 doi:10.20944/preprints202210.0446.v1

Article

Point-of-Care Testing, Spatial Care Paths, and Enhanced Standards of Care – *Preparing Island Communities for Global Warming and Rising Oceans*

Gerald J. Kost [1,*], Anna K Füzéry [2], Louie Kim R. Caratao [3], Samantha Tinsay [4], Amanullah Zadran [5] and Adrian P. Ybañez [6]

1 Fulbright Scholar 2020-2022, ASEAN Program; Director, Point-of-care Testing Center for Teaching and Research (POCT•CTR); Emeritus Professor, Pathology and Laboratory Medicine, School of Medicine, University of California; CEO, Knowledge Optimization, Davis, California, USA 95616
2 Clinical Associate Professor, Department of Laboratory Medicine and Pathology, University of Alberta; North Sector Point-of-care Testing Medical Lead, Alberta Precision Laboratories; Edmonton, Alberta, Canada; anna.fuezery@aplabs.ca
3 Research Assistant, Cebu Technological University, Cebu City, Philippines; LouieKim.Caratao@CTU.edu.ph
4 Municipal Health Officer; Municipality of Bantayan, Cebu, Philippines; SamanthaTinsay@gmail.com
5 Assoc. Dir., POCT•CTR; Public Health Sciences; School of Medicine, University of California, Davis, USA; amanullahzadran01@gmail.com
6 Director of the Institute for Molecular Genetics, Parasitology and Vector-borne Disease (IMGPVD)-Cebu Technological University, Cebu, Philippines; adrian.ybanez@ctu.edu.ph
* Correspondence: GeraldKost@gmail.com, Phone: +1-530-574-3945

Abstract: Our goal is to create point-of-care (POC) strategies that accelerate decision making, increase efficiency, improve outcomes, and enhance standards of care in island communities faced with global warming, rising oceans, population migration, and intensifying weather disasters. We assessed needs in the Bantayan Archipelago and mainland Cebu Province, Visayas Islands, Philippines, to map POC diagnostics, rescue times, and spatial care paths. Significant deficiencies were lack of cardiac troponin testing for rapid diagnosis of acute myocardial infarction, absence of blood gas and pH testing for support of critically ill patients, and geographic gaps prolonging patient transfers and delaying treatment. Strengths comprised primary care that can be facilitated by POC testing, logical inter-island transfers for which decision making and triage could be accelerated with onboard diagnostic testing, and healthcare small-world networks amenable to POC advances, such as pre-hospital testing, that avoid overloading emergency rooms. Healthcare resources must be distributed to archipelago islands, not concentrated in large metropolitan areas inaccessible for emergency interventions. We conclude that a point-of-need focus will help improve public health, decrease disparities in mortality among rural islanders versus urban dwellers, and pave the way for heightened resilience in anticipation of the adverse impact of global warming on vulnerable coastal areas.

Keywords: acute myocardial infarction; coronavirus disease 2019 (COVID-19); island communities; point-of-care testing; spatial care paths

1. Introduction

The goal of this research is to create point-of-care (POC) strategies that accelerate decision making, increase efficiency, improve outcomes, and enhance standards of care in the healthcare small-world networks of island communities faced with global warming, rising oceans, population migration, weather disasters, and public health crises.

This paper is the first to address POC testing (POCT) and global warming, and to draw on the armamentarium of prehospital testing (**Table 1**) **[1-137]** to prepare for future

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

crises. It also is the first to introduce formal geospatial POC strategic planning in the Philippines. Global warming is intensifying the severity of major storms, such as super typhoons, increasing their frequency, and magnifying the size and scope of damage. Ocean levels are projected to rise up to 2.2 meters (~7 feet, 3 inches) by 2150 if climate warming is not abated **[138]**.

Table 1. Prehospital Point-of-care Testing, Decision Making, Outbreak Mitigation, and Outcomes Impact.

Author, Ref., Journal, Year	Diagnostic Portals	Setting/ Environment	Decision Pivots	Innovations, Effectiveness, and Impact on Outcomes
Part 1. Strategies for Point-of-need Testing				
• Ambulances and Emergency Medical Services				
Baker *Aust J Rural Health* 2022	Emergency workforce and resources planning	Rural Australia	POCT	POCT and clinician radiography were more common in smaller facilities. Small and remote facilities adapt by using different workforce structures and bedside investigations.
Fuzery *Clin Lab News* 2021	Ambulance and helicopter EMS teams	Alberta, Canada	POCT standards of care for ambulances	Patients depend on reliable testing form air and ground ambulance teams and the complexity of these environments deserves special considerations leading to standards of care.
Fuzery *Arch Path Lab Med* 2020	Ambulance and helicopter EMS teams	Alberta, Canada	POCT in four field settings	POCT in EMS programs should incorporate specific guidance on quality standards that are needed to address the unique challenges of performing POCT in field settings.
Heaney *J Paramed Pract* 2020	Prehospital triage using "Labkit" with several POC instruments and several tests	Surrey, London, England (unique empowerment study)	Cobas h232 HemoCue i-Stat StatStrip Coag-uChek Pocket-chem	POCT results available at the time of paramedic assessment reduced ED conveyance by 21%. 10% had POCT results requiring unrecognized admission for urgent Rx. 31% of conveyance decisions were changed by POCT. Results suggest both medical and economic benefits in the prehospital setting.
Sanko S *Prehosp Emer Care* 2020	Advance provider response unit in field with POCT	Los Angeles Fire Department, California, USA	POCT	Advanced practice providers such as nurse practitioners with POCT can be incorporated into the prehospital setting to address a growing subset of 911-patients whose needs can be met outside of the ED.
• COVID-19 Test Optimization				
Eng *JCH* 2022 *ODH* 2021	Geospatial mapping of testing sites, mobile van for COVID-19 POCT	Rural Cambodian provinces and California, USA	COVID-19 RAgT, RT-PCR, and Antibody test	Strategic placement of field RAgTs and referral RT-PCR enables proper triage and diagnosis of COVID-19 in the rural Cambodian provinces. A mobile van in California provides community access to rapid COVID-19 testing where outbreaks occur.
Kost *Diagnostics* 2022 *APLM* 2019-22	Diagnostic gateways empowering people for self-care	Mathematical analysis of clinical studies, worldwide	COVID-19 RAgT, saliva RT-PCR test	Visual logistics established the relative merits of home, community, and emergency COVID-19 diagnostic portals along spatial care paths that empower people to protect their families, friends, and workplace colleagues.
Yolo County Public Health and CDC 2022	Vending machines for COVID-19 test kit free distribution	Yolo County public libraries (4), California, USA	COVID-19 RAgT self-testing kits (Flowflex)	First county in California where public health distributes COVID-19 RAgTs free of charge in unlimited numbers creating responsibility for frequency of use and 24/7 empowerment when individual results become available in minutes.
Clinical outreach pioneers Investigative reports 2020-2022	Mobile and door-to-door testing	Several sites worldwide	COVID-19 testing outreach at points of need in the community	Benefits comprise high volume testing; improved access; privacy; multiple test formats (PCR, RAgT, AbT); service for hard-to-reach, marginalized, vulnerable, and underserved people diminishing disparities and inequities;

 doi:10.20944/preprints202210.0446.v1

				increased testing; tracking positivity rates; outbreak mitigation; and partnered vaccination.
• Spatial Care Paths				
Kost *Point of Care* 2016 *Am J Dis Med* 2015 *Clin Lab Int* 2015 *JIFCCLM* 2014	Invention and documentation of the spatial care path concept	Global applications (see references)	Optimizing patient access and medical decision making	POC testing in limited-resource settings is best guided by thorough understanding of the POC geospacer and culture. 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 geography, topography, healthcare, and culture.
Kost *Front Publ Health* 2019 Ferguson *Int J Health Geogr* 2016	Using geographic information systems and geospatial analysis	Isaan, Thailand	POC access to cardiac biomarker testing in spatial care paths	Geospatial analyses improve alternative POCT placement in limited-resource settings by revealing deficiencies in health care access. GISs provide a platform for comparing relative costs, assessing benefits, and improving outcomes. This approach can be implemented effectively to enhance cardiac care.
Part 2. Test Categories				
• Cardiac Biomarkers				
Castro-Portillo *Int J Cardiol* 2022	Adults with acute disease transferred to EDs	Valladolid, Spain	NT-proBNP	POCT NT-proBNP predicts early mortality in acute cardiovascular disease, excellently in cases of syncope, but does not appear to be useful for predicting outcome in patients with acute heart failure.
Jones *J Paramed Pract* 2022	Prehospital stratification of chest pain	Bradford, England	HEART pathway (review)	The use of HEART scores or hs-cTn prehospital by paramedics has the potential to improve patient outcomes.
Pavlovsky *Prehosp Dis Med* 2022	Prehospital risk stratification of non-ST-segment elevation myocardial infarction	Paris Region, Frances	hs-cTnI [3.2 to 50,000 and detection limit 1.1 to 1.9 ng/L] (i-Stat 1), ECG	POC cTnI with ECG allow risk stratification of NSTEMI patients and an optimal referral pathway. Low risk patients should be referred to the ED while high or very high risk, to the CCU or PCI center. Positive cTnI was associated with high- or very high-risk stratification regardless of the time to onset of pain (P <.0001).
Cooper *J Am Coll Cardiol* 2021	AMI triage and rule out in the prehospital setting	Aberdeen, Scotland (secondary analysis of prospective cohort)	hs-cTnI (remainder sample, not POC), ECG	The FN rate of a hs-cTnI value below the LOD and an optimized rule-out threshold missed up to 1 in 40 and 1 in 10 patients with AMI or cardiac death, respectively. Limiting this approach to later presenters or those without known IHD may improve performance.
Cooper *J Am Coll Cardiol* 2021	AMI rule out using the HEART score	Aberdeen, Scotland	ECG, cTnI (Samsung LABGEO)	Paramedics use the HEART score to discriminate risk. Even in combination with out-of-hospital POC cTnI testing, the HEART score does not safely rule out major adverse cardiac events.
Koper *Neth Heart J* 2021	Emergency department, HEART score	Venlo, Netherlands	Fingerstick capillary hs-cTnI	The sensitivity and negative predictive value of the HEART score were 97.0% and 97.6%, respectively, encouraging prospective study of fingerstick POC hs-cTn in a pre-hospital setting.
Lee *Biosensors* 2021	Electrochemical sensor study	Critical Care and Universities, Taiwan	cTnI	Biosensor results correlated with standard clinical laboratory cTnI, suggesting it can deliver fast and accurate cTnI in prehospital settings for rapid Dx and patient management.
Martin-Rodriquez *Eur J Clin Invest* 2021	Prognostic accuracy of prehospital POC cTnT	Multicentric ambulance-based study, Spain	Cardiac troponin T (cTnT)	Determination of cTnT on the ambulance can help to stratify the risk of patients and to detect unknown early clinical deterioration. In the high-risk group (cTnI >100 ng/L), the mortality rate was 61.7%, and in the low-risk group (<40 ng/L), 2.3%.
Stopyra *PloS ONE* 2020	Prehospital stratification of chest pain	North Carolina, USA	HEART pathway and cTn (i-Stat)	>150 paramedics were trained to use POC cTn and to calculate a HEART score. Structured prehospital risk assessment with POC cTn facilitates early identification of

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

	without evidence of STEMI on ECG			high-risk patients who benefit from rapid Rx and triage to tertiary care facilities with interventional cardiac catheterization capability.
Stopyra *Prehosp Emer Care* 2020	Paramedic POC testing when transporting patients	[ECG ST-elevation patients excluded]	Cardiac troponin I (i-Stat)	The specificity and PPV of the POC cTn were 99.2% and 85.7%; sensitivity and NPV, 26.5% and 87.5%. Prehospital cTn can rule-in AMI but should not be used to exclude AMI because of low sensitivity.
Alghamdi *Prehosp Dis Med* 2020 *Emer Med J* 2018	Prehospital rule out of AMI (vs. rule in)	Manchester, England	Cardiac troponin (review paper)	Current evidence does not support the use of POC troponin to exclude AMI due to issues with diagnostic accuracy and insufficient high-quality evidence.
Harjola *ESC Heart Failure* 2020	Multicenter survey of prehospital protocols for AHF	Belgium, Finland, France, Spain, USA, Switzerland	cTn, BNP, 12-lead ECG, UTZ	UTZ and POCT were available in advanced life support and helicopter EMS units in <25% of EMS regions. Protocols for ST-elevation AMI, chest pain, and dyspnea were present in 95.2, 80.8, and 76.0% of EMS regions, respectively.
Johannessen *Open Heart 2020*	Prehospital primary care emergency clinic	Oslo, Norway (low prevalence)	hs-cTnT in 1 hour algorithm	hs-cTnT seems safe, efficient, and applicable for accelerated assessment of patients with non- specific chest pain. Sensitivity was 98.4%; NPV, 99.9%; and 90-day rule out morality; 0.3%.
Kaier *J Am Heart Assoc* 2019	Blood samples from ambulance paramedics	England, Denmark, and Germany	Cardiac myosin-binding protein C	Very early after symptom onset, cardiac myosin-binding protein C improves diagnostic discrimination and could significantly improve the early triage of patients with suspected AMI.
Alghamdi *Emerg Med J* 2018	Prehospital rule out of ACS	Manchester, United Kingdom	cTn (a review of 9 papers)	Based on the currently available evidence, POC troponin assays are insufficiently sensitive to rule out ACS in the prehospital environment.
Kost *Point of Care* 2018	Designing spatial care paths for AMI	Central Vietnam	Cardiac biomarkers	Early upstream POC cTn testing on spatial care paths will expedite transfers directly to hospitals capable of intervening, improving decision making and outcomes following coronary occlusion.
Rasmussen *EHJACC* 2017	Prehospital Dx and risk stratification	Aarhus, Denmark	cTnT	Patients presenting cTn T ≥50 ng/L had 24% 1-year mortality compared with 4.8% for cTnT <50 ng/L (p<0.001). Prehospital cTnT ≥50 ng/L has a poor prognosis irrespective of final diagnosis and high predictive value for identifying high-risk prehospital so that they may be rerouted directly for advanced care at an invasive center.
Stengaard *Biomarkers* 2016	Optimizing prehospital triage	Aarhus, Denmark	hs-cTnT, copeptin in prehospital samples	hs-cTnT and copeptin performed prehospital could potentially improve the diagnostic and prognostic classification of patients with suspected AMI (not POC).
Ezekowitz *J Am Heart Assoc* 2015	Prehospital cTn testing in ambulances	Alberta, Canada	cTn	Ambulance cTn accelerated the time to final disposition. Enhanced and more cost-effective early ED discharge of most patients with chest pain is an unrealized opportunity.
Tideman *Med J Aust* 2014	Royal Air Service fixed wing air ambulance	Rural Australia	POC cTn	Cardiologist-supported remote risk stratification, management, and facilitated access to tertiary hospital-based early invasive management are associated with improved 30-day mortality for patients who initially present to rural hospitals and are diagnosed with AMI. These interventions closed the gap in mortality between rural and metropolitan patients in South Australia.
Stengaard *Am J Cardiol* 2013	Prehospital triage	Aarhus, Central Denmark	Quantitative cTnT	Quantitative prehospital cTnT testing by paramedics is feasible and an elevated cTnT is highly predictive of mortality in suspected AMI.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

