selected pulse oximetry (score 80), chemistry/electrolytes (58), blood bank/transfusion (43), and cardiac biomarkers (36) as first through fourth choices for near-patient testing (Table 3). While for bedside testing, they choose blood gases (63), pulse oximetry (57), chemistry/electrolytes (52), and cardiac biomarkers (29).

DISCUSSION

Medical professionals (respondents) considered *Staphylococcus aureus*, SARS, *Streptococcus pneumoniae*, and Hepatitis B as the top priorities to facilitate evidence-based medicine for crises, emergencies, and disasters. These findings could suggest priorities for enhancing pathogen detection, although respondents may not have articulated MRSA (methicillin resistant *Staphylococcus aureus*) or pandemic influenza strains carefully when answering surveys. Therefore, based on results from other surveys,^{8–11} these tests should be considered for POC detection as well.

A previous extensive field study⁷ in Phang Nga Province with follow-up described the need for, and use of, oxygen saturation monitoring (pulse oximetry), which was found in the present survey among the top five POC tests [i.e., complete blood count, electrolytes/chemistry, blood bank (blood group), oxygen saturation (by pulse oximeter), and hematocrit]. Pulse oximeters to monitor oxygenation status during ambulance transfer, ED evaluation, and ventilation have become available widely, and in the future, should be matched by adequate blood gas analyzers for timely O₂ saturation validations, plus critical arterial pO₂, pCO₂, and pH measurements.⁷

In regard to technical and biohazard features, respondents preferred a test cassette to a Vacutainer with hub, while they also preferred direct to coupled sampling, in part because the former was deemed to have the lowest risk from biohazard disposal and contamination for disaster settings. Hence, the evidence illustrates that health professionals, related agency personnel, and stakeholders encourage innovative designs of POC devices and instruments to avoid adverse events, such as accidental needle punctures and exposure during triage, diagnosis, monitoring, and treatment.^{8–11}

Collaboration within the SWN can empower POC Coordinators, the healthcare team, responders, and other related government personnel from local medical organizations, who enter mutual cooperation in providing POC resources for those with short supply in order to help improve patient outcomes and reduce morbidity and mortality when disaster strikes. Reciprocity was observed during and following the 2004 Tsunami and now represents one of the principles of resilience in Phang Nga Province. Although physical distances separating villages, PCUs, and hospitals generally are not great, risk of sudden and unexpected isolation is high because of the relatively low elevation where PCUs and hospitals are located along extensive coastal areas subject to flooding (see Figure 1).

We found significant differences in respondent selections of environment conditions deemed important. Environment conditions can impact future POC device design, such that both instruments and test cassettes should be able to withstand extreme conditions during disasters when operators are confronted with tsunamis, flooding, or earthquakes. However, there were no statistically significant differences in preferences for field testing locations including a tent, a vehicle, and patient-side (data not shown) outside hospitals when performing POC tests during a disaster.

CONCLUSIONS

Since Phang Nga is one of the six coastal provinces adjacent to the Andaman Sea, it is at high risk from another Tsunami or other unusual flooding events.¹² Therefore, health professionals and directly related public health personnel should cooperate by establishing health policies, setting up disaster response staging hubs, and testing the efficiency of transport systems in order to prepare for potential future emergencies impacting PCUs, Community Hospitals, Regional Hospitals, and in the case of Phang Nga Province, the Naval Base Hospital.

In general, small-world networks at high risk and vulnerable low-resource settings¹³ can use POC testing, with specific user needs to be met as identified in this report, to improve readiness for potential adverse events that are difficult, if not impossible to predict, but not beyond societal capability to anticipate and prepare resources in advance. Particularly relevant when there is no crisis, POC testing can be used to improve everyday health care delivery, urgent patient services, emergency room efficiency, and ambulance transport safety.

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Figure 1. Phang Nga Province Small-World Network

The map shows geographic areas, transportation routes, and locations of medical organizations surveyed—Community, Regional, and Naval Base Hospitals, the Office of Provincial Public Health, and the Office of Prevention and Mitigation.