Venturini *Prehosp Emer Care* 2013	Testing in moving ambulances versus the ED	Maywood, Illinois, USA	cTnI testing site comparison study	No significant difference in whole-blood troponin results was found between cTnI performed in the moving ambulance and the ED.
Prosen *Crit Care* 2011	Differential Dx in prehospital emergencies	Maribor, Slovenia	NT-proBNP, UTZ	UTZ comet-tail sign alone or in combination with NT-proBNP has high diagnostic accuracy in differentiating acute HF-related from COPD/asthma-related causes of acute dyspnea.
Sorensen *Am J Cardiol* 2011	Prehospital Dx and triage of AMI	Aarhus, Denmark	Qualitative cTnT, ECG	Prehospital cTnT testing is feasible with a high success rate and indicates that implementation of quantitative tests with lower detection limits could identify most patients with AMI irrespective of ECG changes.
Kost *Point of Care* 2010	Implementation of POC cTn testing in rural provinces	Thailand	cTnT, NT-proBNP	Following defining pilot studies of need and application, cobas 232 handheld cardiac biomarker testing was implemented in hundreds of sites transforming the care of patients with AMI.
Di Serio *Clin Chem Lab Med* 2006	Ambulance tele-cardiology for managing AMI	Bari, Italy	cTnI (i-Stat), ECG (no patients with ST-segment elevation)	For POCT, cTnI was >0.09 microg/L in 20 AMI patients (91%). The median ambulance TAT was 12 min and median hospital TAT, 40 min. cTnI integrated with telemedicine plays an important role in management of ACS patients related to the pre-hospital phase early Dx/Rx.
Owens *J Electro-cardiol* 2004	Physician-manned mobile CCU	Belfast, Northern Ireland	80-lead ECG body map	The 80-lead BSM is superior to the standard 12-lead ECG in predicting AMI prehospital.
Schuchert *Am Heart J* 1999	Ambulance cTnT-6-mo follow-up of AMI and death	Hamburg, Germany	Qualitative cTnT	Rapid cTnT identified a minority of patients with AMI. Positive prehospital TnT was an objective marker for a worse outcome. During follow-up, patients positive prehospital for cTnT had cardiac events more often (9 of 11) than patients with a negative result (26 of 147; P <.0001).
• Electrolytes, Blood Gases, Ca^{++}, and pH				
Collopy *Air Med J* 2022	POCT during ground & helicopter transport	Wilmington, North Carolina, USA	pO_2, pCO_2, pH, Na^+, K^+, Ca^{++}, Glu, Cr, Lactate, Hct, [epoc]	Care plan alterations occurred in 38.6% of patients undergoing POCT, which most frequently changed care for post-cardiac arrest syndrome (64.7%), sepsis/septic shock (61.8%), diabetic ketoacidosis (54.5%), and pneumonia (49.3%).
Morton *Air Med J* 2022	Prehospital helicopter emergency services	England	Arterial BG, lines (review)	Prehospital guidelines state that monitoring should match in-hospital standards. Clinicians believed arterial BG would allow better monitoring and more targeted treatment.
Murali *Clin Chem Lab Med* 2022	Supporting environment-al stability during air transport	Pittsburgh, Pennsylvania, USA	BG	Temperature excursions are reduced by insulated transport bags with heating and cooling packs. POC blood gas results during air transport improved ventilator management, increased recognition of ventilation-perfusion mismatch, and improved patient tolerance of ventilation.
Cini *Recenti Prog Med* 2021	Home evaluation of COVID-19 patients	Toscana Sud Est., Italy	Potable blood gas analyzer	POCT blood gas analysis made it possible to evaluate and treat at home 52% of COVID-19 patients and admit others directly to the most appropriate ward.
Gruebl *SJTREM* 2021	Prehospital Dx and Rx for out-of-hospital cardiac arrest	Essen, Netherlands	pO_2, pCO_2, pH, Na^+, K^+, Ca^{++}, glucose, lactate, Hct, Cr [epoc]	Prehospital POCT allows rapid detection of pathological acid-base imbalances and potassium and specific interventions that improve the probability of survival. 21% of patients survived to hospital discharge (with POCT, 30%, versus no POCT, 16%, p = 0.01).
Nawrocki *Front Physiol* 2021	High altitude hospital (760 m) and clinic (3,100 m)	Zurich, Switzerland	Portable blood gas analyzer (epoc)	Because of portability and ease of handling, portable blood gas analyzers are valuable diagnostic tools for use in everyday

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

				practice as well as under challenging field conditions at high altitudes.
McPherson *J Paramed Pract* 2019	Prehospital patient disposition	So. Central Ambulance, England	VBG, urea, lactate, Hct, Hgb, electrolytes	POCT improved clinician confidence in decision making and patient disposition validated by better discharge on scene and recontact rates. POCT knowledge increased.
Shin *Crit Care* 2017	Out of hospital cardiac arrest with ER Rx	Seoul and multicenter sites, South Korea	pH, K^+, and other ER POC tests	pH and K^+ levels were independent factors associated with survival to hospital discharge, and pH level was an independent factor related to neurological recovery.
Mikkelsen *SJTREM* 2015	Prehospital blood gas, pH, and metabolite analysis in a mobile emergency care unit	Odense, Denmark	WBA (Radiometer ABL-90)	Only minute changes were needed to use the ABL-90, which helped direct Rx of COPD; release of patients with suspected CO poisoning; speed Dx, blood cultures, and antibiotic Rx of septic shock and septicemia; obviate cyanide toxicity/ anaerobic metabolism from fire exposure through determining lactate levels; and adjust respiratory parameters for intubated patients with elevated intracranial pressure, for which BG pCO_2 fine tuning excelled management using end-tidal CO_2.
Di Serio *Clin Chem Lab Med* 2010	Performing SWOT analysis for air ambulances	Bari, Italy	Arterial BG, glucose, Na^+, K^+, Ca^{++}, Hct/ Hgb	Clinical study results suggest that critical tests performed during the transport of critically ill patients improve patient care. Real-time results during transport must be considered an integral part of the patient care process. Excellent channels of communication are needed between the ICUs, EMS, and laboratories.
Jousi *World J Emer Surg* 2010	Trauma resuscitation with POCT at accident site	Helsinki, Finland	BG	A portable BG analyzer was useful in prehospital monitoring for trauma resuscitation and led to significantly greater awareness of base excess and pH values.
Vos *World J Emerg Surg* 2010	POCT during interhospital transport of critically ill pediatric patients	Maastricht, Netherlands	BG, K^+, Hct, others	POCT led to 42.9% of therapeutic interventions for life threatening results that could not have been discovered otherwise. We recommend POC BG, electrolytes, glucose, and hematocrit during interhospital transports, especially for mechanical ventilator adjustment.
Gruszecki *Clin Chem* 2003	Critical care transport in ambulances and twin-engine jets	Birmingham Alabama, USA	pO_2, pCO_2, pH, TCO_2, O_2 Sat, Na^+, K^+, Cl^-, urea, Cr, Hct, glucose	Our experience shows that POCT can be performed with high reliability and provides rapid critical analyte and blood gas results where no other laboratory analysis is available. POCT in the transport setting is infrequent and is relatively inexpensive. Use of POCT led to changes in patient treatment 30% of the times when testing was performed.
Backer *S Ann Emerg Med* 1999	Back-country evaluation of heat symptoms	Grand Canyon National Park, USA	Na^+ (i-Stat)	POC Na^+ reliably identified exercise-associated hyponatremia, an important cause of heat illness during endurance exercise. The results helped make Rx and disposition decisions.
Herr *Am J Clin Path* 1995	Performing prehospital Dx and Rx on helicopters	Rochester, Minnesota, USA	Na^+, K^+, Hct, Hgb (i-Stat)	Fifteen (18.5%) patients were treated with transfusions, glucose, or insulin based on results obtained during helicopter flight.
		• Glucose and Lactate		
Fuzery Personal communication 2022	Ambulance preparedness and protocols	Alberta Health Services, Canada	Glucose	All ground ambulances operated by AHS have glucose meters, which can be operated by paramedics trained in basic life support only. Paramedics follow written protocols if they suspect hyper/hypoglycemia. The protocols provide direction on when to do a glucose meter test and how to act on the result.
Hill *Air Med J* 2020	Air ambulances in Midwest America	Colorado & Ohio, USA [non-diabetic patients]	Glucose	POC glucose greater than 220 mg/dL should prompt prehospital aggressive balanced resuscitation before arrival at the trauma center to prevent worsening hypotension and hemorrhagic shock.

 doi:10.20944/preprints202210.0446.v1

Remick *Prehosp Emer Care* 2017	Assessing prehospital seizures in pediatric patients	Harbor-UCLA Hospital, California, USA	Glucose	Findings suggest the importance assessing prehospital seizure protocols, which should be studied to identify unique cases where glucose testing might be useful in view of the rarity of prehospital seizures in pediatric patients.
Lerner *Am J Emerg Med* 2003	Paramedic decision making in the field	Buffalo, New York, USA	Glucose	Paramedics successfully treated, without complication, most of the patients with uncomplicated hypoglycemic events. Patients preferred discharge without transport to an ED.
Novak *J Paramed Pract* 2022	Rapid response vehicle with POCT	Oxford, England	Lactate, pH, TCO_2, Ca^{++}, Cr, others (i-Stat)	POCT by ambulance services is feasible and when combined with telephone advice and decision support from physicians, may be effective in reducing hospital admissions for frail patients in supportive care environments.
Galvagno *Shock* 2020	Helicopter prehospital Dx and intervention	Baltimore, Maryland, USA	Lactate (i-Stat)	Lactate outperformed vital signs, including shock index, for detecting shock and predicting the need for LSIs. A lactate level > 4 mmol/L was highly associated with need for LSIs.
Martin-Rodriquez *Eur J Clin Invest* 2020	Prehospital POCT on ambulances	Valladolid, Spain	Lactate	4 mmol/L was the cut-off for low versus high mortality, highlighting the importance of lactate to determine risk of early in-hospital mortality. EMS lactate could improve identification of risky patients and better care.
Martin-Rodriquez *Am J Emer Med* 2018	Prehospital prediction of early (< 30 d) mortality	University of Valladolid, Spain	Lactate	POC lactate with the best sensitivity (84%) and specificity (70%) overall was 4.25 mmol/L. The level can guide us early in the detection of critical patients.
• Hemoglobin A1c				
Shephard *Clin Biochem* 2017	National Indigenous POCT program for diabetes	Rural Australia	HbA1c and quality control	HbA1c POCT in the Aboriginal and Torres Strait Islander Medical Services program has remained analytically sound, matched the quality achieved by Australasian laboratories, and met profession-derived analytical goals for 15years.
Motta *Primary Care Diabetes* 2017	Primary care delivery	South Africa	HbA1c	POCT changed clinical practice by facilitating access to HbA1c testing. Patients achieving optimal glycemic control (HbA1c ≤ 6.5-7.5%) increased by 125%, while those with very poor control (HbA1c > 10%) halved. Mean HbA1c at the first POC test decreased from 9.7% ± 2.4 to 8.4% ± 2.4 for the most recent (paired t-test $p<0.01$).
Kost *Point of Care* 2017 & 2011	Rotating POCT in several rural villages, drones for specimen transport	Limited-resource provinces in Isan and northwest Thailand	HbA1c	Rapid on-site HbA1c testing efficiently identified those poorly controlled. Elevated HbA1c changed primary care strategy, pulling together a rotating team of physicians, nurses, and a pharmacist who adjust therapy and check for albuminuria to prevent advancing disease, dialysis, and adverse outcomes.
Spaeth *Rural Remote Health* 2014	POC HbA1c screening and monitoring	Indigenous populations in remote Australia	HbA1c	We demonstrated POCT can improve timeliness and clinical follow-up in remote locations, while also reinforcing clinical and cultural effectiveness in assisting to improve diabetes management in Indigenous Australians.
Martin *Med J Aust* 2005 Shephard *Rural Remote Health* 2005	Managing diabetes along the rural Mallee Track — top 10 health problems	Building Health Communities, Victoria State, Australia	HbA1c	POC capillary HbA1c testing offers an accurate, practical, and community-friendly way of monitoring diabetes in rural and remote clinical settings. All community and health professional groups surveyed agreed that the POC model should be available to all rural people.
• Hemostasis and D-dimer				
Schober *Am J Emer Med*	Helicopter feasibility decision making	Amsterdam, Netherlands	PT and INR (i-Stat)	Coagulopathy in trauma (e.g., coagulation factor consumption) and non-trauma cases (e.g.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

2021				anticoagulant) demand PT/INR results which were proven feasible in helicopter EMS.
Beynon *SJTREM* 2015	Prehospital hemostasis monitoring	Heidelberg, Germany	PT, INR	Assessment of INR in prehospital emergency care provides valuable information on hemostatic parameters in patients.
Rumpf *Crit Care* 2006	Dx of PE in prehospital emergency setting	Maribor, Slovenia	D-dimer, $PetCO_2$	For PE confirmation, $PetCO_2$ had sensitivity 92.6%, NPV 94.2%, specificity 83%, and PPV 79.2%. Combined clinical probability and $PetCO_2$ may safely rule out PE in patients with suspected PE and positive D-dimer prehospital.
• Ultrasound Imaging				
Christenson *SJTREM* 2022	Home COPD POC intervention	Odense, Denmark	Ultrasound and blood analysis	Emergency medical technicians must show experience and safety in handling shortness of breath as well as POC diagnostics.
Ienghong *Prehosp Dis Med* 2022	Prehospital EMS for Srinagarind Hospital	Khon Kaen, Thailand	Handheld POC ultrasound	Performed on the lung (37.0%), inferior vena cava (30.8%), and cardiac cases (26.4%); 34.9% abnormal and 66 cases (39.1%) with diagnoses confirmed and an accuracy peak of 75.8%.
Dubecq *J Trauma Acute Care Surg* 2021	Triage, diagnosis, severity, Rx, and priority for surgery	French military austere combat settings	Ultrasound-Africa, the Middle East	Ultrasound is valuable for management of mass casualties by improving treatment and triage, especially when surgical resources are limited and can also correct a diagnosis or improve prehospital therapeutic choices.
Nadim *BMC Health Serv Res* 2021	Timely release of patients at the scene	Odense, Denmark	Ultrasound and blood analysis	Prehospital emergency medical technicians can perform UTZ and blood analysis in prehospital evaluation of patients with COPD. None released requested a secondary ambulance within the first 48 hours following intervention.
Schoeneck *West J Emer Med* 2021	Prehospital Dx of CHF, pulmonary edema	New Haven, Connecticut, USA	Portable thoracic ultrasound	Prehospital lung ultrasound B-lines may aid in identifying or excluding CHF as a cause of dyspnea and has reasonably sensitive and specific for the diagnosis of CHF and pulmonary edema.
Sabatino *J Ultrasound* 2020	Primary imaging modality	Sierra Leone, Africa	POC ultrasound	POC UTZ represents a powerful diagnostic tool in a low-income country to improve patient management. Training of non-physician health providers is doable to improve healthcare in resource-limited settings.
Bobbia *Anaesth Crit Care Pain Med* 2018	Dx in EDs and mobile intensive care stations	Nimes, France	Ultrasound	Almost 75% of EDs and nearly 1/3 of mobile intensive care stations are equipped with at least one UTZ device. Physicians trained remains insufficient. UTZ was used at least three times a day in 41% of EDs and 19% of mobile stations.
Chin *J Emer Med* 2013	Field Dx using UTZ	Houston, Texas, USA	Ultrasound	UTZ field diagnoses of pneumothorax, pericardial effusion, or cardiac standstill may directly impact patient resuscitation in the field.
• Toxicology				
Advance Health Medical Cooperative 2022	Mobile van testing and medical examination	Cebu City, Visayas, Philippines	Drug and chemistry tests	Provides mobile diagnostic clinic and testing services in the community for Cebu City and surrounding regions.
Soderqvist *Point of Care* 2018	Prehospital drug testing for mobile ICU patients	Tampere, Finland	Drugs of abuse	Oral fluid screening for illicit substances can be a valuable diagnostic tool in addition to the usual diagnostic methods in EMS patients with unconsciousness due to an unknown cause or intoxication.
Part 3. Clinical Problems				
• Infectious Diseases [See **Part 1** for COVID-19 strategies]				

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

Beeman *Afr J Emer Med* 2022	Patients seeking emergent injury care	Kingali, Rwanda	HIV	Emergency centers are important access points for HIV testing. In Rwanda, 1 in 8 with HIV are unaware of their infection, which impedes epidemic control. This could be addressed by increased testing.
Zadran *Diagnostics* 2022	Lifeline of diagnostic entry points	Central Vietnam	POCT for infectious diseases	Infectious disease testing should be improved and POC tests supplied near patients' homes and in primary care settings for the early detection of infected individuals and the mitigation of the spread of new COVID-19 variants and other highly infectious diseases, such as Monkeypox.
WHO *Guidelines on HIV Testing* July 2021	Decentralized, stand-alone, and self-testing	General	HIV	Community-based rapid HIV testing in both high- and low-prevalence settings closer to people's homes and self-testing can reduce transport costs and waiting times in central hospitals and thereby increase uptake.
Vallely *Welcome Open Research* 2019	POCT for sexually transmitted infections and immediate Rx	Rural health units in limited-resource Papua New Guinea	Antenatal POCT for STD	First randomized trial to evaluate the effectiveness, cost-effectiveness, acceptability, and health system requirements of POC STD testing and treatment to improve birth outcomes in high-burden settings by decreasing preterm and low weight births.
West K *J Emer Med Serv* 2007, 2004	Protecting prehospital providers	General	HIV	Recommendations for protection of prehospital providers and post-exposure testing.
			• Sepsis	
Metelmann *Anesthetist* 2018	Prehospital, emergency staff survey about high sepsis mortality	Greifswald, Germany	qSOFA (quick sequential organ failure assessment)	The majority selected "increased body temperature", "drop in blood pressure" and "altered breathing;" emergency doctors selected "altered mental status" more frequently than nurses and paramedics. All rated early fast sepsis treatment as important.
			• Stroke	
Ebinger *JAMA* 2021	Mobile stroke unit, on-board thrombolysis	Berlin, Germany	Mobile CT scanner and POCT	Dispatch of mobile stroke units, compared with conventional ambulances alone, was associated with lower global disability at three months.
Wendt *Stroke* 2015	Prehospital triage of stroke patients	Berlin, Germany	CT scanner with POCT laboratory on board	Triage of patients with cerebrovascular events to specialized hospitals with stroke units and capabilities for ischemic stroke and neurosurgery can be improved by stroke emergency mobile ambulances with POCT.
Ebinger *JAMA* 2014	Starting thrombolysis in an ambulance	STEMO Consortium, Berlin, Germany	CT scanner with POCT laboratory on board	Compared with usual care, ambulance-based CT scanner and POCT for Dx of ischemic stroke initiated thrombolysis decreasing time to Rx without an increase in adverse events.
Walter *Lancet Neurol* 2012	Mobile stroke unit to accelerate Dx/Rx	Homburg, Germany	CT scanner, POCT, and telemedicine	Only 2-5% of patients receive thrombolytic treatment due to delay reaching hospitals. The mobile unit substantially reduced median time from rescue call to Rx decision, solving the problem of the arrival too late at the ED.
			Part 4. Healthcare Access	
			• Community Paramedics	
Paramedics' new roles Examples	Paramedicine-augmented health delivery	Community sites	POCT is integral to the community paramedic programs	Paramedicine programs improve access to non-emergent health care in rural and remote communities by allowing paramedics and EM technicians to operate in expanded roles assisting with public health, primary care, and preventive services to underserved populations. Community paramedics can provide and connect patients to primary care services; complete post-hospital follow-up care; integrate local public health agencies, home health agencies, and health systems; educate and

 doi:10.20944/preprints202210.0446.v1

				promote wellness; and offer services not available elsewhere. POCT is a successful and valuable part of these paramedicine programs.
• Hospital at Home				
Hospital at Home concept Examples	Continuum care in residences	Home settings	POCT during in-person visits	Hospital-level care in the comfort of the patient's home when registered with a hospital. Caregivers visit daily supplemented by virtual visits. POCT is used during in-person visits. Blood for hospital laboratory testing may be dropped off at the laboratory by the caregiver after their in-person visit.
• Unmanned Aerial Systems (Drones)				
Investigator Application Reports 2015-2022 and Kost *Point of Care* 2017	POC delivery options	Remote settings	Test kits, nucleic acid diagnostics, specimens, blood products	Transporting specimens via small drones does not affect the accuracy of routine chemistry, hematology, and coagulation tests results. Drone-based medical delivery models offer an innovative approach to addressing longstanding issues of health care access and equity and are particularly relevant to COVID-19. Additionally, the use of an AED-equipped drone has the potential to reduce time to defibrillation in out-of-hospital cardiac arrest.

Abbreviations: AbT, antibody test; ACS, acute coronary syndrome; AED, automated external defibrillator; AHF, acute heart failure; AHS, Alberta Health Services; AMI, acute myocardial infarction; *APLM, Archives of Pathology and Laboratory Medicine;* BG, blood gases (pO_2, pCO_2, pH); BNP, blood natriuretic peptide (or NT-proBNP); Ca^{++}, ionized calcium, typically measured in whole blood; CCU, cardiac (coronary) care unit; CHF, congestive heart failure; CO, carbon monoxide; COPD, chronic obstructive pulmonary disease; COVID-19, Coronavirus infectious disease 2019; Cr, creatinine; CT, computerized tomography; cTn, cardiac troponin I (cTnI) or T (cTnT); Dx, diagnosis; *EHJACC, European Heart Journal - Acute Cardiovascular Care*; ED, emergency department; EMS, emergency medical services; ER, emergency room; FN, false negative; HC, healthcare; Hct, hematocrit; HEART, protocol comprising history, electrocardiogram, age, risk factors, and troponin; HF, heart failure; Hgb, hemoglobin; hs-cTn, high sensitivity cTn; ICU, intensive care unit; IHD, ischemic heart disease; INR, International Normalized Ratio; *JAMA, Journal of the American Medical Association*; *JCH, Journal of Cambodian Health*; *JIFCCLM, Journal of the International Federation of Clinical Chemistry and Laboratory Medicine*; LSI, life-saving interventions; NPV, negative predictive value; NSTEMI, non-ST-segment elevation myocardial infarction; *ODH, Omnia Digital Health*; PCI, percutaneous coronary intervention; PE, pulmonary embolism; $PetCO_2$, probability and end-tidal CO_2; POC, point-of-care; POCT, POC testing; PPV, positive predictive value; PT, prothrombin time; qSOFA, quick sequential (sepsis-related) organ failure assessment; RAgT, rapid antigen test; RT-PCR, reverse transcriptase-polymerase chain reaction; Rx, treatment; *SJTREM, Scandian Journal of Rescue, Trauma, and Emergency Medicine*; STEMO, stroke emergency mobile (unit); STI, sexually transmitted infections; SWOT, strengths, weaknesses, opportunities, and threats; SWN, small-world network; TAT, turnaround time; TCO_2, total carbon dioxide; VBG, venous blood gasses; WHO, World Health Organization; and WBA, whole-blood analyzer.

The Philippines lies in the "typhon alley" of the Pacific. In December 2021, the Visayas Islands, a group of seven large and hundreds of smaller islands situated among the Visayan, Samar, and Camotes Seas, were hit by the devastating Super Typhoon, Odette (Rai). **[139]** Odette caused a major disaster, loss of 410 lives, and over $1 billion USD in damage.

Every centimeter increase in ocean levels (from global warming) magnifies typhoon surges, flooding, and inundation **[138]**. Storm surges can cause more damage and loss of life than the high velocity winds encountered in a typhoon. Storm severity is increasing exponentially, and poor planning can adversely impact rescue, critical care, and medical outcomes **[138]**. Please see the personal encounter with a super typhoon, a narrative by coauthor, L.C.

Personal Account of Super Typhoon Yolanda by Co-author [L.C.]

I lived most of my childhood on Bantayan Island. I was 15 years old when Super Typhoon Yolanda (Haiyan) made landfall on November 8, 2013, and the eye of the typhoon swallowed my island. This Category 5 typhoon had maximum sustained winds of 268 kph with gusts up to 324 kph.

 doi:10.20944/preprints202210.0446.v1

Storm surges wiped out coastal areas where I lived. Winds and floods damaged utilities, infrastructure, transportation, and livelihoods. Fortunately, we evacuated before my family home was destroyed. My family survived. Severe road damage delayed disaster response and rescue.

We were ill prepared for this level of crisis. Power failed. Few had generators. Public knowledge of severe typhoons was lacking. People fought over relief goods and resources. Local Government Units became aware of the importance of disaster preparedness, coastal vulnerability, and adverse outcomes.

Lessons learned from Super Typhoon Yolanda allowed Bantayan Island to prepare urgently and avoid more crises. Then, Super Typhoon Odette (Rai) devastated Cebu Province in December 2021. Weather disasters occur more frequently now. We must creatively use new technologies to prepare for global warming and the perilous impact of typhoons.

Archipelagos will be increasingly vulnerable and perpetually at risk forcing populations to move from coastal areas and concentrate at higher density on the larger islands. We selected the Bantayan Archipelago, located in Cebu Province, Visayas, for detailed consideration of how to use POCT strategies to meet important current needs and improve resilience, while also preparing for an unpredictable future.

2. Materials and Methods

2.1. Definitions and Conventions

As originally defined and later codified in print by a clinician-laboratorian team **[140]**, point-of-care testing (POCT) is medical testing at or near the site of patient care. A diagnostic portal is the entry point where the patient self-tests or first seeks, obtains, or is administered diagnostic testing to rule in or rule out a medical condition and then as needed, expeditiously receives care from home to hospital **[8]**.

A small-world network (SWN) represents the integrated system of emergency medical services (EMS), rescue routes, healthcare sites, diagnostic resources, medical specialists, and telecommunications that, among other features, assure wellness for a community in the context of its local geography, topography, and culture **[141]**.

The physical SWN [i.e., SWN(p)] can be transformed into a time domain network, *SWN(t),* that anticipates the dynamics of responses and rescues, whether under normal conditions, emergencies, or major crises, such as typhoons.

We illustrate temporal transformations for the Bantayan Archipelago by plotting rescue time contours corresponding to ambulance transfers based on raw data collected from local experts and public health teams led by co-author S.T. directly overseeing the welfare of people in the archipelago.

A spatial care path is the optimized route the patient takes through the healthcare SWN to definitive care facilitated by POC screening, testing, and monitoring, which merge prevention and intervention to enhance public health and standards of care **[27-30,49,87]**.

Spatial care paths can be adapted for unusual topologies like those found in island communities. They may include home self-testing, mobile testing, and drone conveyances of equipment and specimens. Understanding how to design and analyze spatial care paths allows one to optimize placements of POCT at the starting portal and along the way to treatment.

2.2. Needs Assessment

We performed needs assessment [**142**] during several visits to healthcare facilities in the Bantayan Archipelago and other locales on mainland Cebu. We adapted well-established investigational methods for geospatial data collection conducted in other limited-resource countries **[49,58,106]**. We focused on Coronavirus infectious disease (COVID-19)

 doi:10.20944/preprints202210.0446.v1

testing, cardiac biomarkers, POCT, ambulance rescue, emergency medicine, critical care testing (e.g., blood gases, pH, electrolytes, and ionized calcium), clinical laboratories, and the organization of resources in the healthcare small-world network in anticipation of the adverse impact of global warming on vulnerable coastal areas and emergency services.

We investigated the special topographical and temporal characteristics of medical delivery systems within and between islands in the archipelago. We asked interviewees about the value of POCT and determined actual capabilities versus future demands. We collected data either directly during visits or in follow-up through telephone calls, respondent emails, and Zoom sessions with healthcare professionals in Cebu Province and Bantayan Archipelago.

Please see the **Supplement** for the actual needs assessment questionnaire (in English) used to structure data gathered during discussions with hospital directors and administrators, clinical chiefs, physicians, nurses, EMS personnel inclusive of land ambulance and sea ambulance operators, and laboratory technologists, as well as clinicians and academic advisors. Respondents and interviewees (total of 108) were, with few exceptions, fluent in English. All major healthcare sites responded to the survey. The response rate was 100%. The Supplement also documents time analysis of Palawan Island (**Figure S1**).