Figure 2. Priorities for Diagnostic Tests during Disasters

Respondents selected complete blood count, electrolytes/chemistry, blood bank (blood group), oxygen saturation (by pulse oximeter), and hematocrit as the five most important POC tests to have in the Phang Nga Province small-world network. These tests differed significantly from one or more of the three other asterisked tests (urinalysis, glucose, and stool exams) shown in the bar graph. [*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$]

Figure 3. Environment Considerations for Future POC Devices during Extreme Environmental Conditions

Respondents chose temperature, vibration, humidity, and impact shock as the four most important environmental conditions to consider when designing POC devices for high risk settings, all four of which differed significantly from one or both of the other asterisked conditions (submersion and acceleration). [*** P<0.001, ** P<0.01, * P<0.05]

Table 1

Pathogen Test Menus for Emergency and Disaster Care

Objective	Weighted Score	Pathogen
A Civil disaster infections(n = 24)	53	<i>Staphylococcus aureus</i>
	42	<i>Klebsiella</i> species
	41	Dengue fever virus
	36	<i>Pseudomonas aeruginosa</i>
	34	HIV1 and 2
	30	Hepatitis B
	28	<i>Enterobacter</i> species
	23	<i>Vibrio cholerae</i>
	23	<i>Plasmodium vivax</i>
	20	<i>Plasmodium falciparum</i>
	18	<i>Streptococcus pyogenes</i>
B. Respiratory pandemics (n = 24)	60	SARS
	60	Avian influenza (H5N1)
	45	Respiratory syncytial virus
	43	<i>Streptococcus pneumoniae</i>
	42	Influenza A/B
	41	<i>Mycobacterium tuberculosis</i>
	37	<i>Haemophilus influenza</i>
	35	<i>Mycoplasma pneumoniae</i>
	34	<i>Staphylococcus aureus</i>
	33	<i>Klebsiella</i> species
	26	Pandemic (H1N1) 2009 influenza
C.Bloodstream infections (n = 24)	95	<i>Streptococcus pneumoniae</i>
	85	<i>Staphylococcus aureus</i>
	75	<i>Escherichia coli</i>
	72	<i>Pseudomonas aeruginosa</i>
	65	<i>Streptococcus</i> species
	52	<i>Klebsiella</i> species
	48	Methicillin resistant <i>Staphylococcus aureus</i>
	43	<i>Enterobacter</i> species
	31	<i>Acinetobacter baumannii</i>
	30	Coagulase negative <i>Staphylococcus</i>
D. Emergency blood donor screening (n = 24)	155	Hepatitis B
	150	HIV 1 and 2
	138	Hepatitis C
	68	Epstein-Barr virus
	61	Dengue fever virus

Objective	Weighted Score	Pathogen
	57	<i>Cytom egalovirus</i>
	49	Parvovirus B19
	49	Chikungunya virus
	43	Hum an T-cell lymphotropic virus 1 and 2 (HTLV 1 and 2)

Table 2

Device Design: Comparison of Sample Collection Methods for Disaster Settings

N = 23		Criteria	N = 21	
Vacutainer® +Hub	Test Cassette		Coupled Sampling	Direct Sampling
16	7	Lowest risk of contamination	6	15
14	9	Lowest risk of operator error	10	11
7	16	Lowest risk from biohazard disposal	5	16
6	17	Lowest recurring cost	8	13
10	13	Overall, the best sample method	6	15
53	62	Overall scores	35	70

Table 3

Top Ranked Diagnostic Test Groups for Near-Patient and Bedside Testing within an Alternate Care Facility

For Near-Patient Testing	Weighted Scores	Rank	Weighted Scores	For Bedside Testing
Pulse oximetry	80	1	63	Blood gases
Chemistry/Electrolytes	58	2	57	Pulse oximetry
Blood Bank/Transfusion	43	3	52	Chemistry/Electrolytes
Cardiac Biomarkers	36	4	29	Cardiac Biomarkers
Blood gases	35	5	28	Hematology
Hematology	17	6	26	Rapid Microbiology Tests
Rapid Microbiology Tests	10	7	24	Coagulation
Coagulation	8	8	9	Blood Bank/Transfusion