Briefly, topics in the questionnaire comprised a) facility overview and demographics, b) POCT, c) patient transport and critical care access, d) clinical laboratory, e) medical problem solving in the community, and e) summary of field observations. We collected global positioning system (GPS) coordinates to facilitate accurate mapping of healthcare resources to a nautical map with background longitude and latitude grid **[143]**.

From on-site interviews and follow-up, we collated demographic facts about each medical site or laboratory, such as the number of hospital beds, professional services, the status of critical care units, diagnostic test clusters, and the impact of patients diagnosed with COVID-19, acute myocardial infarction, and other critical medical conditions on emergency rooms and rescue services.

We worked with local officials and engineering staff to detail transportation links between outlying islands, Bantayan Island, and referral centers in Cebu City. We mapped minimum and maximum ambulance transfer times on land and sea. Experts identified key locations of ports, helipads, and airports. Secondary web sources for travel times occasionally were used to confirm transport time contours.

2.3. Data Aggregation and Follow-up Details

Needs assessment forms were left with medical and laboratory staff, EMS personnel, and administrators to complete after on-site visits and then scan and email to the research team headquarters at Cebu Technological University, Cebu City. Data were collated using spreadsheet software. Tables 2 and 3 below summarize details of the data we collected. Data also are illustrated visually in the figures ("visual logistics") below.

Team members initiated follow-up telephone, email, and Zoom contacts for clarification. High impact sites, including the District Hospital in Bantayan Town, were contacted by phone several times to fill in diagnostic testing details. The POCT Center for Teaching and Research (POCT•CTR) in the United States reviewed results.

2.4. Travel Time Contours in Small-World Networks

Disaster Risk Reduction and Management Office (DRRMO) leadership stated that ambulances travelled on main roads to avoid hazards potentially encountered on small connectors and short-cuts. DRRMO staff documented the shortest and longest intervals needed to load a patient at the scene onto an ambulance, transfer the patient to the District Hospital in Bantayan Town, and unload the patient at the emergency room.

Summed travel increments generated minimum and maximum time responses for the archipelago and its connections to Cebu City. Where areas of coverage were limited, distance and speed were used to fill in incremental times. DRRMO staff defined transport

 doi:10.20944/preprints202210.0446.v1

times for outlying islets in the archipelago and included time needed for port embarkation, sea ambulance transfer, port disembarkation, and land ambulance transfer.

2.5. Geospatial Analysis and Temporal Contour Mapping

We followed the techniques in Ferguson et al. **[32]** for geospatial analysis. We highlighted main ambulance routes on the nautical map of Bantayan Island and defined the primary EMS pathways. Next, we marked road points where rescue transit times were equivalent. Splines were fit to these points, then connected to form smooth temporal contours.

Transfer intervals were not linearly distributed across the highway geography because of ambulance passage through city zones, urban congestion, and topological features of the islands that cause predictable and unpredictable delays. Transport durations depend on ocean winds, weather conditions, and tides, as well as on the standby position of the sea ambulance at a distant island (Lipayran). Therefore, they are not proportional to nautical distance.

Maximum transfer times included allowance for unexpected but common delays, as expressed by ambulance drivers in the Bantayan DRRMO. We extended the process to outlying islands, where durations of minimum and maximum transfer times by sea ambulance were much longer than ground ambulance transfer on the main island and to Vicente Sotto Memorial Medical Center, a destination level three referral hospital and Heart Center in Cebu City.

The DRRMO Chiefs in the three municipalities of Bantayan Archipelago completed a separate questionnaire about the worst- and best-case ambulance transport times to Bantayan District Hospital. The questionnaire listed all barangays and islets with specific ambulance rescue time intervals to be filled in. The Chiefs were interviewed on-call to double check ambulance speeds and transport times. We used OpenStreetMap and GoogleMaps to confirm distances and conversions of nautical miles to kilometers.

The Chiefs indicated that ambulance speeds depended on urgency, patient welfare, and actual road traffic. Based on their completed questionnaire, the worst-case ambulance rescue speed was 40 km/hr, while the best-case speed was 60 km/hr, on average. Completed questionnaires lacked data for some Santa Fe barangays where basic ambulance rescue speeds were applied.

The data were then illustrated with maps of Bantayan Archipelago that mark the road points in each barangay and port points on each islet with ambulance rescue times. The marked road and port points were interconnected with splines for equivalent time intervals. The splines covered the scope of the area for identical durations of rescue. Time intervals for each geographic contour then generated the temporal contours of ambulance rescue to the Bantayan District Hospital.

Sea ambulances capable of saving lives respond to local emergencies when stationed at Lipayran Island 16 km from the Bantayan port. Sea ambulance transit from Lipayran Island to Bantayan Port requires 18 minutes with an open water net speed of 53.3 km/h. Distress calls from islets far from the Bantayan mainland (e.g., Botigues, Doong, Mambacayao, Luyongbaybay, and Hilotongan Islands) require an additional 5-10 minutes. During rainy and windy days with ocean swells and other delays, island residents use their sandboats/pumpboats as alternative transportation. This generates the worst-case scenario with an added 30-45 minute delay.

For mainland Cebu, the Chief of the DRRMO in Bogo City provided details for ground ambulance rescue and travel time. The average ambulance speed reached 100km/hr with an additional 30-minute delay due to traffic and road conditions when passing through urban regions. The average of 100 km/hr plus a 30-minute delay for congestion was used as the basis for constructing temporal contours showing rescue times from the far northern and southern regions of Cebu Island.

A 15-minute delay was added to sites within and adjacent to Cebu City. We used OpenStreetMap and GoogleMaps for validation of distances. However, like the Bantayan

 doi:10.20944/preprints202210.0446.v1

Archipelago, temporal contours were created primarily from raw data obtained from expert local DRRMO staff.

2.6. Population and Respondent Demographics

One coauthor [S.T.] and her public health team on Bantayan Island projected current demographics for the barangays and islets of the Bantayan Archipelago from the most recent Philippines census. Population projections are posted online **[144]**. We used these data to identify numbers of people living on Bantayan Island, surrounding islands, and small islets farther out in the archipelago.

The categories and number of needs assessment respondents and interviewees comprised: Administrative Officer, 11; Administrative Head, 1; Bantayan Island Resident, 5; Chief/Head of DRRM/Rescue, 5; Company Chief Executive Officer, 1; Director/ Chief of Hospital, 4; DRRM/Rescue/EMS Officer 14; Emergency Medicine Department Head, 1; Engineer, 1; Ethics Head, 1; Head of Facility, 2; Head of Public Health, 1; Human Resource Officer, 1; Laboratory Assistant, 7; Land Ambulance Driver, 4 Lineman (assigned in Bantayan Islets), 1; Manager, 1; and Medical Laboratory Technologist, 16.

Further: Midwife and Birthing Care Staff, 3; Municipal Environment and Natural Resources Officer, 1; Municipal Health Officer, 5; Municipal Office Personnel, 1; Nurse, 3; Office Staff (CTU), 2; Operations Head, 1; Pathology Department Head, 1; POC Coordinator, 1; Public Health Nurse, 1; Pumpboat/ Sandboat Operator, 4; Radiology Technologists, 1; Sea Ambulance Operator, 2; State University College President, 1; University Researcher, 1; University Vice-President of Research and Development, 1; Van drivers, 2 — Total personnel, 108.

2.7. Ethics Approval

This research and the needs assessment questionnaire were reviewed and approved by the Cebu Technological University (CTU) Ethics Committee, which issued a certificate of exemption [No. 01-001-2022, 26 May 2022]. No patient records were accessed, no personal information was recorded, and no respondent sites were identified. Data were collected from May through October 2022.

3. Results

Results comprise geospatial analysis, diagnostic tests, time analysis, and spatial care paths. Tables summarize healthcare resources and diagnostic testing. A series of illustrations steps through EMS response times and spatial care paths for acute medical crises. We start by describing the medical geospatial lanscape of mainland Cebu and the Bantayan Archipelao to orient the reader to this region of the Visayas Islands.

3.1. Geospatial Analysis

Figure 1 shows Cebu Province in the Visayas island group of the Philippines (upper right inset) and the location of the Bantayan Archipelago to the northwest. Rapid rescue presents a fundamental problem for the archipelago, surrounding islands, and islets. In the southern tip of mainland Cebu, people often take a "shortcut," that is, a ferry to Negros, the island to the west, to expeditiously seek critical care in Dumaguete.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

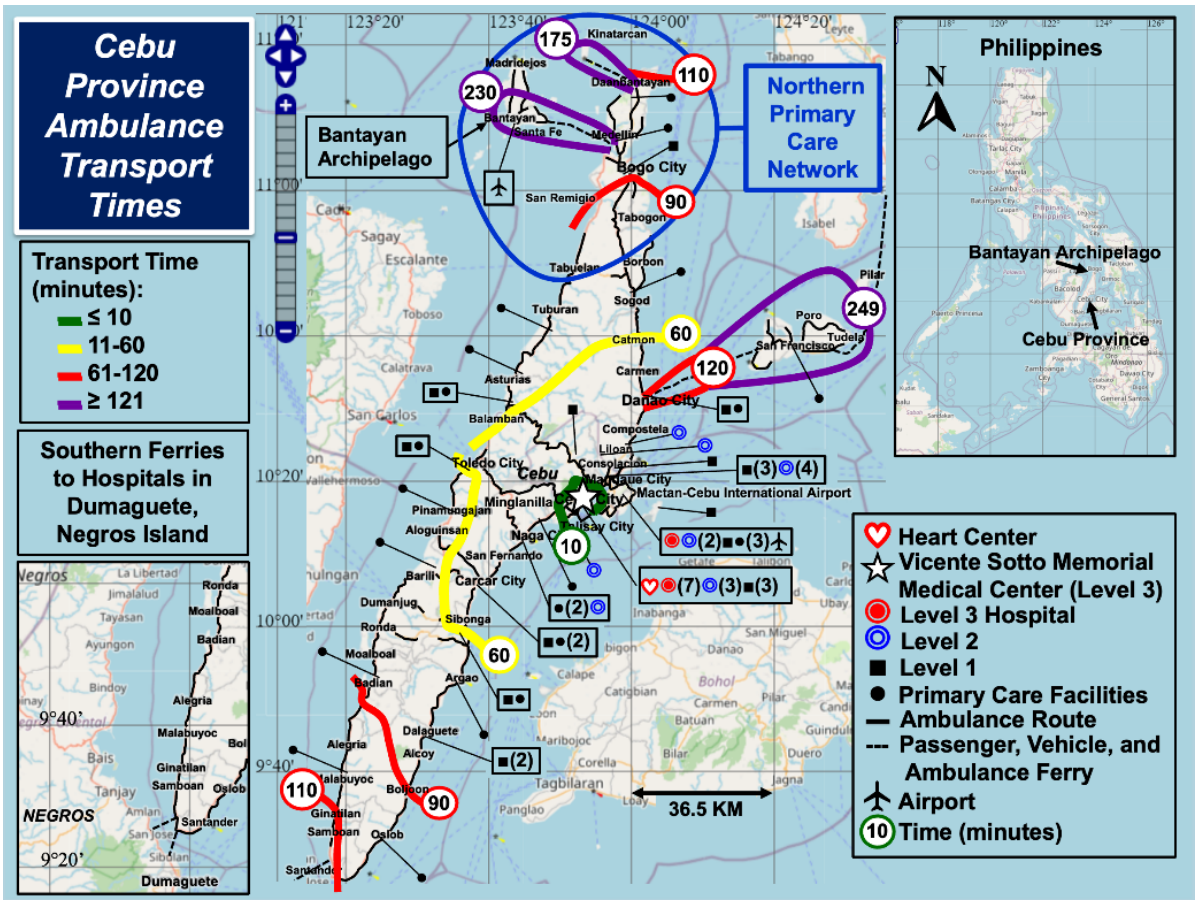

Figure 1. Cebu Province Ambulance Transport Time. Mainland Cebu is long and linear. The contours show ambulance transport times to Vicente Sotto Memorial Medical Center in Cebu City where healthcare facilities are concentrated. Bantayan Archipelago is situated within the northern primary care network. People use southern ferries to shortcut to hospitals in Negros Province. About 608 km (378 miles) to the west is Palawan Island (see **Figure S1**), another long linear island in the Visayas with similar healthcare delivery delays.

Narrow, windy, and landslide-prone mountainous roads prolong transport times on mainland Cebu. Challenges arise for emergency rescue and ambulance transfer from Bantayan Archipelago to tertiary care in Cebu City (Table 2). Rapid treatment of critical conditions like acute myocardial infarction may not be possible.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

Table 2. Ambulance Rescue in the Bantayan Archipelago.

Region or Site	Carriage	Service	Type	Vehicles/ Vessels	Geospatial Coverage	POCT Instruments
1. Municipality[a]						
Madridejos	Rescue vehicle	On-scene rescue, transport, and basic life support	NC	3	Northern Bantayan Island	Pulse Oximeter
Bantayan	Same as above	Same as above	NC	7[b]	Central	Pulse Oximeter
Santa Fe	Same as above	Same as above	NC	2	Southern	Pulse Oximeter
2. District Hospital						
	Ambulance	Patient transport, basic or advanced life support depending on staff availability	I, II planned	2	Bantayan Island	Pulse oximeter, Glucose meter
3. Outer Islands						
Bantayan Port	Sea ambulance[c] (outboard motor)	Basic life support, patient transport	NC	1 + 1 more planned[d]	Primarily southwest islands in the archipelago	Pulse Oximeter
Both ports	Sand Boat (very slow)	Back-up for rough weather	NC	(used as needed)	Both regions	None
Santa Fe Port	Sea ambulance (outboard motor)	Basic life support, patient transport	NC	1	Sea areas east of Bantayan Island (rarely private islands)	Pulse Oximeter
4. Potential Future Resources						
Helipads located at or near the District Hospital and on Doong Island	Helicopter – Air ambulance	From outer islands to District Hospital and from the archipelago to Cebu City	-	2	Sites of crises, emergencies, disasters, and epidemic outbreaks	Potential for onboard Dx, Rx, and live telehealth guidance
Air ambulance at the airport located near Santa Fe	Fixed wing aircraft &/or sea plane - Air ambulance	Point-to-point critical in-flight support and fastest means of patient transport	-	1	From Bantayan Island to Cebu City or Manila based on diagnosis and therapeutic needs	Potential for diagnostics-guided therapy in flight

Abbreviations: DOH, Department of Health; DRRMO, Disaster Risk Reduction and Management Office; Dx, diagnosis; NA, not available; NC, not yet classified by the DOH as either type I (basic life support) or type II (advanced life support); POCT, point-of-care testing; and Rx, treatment.

Footnotes: a) Each municipality operates a DRRMO that provides emergency assistance for the community. b) The Bantayan local government unit operates two vehicles for patient transport (e.g., appointments) and two for transport to cities on mainland Cebu (Bogo, Danao, or Cebu City); three vehicles operated by the DRRMO respond to on-scene emergency calls, but also provide patient transport within the municipality. The type of patient support depends on staff availability and basic (most personnel) or advanced life support training. c) The sea ambulance operates under the jurisdiction of DRRMO services. d) An additional sea ambulance will be acquired for navigating low tides. In low tides, the port of call changes to a sandbar southwesterly from Bantayan Island where a new dock will be built on the southern shoreline of Barangay Sulangan.

Interventional cardiac care is limited to a few hospitals in Cebu City approximately 140 km to southeast of Bantayan Town. The ferry from Bantayan Island to mainland Cebu is slow (90 minutes). Helicopter and fixed wing airplane transport are not generally available to the public but may be for the privileged few wealthy enough to pay high fees.

Testing on board ambulances generally is limited to pulse oximeters that measure oxygen saturation continuously and glucose meters that measure discrete capillary glucose levels, but test strips may not available. Therefore, prehospital diagnosis using POC technologies is extremely limited and unreliable.

Testing for COVID-19 must wait until patients arrive at a larger healthcare site, such as a rural health unit that performs a rapid antigen test (RAgT) useful mainly when

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

prevalence is low and the district hospital, which offers RAgTs and RT-PCR assays, the latter capable of both ruling in and ruling out SARS-CoV-2 infection at higher prevalence **[8]**.

3.2. Diagnostic Tests

Table 3 documents diagnostic tests and instruments **[145-147]** available at healthcare facilities in the Bantayan Archipelago. **Figure 2** shows healthcare facility locations. Most diagnostic testing is basic, except for the use in Rural Health Units of the GeneXpert **[148]** for the molecular detection of tuberculosis, a grass roots program promoted by the government of the Philippines to mitigate local contagion. Barangay Health Stations provide primary care, but in about half, needed diagnostics like glucose meters lack test strips and cannot be used (see **Table 3**).

Table 3. Diagnostic Testing Performed at Healthcare Sites in the Bantayan Archipelago.

Healthcare Site (N), Goal, and Hours	Diagnostic Tests			
	Hematology	**Chemistry**	**Microbiology**	**Notes and Exceptions**
Barangay Health Stations (49). Preventative care. (No beds.) M-F 8-5 and on call Saturday/Sunday.	None	Glucose meter (operable when test strips are available), O_2 saturation (pulse oximeter)	None	•27 (55.1%) Barangay Health Stations have glucose test strips. •22 (44.9%) without strips cannot use meters.
Birthing Homes (3). Midwives assist deliveries. Open 24/7.	None	Pulse oximeter, glucose meter, pregnancy test	None	•Prenatal screening is performed in Rural Health Units.
Rural Health Units (3). Preventative and primary care. M-F 8-5 and on call Saturday/ Sunday.	CBC, Hct, platelet count, blood typing (A, B, O, Rh)	O_2 saturation (pulse oximetry), FBS/RBS, SGOT, SGPT, uric acid, Chol, Cr, BUN, UA, lipid panel, pregnancy test (urine beta-HCG)	COVID-19 RAgT, HIV, TB (GeneXpert), Dengue (NS1), stool exam (gross, bacteria, parasites, ova), syphilis, HBsAg	•Prenatal screening comprises CBC, FBS, HBsAg, and UA. •Lipid panel — total cholesterol, triglycerides, HDL, and LDL. •No blood gas testing. • UTZ — availability depends on radiologists.
District Hospital (1). ER, labor and delivery, limited surgery (e.g., C-section); local referral hospital with limited specialty services. 25 beds with reserve capacity to 55. M-Sat 8-5, on call evenings, Sunday.	CBC, Hct, platelet count, HgbA1c, blood typing	Electrolytes[a] (Ca^{++}, K^+, Na^+, Cl^-), Glu, FBS, OGTT, ALT, AST, uric acid, Chol, lipid panel, Cr, BUN, UA, pregnancy test. Glucose meters and pulse oximeters in the ER.	COVID-19 RAgT, RT-PCR. HIV, *Dengue* (duo rapid test), *Salmonella typhi* (rapid test), stool exam, FOB, syphilis, HBsAg, HCV screening test	•Qualitative cTnI testing[b] is performed in lab only when reagents are available. [No cTnT.] •Blood gas testing (pO_2, pCO_2, pH) not available. • Genrui[c] instrument for cTnI, NT-proBNP, CK-MB, and myoglobin testing not used – no reagents.
Private Laboratory				
Oasis. Referral lab and limited diagnostic care. M-Sat 7-6. Closed Sundays.	CBC and blood typing on site	Pregnancy test (serum) and UA on site	Syphilis and stool exam on site	•UTZ for pregnancy. •Branch lab outsources other tests to main lab in Bogo, Cebu Province.

Abbreviations: 24/7, service all days/hours; ALT, alanine transaminase (SGPT, serum glutamic pyruvic transaminase); AST, aspartate transaminase (SGOT, serum glutamic oxaloacetic transaminase); BUN, blood urea nitrogen; CBC, complete blood count; Chol, cholesterol; CK-MB, creatine kinase MB isoenzyme; COVID-19, Coronavirus infectious disease 2019; Cr, creatinine; cTnI/T, cardiac troponin I /T; ER, emergency room; FBS, fasting blood sugar; FOB, fecal occult blood; HBsAg, hepatitis B surface antigen; HgbA1c, hemoglobin A1C; HCG, human chorionic gonadotropin hormone; Hct, hematocrit; HDL, high density lipoprotein; HIV, human immunodeficiency virus; LDL, low density lipoprotein; Myo, myoglobin; NS1, Non-Structural Protein 1; NT-proBNP, NT-proB type brain natriuretic peptide; OGTT, oral glucose tolerance test; RAgT, rapid antigen test; RBS, random blood sugar; RT-PCR, reverse transcription polymerase chain reaction; TB, Tuberculosis; UA, urine analysis; and UTZ, ultrasound.
Footnote References: a) 145, b) 146, and c) 147.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

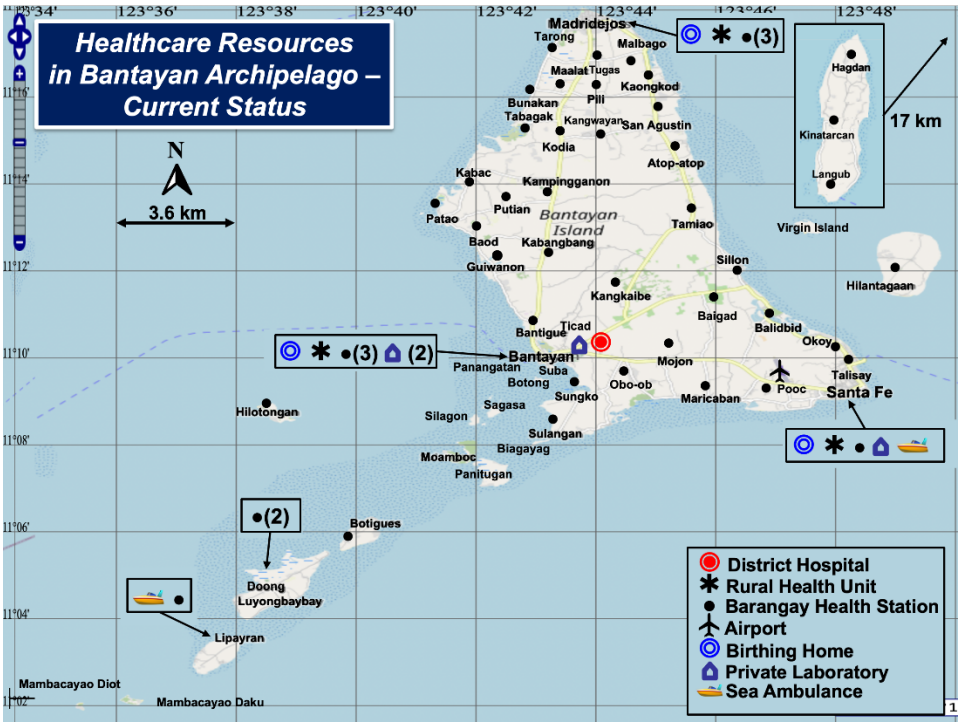

Figure 2. Healthcare Resources in Bantayan Archipelago — Current status This figure shows the distribution of healthcare resources in the small-world network of the Bantayan Archipelago. The District Hospital, a basic resource not categorized as to level, is the main referral site on Bantayan Island.

The district hospital in Bantayan has an active emergency room, which we inspected, and offers a broad laboratory test menu (see the middle column). Specimens referred there may sit idle because reagents are not available. Important tests, such as quantitative cardiac troponin I and T, brain natriuretic peptide (BNP, NT-proBNP), and other cardiac biomarkers cannot be performed. There is no whole-blood analyzer for measuring blood gases and pH on Bantayan Island.

Satellite private laboratories vary in service delivery. They mainly perform chemistry tests and at times refer specimens to Bogo City to the east on the Cebu mainland with turnaround times up to days. In addition to diagnostics, sea ambulances are equipped with an ambulance stretcher, an AED (automated external defibrillator), suction machine, nebulizer, aneroid sphygmomanometer, stethoscope, oxygen cylinder, and examining light.

3.3. Time Analysis

Rescue services are well organized (see **Table 2**). However, natural geography, topography, and inclement weather prolong sea and land transfers. **Figures 3** and **4** show minimum and maximum patient transport times with color-coded contours. During bad weather, tides interfere with sea ambulance transport. Rescue personnel use an alternate docking site toward the southwest of Bantayan Island (see **Figure 4**). Personnel must then carry the patient to a ground ambulance for safe travel.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

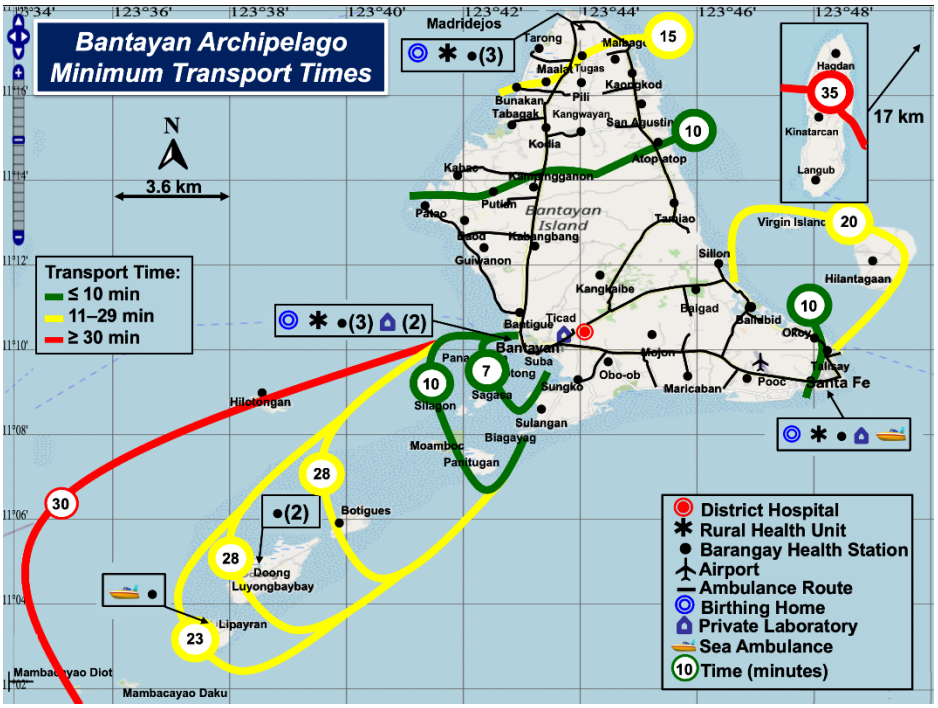

Figure 3. Bantayan Archipelago Minimum Transport Times The contours represent the best-case ambulance transfer times on land and sea. They become progressively longer radiating out from the District Hospital. Time intervals were determined from raw data provided by sea and land ambulance operators.

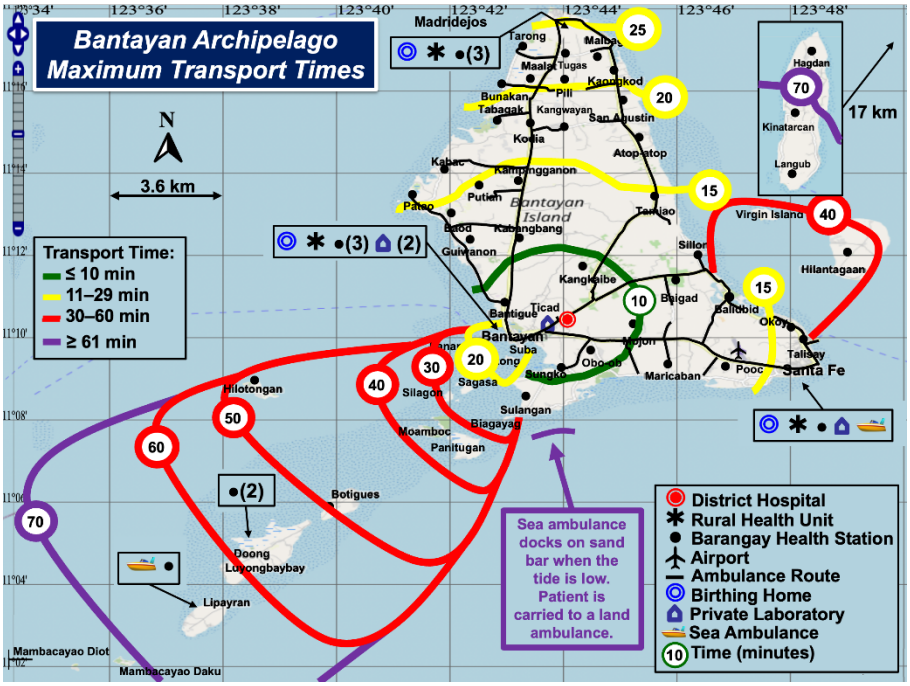

Figure 4. Bantayan Archipelago Maximum Transport Times In contrast to **Figure 3**, the contours here are maximum transport times. In low tides, the port of call changes to a sandbar southwest from Bantayan Island where a new dock will be built on the southern shoreline of Barangay Sulangan. Meanwhile, patients must be hand ported from the sea ambulance to the land ambulance waiting on shore.

3.4. Spatial Care Paths

3.4.1. Acute Myocardial Infarction

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

Spatial care path analysis for patients who reside on the southwest islands and islets of the Bantayan Archipelago and have acute chest pain revealed a serious problem (**Figure 5**). Suppose an elevated cardiac troponin T or I is documented rapidly by sea ambulance operators and their crew. Telehealth ECG monitoring by a cardiologist who is actively communicating during the transfer could allow the ambulance to bypass local health facilities en route to fixed wing aircraft that transports the patient to Cebu City. However, the minimum total transport time (95 min) to Vicente Sotto Memorial Medical Center, a Level 3 hospital in Cebu City is excessive.

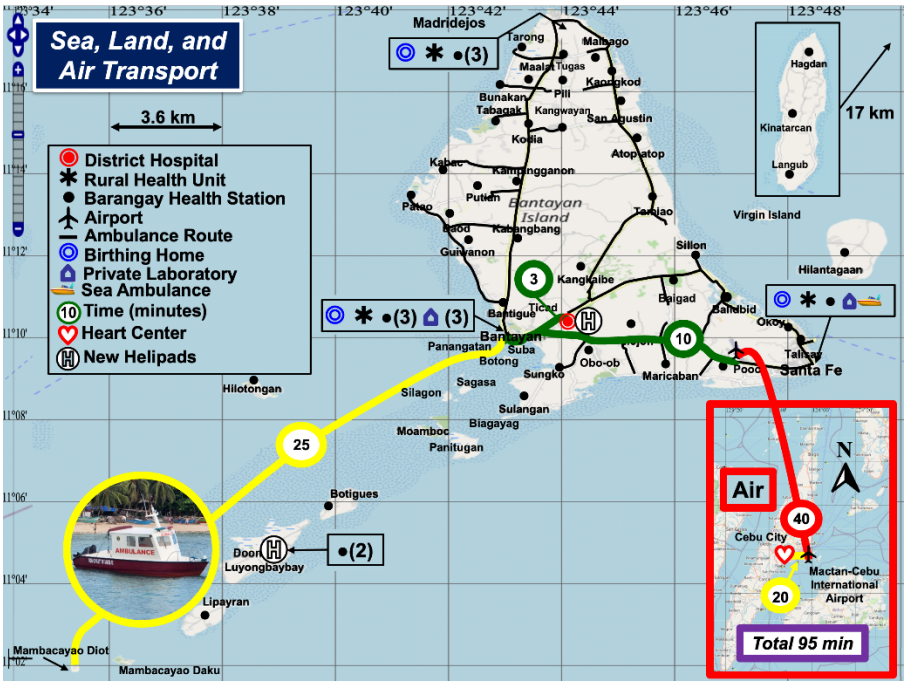

Figure 5. Spatial Care Paths for Acute Myocardial Infarction ***Spatial Care Path Analysis:*** A patient with acute myocardial infarction must endure four time-consuming transport legs: a) sea ambulance (the diagnostic portal) from the islet to the port in Bantayan Town (yellow), b) land ambulance from the port to the airport (green), c) fixed wing air transport to the Cebu-Mactan International Airport (red), and d) land ambulance to Vicente Sotto Memorial Medical Center in Cebu City (yellow), where interventional cardiologists are available. The total transit time is 95 minutes (purple box). ***Optimized Spatial Care Path:*** If the spatial care path connects directly to the District Hospital via the green spline leading to it from the port, transit time would be <30 minutes, a potentially life-saving redirection, providing the district hospital is upgraded with cardiologists who can intervene.

For an expeditious transfer of 28 min (25 min by sea, 3 min on land), which might be lifesaving, the spatial care path could be redirected to the Bantayan District Hospital via the short green connector from the port in **Figure 5**. Elevated cardiac troponin I or T on the sea ambulance would alert the catheterization team to prepare, further improving efficiency, increasing chances of survival, and elevating the local standard of care. Interventional care by a cardiologist would require a significant upgrade of specialists and supporting personnel, facilities, and equipment at the District Hospital.

Another option would be to transport the patient directly to a Heart Center in Cebu City by helicopter (**Figure 6**). A nurse could perform critical care testing onboard the helicopter. Unfortunately, there is no helicopter service available, and inclement weather conditions would ground the helicopter as well as the fixed wing aircraft (see **Figure 5**). Hence, the most reliable solution is to upgrade the District Hospital for interventional care by a cardiologist. Then, the spatial care path would be optimized.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

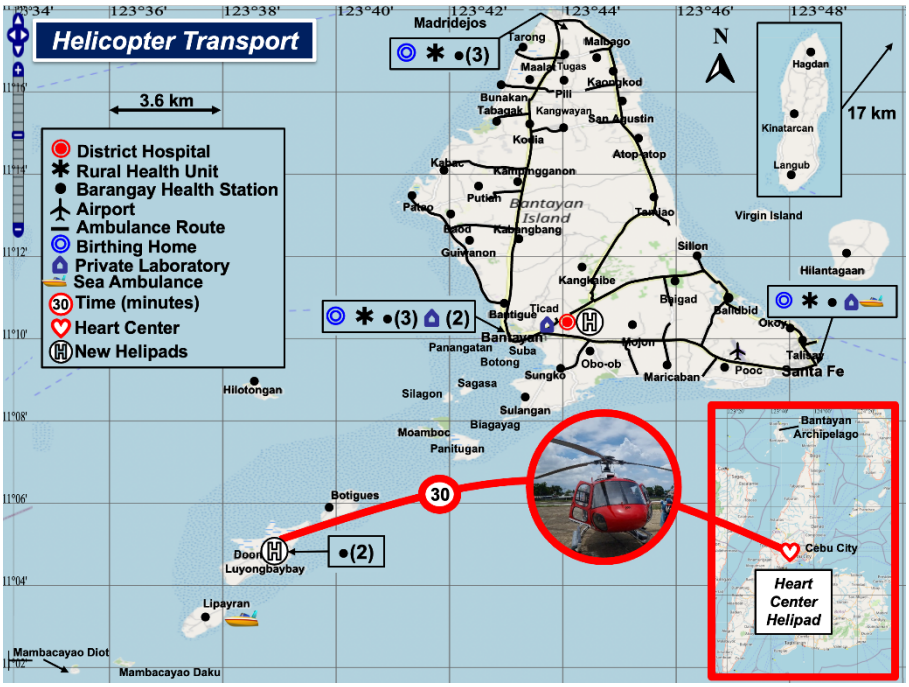

Figure 6. Helicopter Rescue Helicopters and helipads are not currently available. However, direct helicopter transport could decrease the transport time from archipelago islands to Heart Centers in Cebu City to 35 minutes. Two recommended sites for island helipads are shown in the figure.

3.4.2. Hypo-/Hyperglycemia, Diabetes Screening, and Therapeutic Monitoring

Sea and land ambulances in the Bantayan Archipelago are equipped with glucose meters. Although most glucose meters are not capable of producing accurate quantitative results when glucose is very low or high **[149-151]**, ambulance operators may discover acute hypo- and hyperglycemia during the first encounter with the patient and quickly establish a spatial care path to the nearest emergency room where admission testing can quantitate the exact degree of glucose abnormality. If comatose, the patient will require rapid evaluation and possibly administration of 50 mL of 50% dextrose.

We could not find HbA1c testing in Barangay Health Stations or Rural Health Units for diabetes screening and therapeutic monitoring. However, the Municipality of Bantayan will purchase a HbA1c instrument before the end of the year. Below we suggest mobile HbA1c testing on vans that rotate to sites near patient homes, Barangay Health Stations, and workplaces. In effect, mobile testing can be moved up the spatial care path nearer the patient, which would avoid downstream delays transporting specimens and receiving results, not to mention time and expense away from productive work to travel to distant testing sites.

3.4.3. COVID-19, Monkeypox, and other Infectious Diseases

Community access to COVID-19 testing was limited with no self-testing or saliva testing programs in place. RAgTs were not performed on ambulances (see **Table 2**) to help protect rescue personnel and warn destination emergency room staff. Rarely, people who could get kits tested at home, but there was no government distribution program.

Barangay Health Stations lacked COVID-19 testing. Rural Health Units offered COVID-19 RAgTs. The District Hospital laboratory performs RT- PCR testing (see **Table 3**). Travel time to the district hospital from outlying islands (see **Figure 4**) for confirmation of RAgT results is quite prolonged.

Spatial care paths start at discrete sites where people first find diagnostic portals. With a pattern of limited COVID-19 testing, delays in submitting swab and other types of specimens and receiving results can spread contagion. Analysis suggests that testing

 doi:10.20944/preprints202210.0446.v1

could be moved out into the community. Even children are capable of reliable self-testing **[152,153]**.

Figure S2 (in the Supplement) compares the performance patterns of COVID-19 testing conducted in homes, communities, and emergency rooms. It illustrates the dependence of false negatives on increases in prevalence **[8]**. Community testing with Tier 2 (sensitivity ≥ 95%, specificity ≥97.5%) RAgTs performs reasonably well **[11-13]** at the detectable low community prevalence apparently in effect.

Mobile testing on vans **[7]** that rotate throughout the community could improve access to COVID-19 testing (**Table S1**). A spatially flexible strategy can also ensure accessible testing for other infectious diseases, such as Monkeypox, HIV, Dengue, and Influenza A and B. Another option would be to position test kit vending machines near municipal halls in the community **[16]**. We illustrate these exciting point-of-need options below.

3.4.4. Tuberculosis Peripheral Care — In Progress

The United States Agency for International Development (USAID) and the Bantayan Public Health team (led by S.T.) launched a pilot program that benefits the at-risk, geographically isolated, and disadvantaged population on Bantayan and other islands. This POC initiative is part of the "introducing New Tools Project (iNTP)" being rolled out in nine high TB burden countries, including Cambodia, Vietnam, and the Philippines in Southeast Asia **[154]**.

Technology for POCT funded by the USAID comprises a) the Fuji X Air Ultraportable Chest X-ray (UP CXR), a battery-operated, lightweight, and ultra-portable unit with low radiation exposure and artificial intelligence-aided detection; b) the TrueNAT machine, a portable battery-operated device for detection of Mycobacterium tuberculosis complex bacteria (MTBC) and rifampicin resistance within an hour; and c) patient home self-video monitored to assure medication compliance **[155,156]**.

This molecular diagnostic instrument is cost-effective with low equipment and test costs. It requires minimal biosafety requirements and is intended for the peripheral level, that is, community health facilities or mobile clinics. See reference **156** for the implementation guide. It uses the first World Health Organization-recommended rapid molecular test for TB detection and rifampicin resistance. At the time of writing, this pilot program has already discovered ~9% infected with TB out of 432 patients screened in the Municipality of Bantayan.

4. Discussion

Global warming threatens island nations. Rising oceans significantly impact the Bantayan Archipelago (**Figure 7**), other island groups in the Philippines, and island nations such as Maldives, the islands of which have a maximum ground level height of only 2.4 meters (7 feet, 10 inches). In Indonesia, the country already is inventorying its 17,508 islands (6,000 inhabited) **[157]** because some have begun to disappear.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

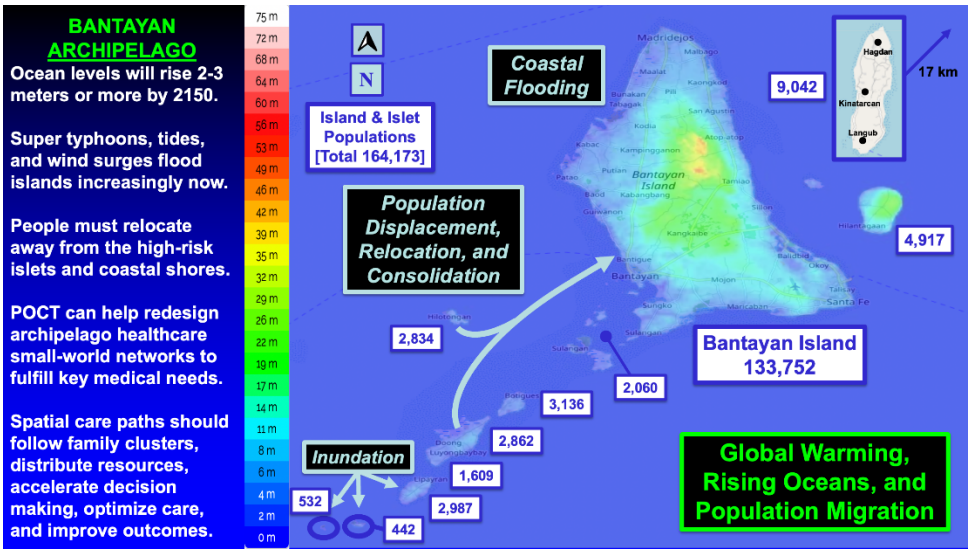

Figure 7. Global Warming, Rising Oceans, and Population Migration Global warming, rising oceans, and population migration demand changes in the way healthcare services, especially during emergencies, are delivered. Prehospital testing represents an adaptive means for rapid decision making and treatment at points of need, as illustrated in the next figure.

Ocean levels will continue to increase unless global stewardship tames carbon dioxide emissions. In view of the track record of carbon dioxide accumulation, reversal or even significant abatement of warming trends seems unlikely. Progressively stronger and more frequent super typhoons in the Pacific portend increased isolation and give real urgency to the widespread deployment of POC strategies to create autonomy in island settings.

Currently, access to diagnostic testing remains problematic, particularly for people distant from metropolitan tertiary care. In the coming decades, the Philippines can benefit from significant improvements in point-of-care inventions and innovations. Using a province-wide approach to public health planning and healthcare funding that aims to distribute POC resources geographically should prove beneficial. Placing 80% of patient care episodes in the community would help relieve stressed emergency rooms, especially during outbreaks of COVID-19 or new threats.

Since the last major compilation of POC technologies for disaster, emergencies, and public health crises **[158]**, prehospital diagnostics have blossomed to vastly increase the efficiency and effectiveness of healthcare systems. Prehospital diagnosis produces positive impact on outcomes for several medical challenges (see **Table 1**) and can help optimize island healthcare by mobilizing diagnostic solutions where shared resources must be conserved. In the Bantayan Archipelago the benefits of POCT should accrue not only from more efficient medical care compared to the current state, but also from an improved safety net for tourism and other activities that promote local economies. Regional enhancements could help justify some of the costs of higher-level healthcare services.

While this paper represents the first to design POC strategies and spatial care paths for global warming, rising oceans, and super typhoons, other investigators emphasize the general need for POCT in island communities. For example, Fernando et al. **[159]** evaluated a rapid diagnostic test for the diagnosis of malaria when preventing reestablishment in Sri Lanka. Regarding geospatial analysis, Oviedo et al. **[160]** combined serological, antigen detection, and DNA data for *Plasmodium falciparum* to generate robust geospatial estimates of malaria transmission in Haiti with confident description of its spatial epidemiology.

In the same setting, Rogier et al. **[161]** showed rapid diagnostic tests for *Plasmodium falciparum* in clinical and community settings had sensitivity 86.3-96.0% with specificity 90.0-99.6% resulting in a significant, but limited number of positive tests. Although so far this year no cases of malaria have been documented in the Bantayan Archipelago, seventy-

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

four cases of Dengue fever have appeared, which supports our recommendation (see **Figure 8** below) for mobile Dengue testing (NS1, IgG, IgM) to minimize epidemiological dissemination and warn of potential hemorrhagic fever which may require hospitalization, hourly bedside hematocrit monitoring, and transfusion support.

Studying healthcare small-world networks of remote central Vietnam, Ventura et al. **[162]** concluded that public health should fund enhanced access to POC diagnostics for diabetes in the limited-resource region. Kost et al. **[49]** recommended early upstream POC cardiac troponin testing on spatial care paths to expedite transfers directly to hospitals capable of intervening, improve outcomes following coronary occlusion, enhance standards of care, and assure high-value evidence-based learning, since POC results nurture rapid decision making by young physicians. Nguyen et al. **[163]** recommended that POC coordinators manage bedside technologies, quality assurance, and independent accreditation. During interviews we encountered only one POC Coordinator at Vincente Sotto Memorial Medical Center, a level three referral hospital in Cebu City. None were available in the Bantayan Archipelago.

Working in sparsely populated Australia, Hengel et al. **[164]** found that, "…decentralized POC testing should be considered for communities in need, especially those that are undertested and socially vulnerable" and that, "…decentralized testing should be part of the core global response towards suppressing COVID-19." For clinical services in New Zealand where the guiding principles are to improve health access and medical outcomes, Herd and Musaad **[165]** concluded that POCT in the rural and remote settings of the island nation can be rewarding for clinicians and an "…important component of the health system to improve outcomes and reduce inequity…" now and in the future. Therefore, one can reasonably expect that the POC strategies illustrated in **Figure 8** and recommended in **Table 4** will improve outcomes and reduce inequities in medical care in the archipelagos of the Visayas Islands.

5. Conclusions and Recommendations

Figure 8 illustrates how prehospital POCT could be positioned in Bantayan Archipelago to a) meet demands discovered during needs assessment, b) distribute access to care where natural terrain and island locations slow rescue over the ocean, c) accommodate people in need of flexibility for increasingly inclement weather, and d) deal with infectious disease threats, such as COVID-19 and Monkeypox, which has begun to appear in the Philippines.

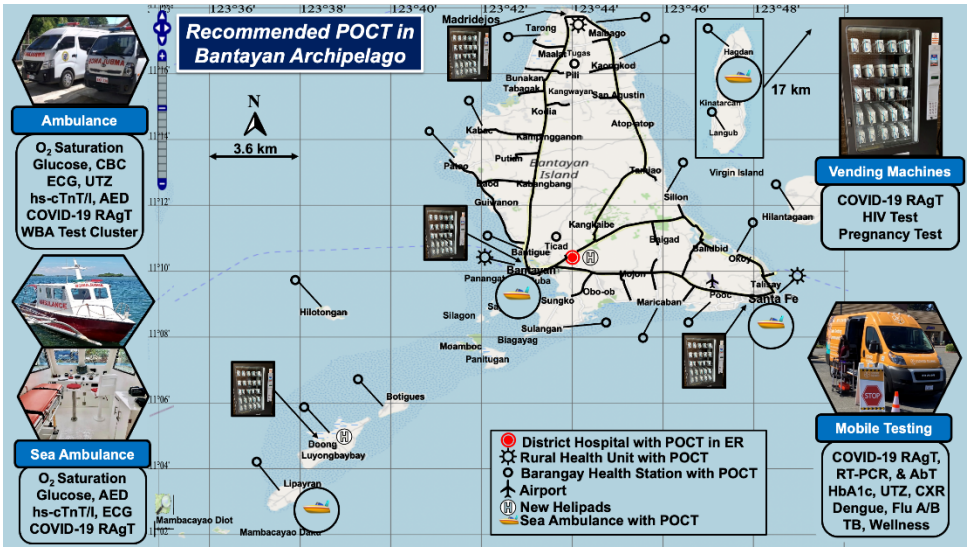

Figure 8. Proposed Sites of POCT in the Bantayan Archipelago The POC test clusters shown in the margins draw on evidence of efficacy documented in **Table 1** and include some, but not all of the

 doi:10.20944/preprints202210.0446.v1

prehospital tests recommended in **Table 4**. This figure also illustrates a recommendation for a third sea POCT-equipped ambulance stationed at the Bantayan Port. Please see the text for explanation of prehospital diagnostics. Abbreviations: AED, automated external defibrillator; CBC, complete blood count; CXR, chest x-ray; ECG, electrocardiogram; Flu A/B, influenza A/B; HbA1c, hemoglobin A1c; HIV, human immunodeficiency virus; hs-cTn T/I, cardiac biomarkers troponin T or I; RAgT, rapid antigen test; RT-PCR, reverse transcriptase polymerase chain reaction; TB, tuberculosis; UTZ, ultrasound; and WBA, whole-blood analyzer.

Figure 8 strategizes prehospital COVID-19 testing to mitigate spread **[159,160]**. Recent evidence shows that >50% of adults with recent Omicron variant infection were unaware of their infectious status **[161]**. A new National Institutes of Health initiative will fund $300 million to improve COVID-19 POC test performance, enhance access to testing, and obviate the need for serial testing to decrease false negatives **[162]**. Improved access to testing may alleviate confounding problems, such as recently increased antibiotic resistance that undermines antibiotic therapy **[163]**.

The current use of vending machines to distribute COVID-19 testing enjoys several advantages, including easy access, quick results, and safety — people seeking test kits do not expose others if the equipment is kept clean. People extract a test kit, test themselves or family, and obtain immediate results. That empowers them to care for each other, especially seniors who are still dying (hundreds per day in the United States) at disproportionate rates [**164**].

Table 4 presents our recommendations for prehospital POCT that will accelerate decision making, improve efficiency, and relieve emergency room overload. Each strategy is backed by evidence in **Table 1**, critical needs identified during our onsite field surveys, expert input from public health officials, and spatial care path analysis results in other limited-resource settings in Southeast Asia **[27-32,49,87]**.

Table 4. Recommended Patient-focused Point-of-care Diagnostics and Spatial Care Path Acceleration in the Bantayan Archipelago.

Medical Challenge	Diagnostics	Implementation Sites for Rapid Action	Enhanced Outcomes (based on the evidence in Table 1)
Acute abdomen	CBC, enzymes (ALT, AST, lipase), ECG, abdominal UTZ	Rural health unit triage diagnostics with progressive plan for district hospital support of transfer to tertiary care medical facility	Diagnose and stabilize patients with acute abdomen (e.g., appendicitis, pancreatitis,) before transferring to a tertiary medical facility
Acute myocardial infarction	POC qualitative or semi-quantitative cTnI/ cTnT	Ambulance, barangay health station, and rural health unit rule in of AMI	Fast TTAT, earlier triage, bypass time-consuming intermediate processing steps, appropriate and timely therapy (e.g., CABG, PCI), improve survival, and diminish mortality in rural versus urban environments (see **Figure 8** for a SCP example)
	Quantitative cTn, hs-cTnI or hs-cTnT	Rural health unit, district hospital, or heart center for rule-in and rule-out AMI with Rx in <60 min	
COVID-19	POC RAgT, self-testing, home LAMP tests (free)	Ubiquitous access - vending machine, mobile vehicle (ambulance, health van), barangay health station, rural health unit, pharmacy, more	Self-testing empowerment, early detection, family and workforce protection, outbreak mitigation, new public health paradigm, patient education, and precedents for the next pandemic
	RT-PCR	Rural health unit, district hospital	
	Viral load	Academic or reference laboratory	
Critical care interface	O_2 saturation (pulse oximetry), electrolytes, BG, Ca^{++}, and pH	Land and air ambulance	Pulmonary and cardiac support, decreased morbidity and mortality
		Rural health unit, emergency room	
Critical care transport	Glucose, lactate PT (INR), D-dimer	Prehospital transport and ambulance services	Risk stratification, spotting critical patients, triage to intensive care, hemostasis Rx, PE management

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2022 doi:10.20944/preprints202210.0446.v1

Prediabetes and diabetes diagnosis and therapeutic monitoring	HbA1c near homes every three months	Rotating POC HbA1c instruments in community sites during physician rapid Dx and Rx on site	Earlier Dx of prediabetes and diabetes, improved control of patients under Rx
	Critical care packages of POC tests (above)	Ambulances for immediate detection of hypoglycemia and hyperglycemia	Risk mitigation from onsite Dx of diabetic ketoacidosis, hyper-glycemic hyperosmotic coma, and other glucose hemostasis problems
"Hidden" problems	POC ultrasound	Sea, land, and air ambulances, primary care network, ER/EDs, and barangay health stations in the surrounding islets and islands	Numerous applications for triage, acute care, intubation, and orthopedics
Infectious diseases	POC STI (STD), Dengue, EVD, Monkeypox, and other rapid tests	All points of need depending on deadly outbreaks and community prevalence of sexually transmitted diseases (e.g., Monkeypox)	Rapid Dx, reduced opportunity costs, improved infant welfare, earlier start of isolation, and decreased time to Rx
Non-life-threatening acute conditions	O_2 saturation, electrolytes, glucose, BUN, Cr, BNP (or NT-proBNP), portable ECG	Paramedic outreach to the patient home, community center, and barangay health station	On site Dx, triage, and Rx of CHF and COPD exacerbations, dehydration, UTI, and other acute conditions in or near homes to spare EMS resources, avoid overload of ERs, and allow faster response for more pressing cases
Obstetric emergencies	CBC, glucose, ECG, pelvic UTZ, CTG	Coordinated strategy by barangay health station, rural health unit, and district hospital to supply fetal heart monitoring along with basic POC tests already available on site	Decrease infant and maternal mortality due to obstetric complications (e.g., prolonged labor, placenta previa, and uterine atony)
Sepsis and septic shock	Test clusters drawn from suitable instruments (e.g., Cobas h232, HemoCue, i-Stat, StatStrip, CoaguChek, or Pocket-chem)	Land ambulance for rescue with on scene victim evaluation by means of a kit of POCT handheld instruments	Change in conveyance decisions, reduced transport time, recognition of critical medical problems requiring admission and Rx, economic benefits, and enhanced survival, morbidity, and mortality
	Molecular diagnostics	District hospital rapid molecular detection of pathogens (handheld and portable molecular diagnostics)	
Snake bite	PT (INR), aPTT, Hct/ Hgb	Barangay health stations (depending on local prevalence of snake bites in the primary care network)	Rapid identification of coagulopathy, especially in children, and administration of antivenom
Stroke	CT scanner with POCT	Stroke ambulance	Rapid discovery of ischemic stroke, earlier administration of thrombolytics, transport directed to stroke centers without delay, improved outcomes
Transfusion support	POC Hct/Hgb, blood typing (A, B, O, and Rh)	Drone-facilitated delivery of blood products to outlying islands, transport of specimens for diagnostic tests	Fundamental life support where it is lacking due to isolation in emergency situations

Abbreviations: ALT, alanine transaminase (SGPT, serum glutamic-pyruvic transaminase); AMI, acute myocardial infarction; aPTT, activated partial thromboplastic time; AST, aspartate aminotransferase (SGOT, serum glutamic oxaloacetic transaminase); BG, blood gases (pO_2, pCO_2, pH); BNP, blood natriuretic peptide (or NT-proBNP); BUN, blood urea nitrogen; Ca^{++}, ionized calcium [must be measured with a (portable) blood gas or whole-blood analyzer]; CBC, complete blood count; CABG, coronary artery bypass graft; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; COVID-19, Coronavirus infectious disease 2019; Cr, creatinine; CTG, cardiotocography (continuous recording of the fetal heart rate obtained via an ultrasound transducer placed on the mother's abdomen); cTn, cardiac troponin I (cTnI) or T (cTnT); Dx, diagnosis; ECG, electrocardiogram; ED, emergency department; EMS, emergency medical services; ER, emergency room; EVD, Ebola virus disease; HbA1c, hemoglobin A1c; Hct, hematocrit; Hgb, hemoglobin; hs-cTn, high sensitivity cTn; INR, International Normalized Ratio; LAMP, loop-mediated isothermal isolation; PCI, percutaneous coronary intervention; PE, pulmonary embolism; POC, point-of-care; POCT, POC testing; PT, prothrombin time; RAgT, rapid antigen test; RT-PCR, reverse transcriptase-polymerase chain reaction; Rx, treatment; STI, sexually transmitted infection (STD, ST disease); UTZ, ultrasound; and WBA, whole-blood analyzer.

 doi:10.20944/preprints202210.0446.v1

We recommend acceleration of treatment for patients with acute myocardial infarction by using POC strategies. A study by Tideman et al. **[53]** showed prehospital ECG, POC cardiac troponin testing, and cardiologist guidance during transport decreased inequities in mortality rates, which were higher for people living in rural versus urban areas. Spatial care path analysis (see **Figures 5** and **6**) for acute myocardial infarction can be applied to other islands in the Visayas, such as Palawan Island (see **Figure S1**), which is highly linear and quite remote.

Public health officials can weigh the merits of targeted POCT for specific diseases by considering prevailing prevalence as people migrate to Bantayan Island. They can stage the implementation of rapid response testing and expedite decision making incrementally. Valuable evidence will become available for future healthcare planning by public health officials in other island communities and generally, in island nations.

Global warming, rising oceans, super typhoons, and preparedness for weather disasters call for long-term investment. We suggest documenting impact on morbidity and mortality to help prioritize funds toward fulfillment of immediate needs versus long-term investments. However, POCT can meet several needs identified in this research now. Timely mobility of diagnostics will help avoid future losses, alleviate geospatial disparities, and prepare island communities for more frequent and severe public health crises.

Author Contributions: G.K. designed the project with the assistance of A.F. and wrote this paper based on evidence and input from the co-author team. L.C. administrated the field survey, helped process raw data, and illustrated findings, except **Figure 7**, which was created by G.K. All co-authors participated in construction of the tables, except **Table 1**, which was collated by G.K. from published evidence. A.Y. helped administrate professional and collegial support for needs assessment field work.

Funding: This research was supported by the Point-of-Care Testing Center for Teaching and Research (POCT•CTR); by Dr. Kost, its Director; by a Fulbright Scholar Award (to G.K.); and by Cebu Technological University.

Institutional Review Board Statement: See Section 2.7.

Informed Consent Statement: No consents.

Data Availability Statement: The paper presents collated results. Raw data are available from the authors. The needs assessment questionnaire appears in the Supplement.

Acknowledgments: Cebu Technological University was the academic sponsor of the Fulbright Scholar Award, ASEAN Program 2020-2022 [to G.K.] that in part supported this research. Staff at the Vicente Sotto Memorial Medical Center contributed advice regarding heart centers, critical care, hospital organization, service levels, and patient transport. The DRRMO Engineer for sea and land ambulance services in Bantayan Town gathered especially valuable transit time and route raw data. Rapid Ambulance in Cebu City provided valuable input. The authors thank the creative students, research assistants, and foreign focus groups in Cambodia, the Philippines, Thailand, and Vietnam whose urgency of need inspired this project. Figures and tables are provided courtesy and permission of Knowledge Optimization, Davis, California.

Conflicts of Interest: There are no conflicts of interest to declare.

References

1. Baker T, Moore K, Lim J, Papanastasiou C, McCarthy S, Schreve F, et al. Rural emergency care facilities may be adapting to their context: A population-level study of resources and workforce. *Aust J Rural Health*. **2022,** *30(3),* 393-401.
2. Fuzery AK, Kost GJ. Point-of-care testing by ambulance teams: An opportunity for a new standard. *Clin Lab News*. **2021**, *47*, 6,8-13.
3. Fuzery AK, Kost GJ. Point-of-care testing practices, failure modes, and risk mitigation strategies in emergency medical services programs in the Canadian province of Alberta. *Arch Path Lab Med.* **2020**, *144*, 1352-1371.
4. Heaney K, Whiting K, Petley L, Fry I, Newton A. Point-of-care testing by paramedics using a portable laboratory: an evaluation. *J Paramed Pract*. **2020**, *12(3)*, 100-108.

5. Sanko S, Kashani S, Ito T, Guggenheim A, Fei S, Eckstein M. Advanced practice providers in the field: Implementation of the Los Angeles Fire Department Advanced Provider Response Unit. *Prehosp Emerg Care.* **2020** Sep-Oct, *24(5)*, 693-703.
6. Eng M, Kost GJ. Point-of-care testing, geospatial care paths, and standards of care for endemic Coronavirus Disease 2019 in rural provinces of Cambodia. *Journal of Cambodian Health.* **2022**, revision pending acceptance.
7. Eng M, Zadran A, Kost GJ. COVID-19 risk avoidance and management in limited-resource countries. Point-of-care strategies for Cambodia. *Omnia Digital Health.* **2021**, *6/7*, 112-115.
8. Kost GJ. The Coronavirus Disease 2019 spatial care path: Home, community, and emergency diagnostic portals. *Diagnostics.* **2022**, *12(1216)*, 1-16. https://doi.org/10.3390/diagnostics12051216
9. Kost GJ. The COVID-19 Grand Challenge: Setting expectations and future directions for community and home testing. *Archives of Pathology & Laboratory Medicine (APLM).* **2022**, *146*, 789-790.
10. Kost GJ. Home antigen test recall affects millions: Beware false positives, but also uncertainty and potential false negatives. *APLM*. **2021**, *146*, 403.
11. Kost GJ. Diagnostic strategies for endemic Coronavirus disease 2019 (COVID-19) — Rapid antigen tests, repeat testing, and prevalence boundaries. *APLM*. **2021**, *146*, 16-25.
12. Kost GJ. The impact of increasing disease prevalence, false omissions, and diagnostic uncertainty on Coronavirus disease 2019 (COVID-19) test performance. *APLM*. **2021**, *145*, 797-813.
13. Kost GJ. Designing and interpreting COVID-19 diagnostics: Mathematics, visual logistics, and low prevalence. *APLM*. **2021**, *145*, 291-307.
14. Kost GJ. Geospatial spread of antimicrobial resistance, bacterial and fungal threats to COVID-19 survival, and point-of-care solutions. *APLM.* **2021**, *145*, 145-167.
15. Kost GJ. Geospatial hotspots need point-of-care strategies to stop highly infectious outbreaks: Ebola and Coronavirus. *Arch Pathol Lab Med*. **2020**, *144*, 1166–1190. doi: 10.5858/arpa.2020-0172-RA.
16. Public Health Department, Yolo County, California. City of Davis. **2022**. https://cityofdavis.org/coronavirus [Accessed August 31, 2022.]
17. Centers for Disease Prevention and Control. ELC Enhancing Detection Expansion. Epidemiology and Laboratory Capacity for Prevention and Control of Emerging Infectious Diseases. Atlanta, GA: CDC, **2021**, 17 pages. https://www.cdc.gov/nce-zid/dpei/pdf/elc-enhancing-detection-expansion-faq-508.pdf [Accessed August 31, 2022.]
18. Baker DR, Cadet K, Mani S. COVID-19 testing and social determinants of health among disadvantaged Baltimore neighbor-hoods: A community mobile health clinic outreach model. *Popul Health Manag*. **2021**, *24(6)*, 657-663.
19. Fiscus L, Towns R, Wood S, Oliver P, Fox S, Weathers A, et al. Spotlight on the safety net: Deploying mobile COVID-19 testing programs in North Carolina as an approach to improving health equity. *N C Med J.* **2021**, *82(1)*, 80-82.
20. Frimpong M, Amoako YA, Anim KB, Ahor HS, Yeboah R, Arthur J, et al. Diagnostics for COVID-19: A case for field-deployable, rapid molecular tests for community surveillance. *Ghana Med J.* **2020**, *54(4 Suppl)*, 71-76.
21. Gulley T, Tyson T, Collins E, Helton R, Hill-Collins P, France N, et al. The Health Wagon Partners with the Virginia Department of Health to provide COVID-19 testing in rural Southwest Virginia. *J Appalach Health.* **2020**, *2(3)*, 146-149.
22. Jiménez J, Parra YJ, Murphy K, Chen AN, Cook A, Watkins J, et al. Community-informed mobile COVID-19 testing model to addressing health inequities. *J Public Health Manag Pract.* **2022**, *28(Suppl 1)*, S101-s10.
23. Lau CSM, Johns J, Merlene S, Kanya S, Taber A, Melander D, et al. Trends in COVID-19 testing and positivity rates from a mobile testing program in the Phoenix metropolitan area. *J Community Health*. **2021**, *46(6)*, 1221-5.
24. Lau CSM, Shu S, Mayer J, Towns M, Farris A, Washington F, et al. COVID-19 trends in the Phoenix metropolitan area from a mobile testing program: Last quarter of 2020. *J Community Health.* **2021**, *46(6)*, 1078-82.
25. Neely J, Eddins A, Lesure N, Dee D, Real R, Singer R, et al. Privacy, or the lack thereof, and its implications for dignity in mobile COVID-19 testing. *SAGE Open Nurs.* **2021**, *7*, 23779608211029096. doi: 10.1177/23779608211029096.
26. Vinjerui KH, Elgersma IH, Fretheim A. Increased COVID-19 testing rates following combined door-to-door and mobile testing facility campaigns in Oslo, Norway, a difference-in-difference analysis. *Int J Environ Res Public Health*. **2021**, *18(21)*. doi: 10.3390/ijerph182111078.
27. Kost GJ, Ferguson WJ. Spatial care paths strengthen links in the chain of global resilience: Disaster caches, prediabetes, Ebola Virus Disease, and the future of point of care. *Point of Care.* **2016**, *15*, 43-58.
28. Kost GJ, Ferguson WJ, Hoe J, Truong AT, Banpavichit A, Kongpila S. The Ebola Spatial Care Path™: Accelerating point-of-care diagnosis, decision making, and community resilience in outbreaks. *Am J Disaster Med*. **2015**, *10(2)*, 121-43. doi: 10.5055/ajdm.2015.0196.
29. Kost GJ, Ferguson WJ, Truong A-T, Prom D, Hoe J, Banpavichit A, et al. The Ebola Spatial Care Path: Point-of-care lessons learned for stopping outbreaks. *Clin. Lab. Int*. **2015**, *39*, 6–14.
30. Kost GJ, Ferguson WJ, Kost LE. Principles of point of care culture, the spatial care path, and enabling community and global resilience. *J Intl Fed Clin Chem Lab Med*. **2014**, *25*, 134-153.
31. Kost GJ. Geospatial science and point-of-care Testing: Creating solutions for population access, emergencies, outbreaks, and disasters. *Front Public Health*. **2019**, *7*, 329. doi: 10.3389/fpubh.2019.00329.
32. Ferguson WJ, Kemp K, Kost G. Using a geographic information system to enhance patient access to point-of-care diagnostics in a limited-resource setting. *Int J Health Geogr.* 2016 Mar 1;15:10. doi: 10.1186/s12942-016-0037-9.

33. Castro-Portillo E, López-Izquierdo R, Sanz-García A, Ortega GJ, Delgado-Benito JF, Castro Villamor MA, et al. Role of prehospital point-of-care N-terminal pro-brain natriuretic peptide in acute life-threatening cardiovascular disease. *Int J Cardiol*. **2022** Jun 16, *S0167-5273(22)*, 00923-8. doi: 10.1016/j.ijcard.2022.06.025.
34. Jones C, Lightowler B. The efficacy of the HEART score in prehospital settings. *J Paramed Pract*. **2022**, *14(5)*, 198-211.
35. Pavlovsky T, Obadia M, Ragot S, Douay B, Casalino E, Ghazali DA. Predictors of risk stratification and value of point-of-care of high-sensitivity cardiac troponin-I in EMS management of non-ST-segment elevation myocardial infarction: A retrospective study. *Prehosp Disaster Med.* **2022**, *37(3)*, 365-372.
36. Cooper JG, Ferguson J, Donaldson LA, Black KMM, Horrill JL, Davidson EM, et al. Could high-sensitivity cardiac troponin testing rule out acute myocardial infarction in the prehospital setting? *J Am Coll Cardiol*. **2021**, *78(23)*, 2392-2394.
37. Cooper JG, Ferguson J, Donaldson LA, Black KMM, Livock KJ, Horrill JL, et al. The ambulance cardiac chest pain evaluation in Scotland study (ACCESS): A prospective cohort study. *Ann Emerg Med*. **2021** Jun, *77(6)*, 575-588.
38. Koper LH, Frenk LDS, Meeder JG, van Osch FHM, Bruinen AL, Janssen MJW, et al. URGENT 1.5: diagnostic accuracy of the modified HEART score, with fingerstick point-of-care troponin testing, in ruling out acute coronary syndrome. *Neth Heart J.* **2022**, *30(7-8)*, 360-369.
39. Lee TH, Chen LC, Wang E, Wang CC, Lin YR, Chen WL. Development of an electrochemical immunosensor for detection of cardiac troponin I at the point-of-care. *Biosensors (Basel)*. **2021**, *11(7)*.
40. Martín-Rodríguez F, Sanz-García A, Castro-Portillo E, Delgado-Benito JF, Del Pozo Vegas C, Ortega Rabbione G, et al. Prehospital troponin as a predictor of early clinical deterioration. *Eur J Clin Invest.* **2021**, *51(11)*, e13591.
41. Stopyra JP, Snavely AC, Smith LM, Harris RD, Nelson RD, Winslow JE, et al. Prehospital use of a modified HEART pathway and point-of-care troponin to predict cardiovascular events. *PLoS ONE* **2020**, *15(10)*, e0239460.
42. Stopyra JP, Snavely AC, Scheidler JF, Smith LM, Nelson RD, Winslow JE, et al. Point-of-care troponin testing during ambulance transport to detect acute myocardial infarction. *Prehosp Emerg Care*. **2020**, *24(6)*, 751-759.
43. Alghamdi A, Alotaibi A, Alharbi M, Reynard C, Body R. Diagnostic performance of prehospital point-of-care troponin tests to rule out acute myocardial infarction: A systematic review. *Prehosp Disaster Med.* **2020**, *35(5)*, 567-573.
44. Alghmadi A, Body R. BET 1: Prehospital cardiac troponin testing to 'rule out' acute coronary syndromes using point of care assays. *Emerg Med J*. **2018** Sep, 35(9), 572-574.
45. Harjola P, Miró Ò, Martín-Sánchez FJ, Escalada X, Freund Y, Penaloza A, et al. Pre-hospital management protocols and perceived difficulty in diagnosing acute heart failure. *ESC Heart Fail.* **2020**, *7(1)*, 289-296.
46. Johannessen TR, Vallersnes OM, Halvorsen S, Larstorp ACK, Mdala I, Atar D. Pre-hospital one-hour troponin in a low-prevalence population of acute coronary syndrome: OUT-ACS study. *Open Heart*. **2020**, *7(2)*.
47. Kaier TE, Stengaard C, Marjot J, Sørensen JT, Alaour B, Stavropoulou-Tatla S, et al. Cardiac myosin-binding protein C to diagnose acute myocardial infarction in the pre-hospital setting. *J Am Heart Assoc*. **2019**, *8(15)*, e013152. doi: 10.1161/jaha.119.013152.
48. Alghamdi A, Body R. BET 1: Prehospital cardiac troponin testing to 'rule out' acute coronary syndromes using point of care assays. *Emerg Med J*. **2018**, 35(9), 572-574.
49. Kost GJ, Zadran A, Duong TTB, Pham TT, Ho AVD, Nguyen NV, et al. Point-of-care diagnosis of acute myocardial infarction in Central Vietnam: International exchange, needs assessment, and spatial care paths. *Point of Care.* **2018**, *17(3)*, 73-92.
50. Rasmussen MB, Stengaard C, Sørensen JT, Riddervold IS, Hansen TM, Giebner M, et al. Predictive value of routine point-of-care cardiac troponin T measurement for prehospital diagnosis and risk-stratification in patients with suspected acute myocardial infarction. *Eur Heart J Acute Cardiovasc Care.* **2019**, *8(4)*, 299-308.
51. Stengaard C, Sørensen JT, Ladefoged SA, Lassen JF, Rasmussen MB, Pedersen CK, et al. The potential of optimizing prehospital triage of patients with suspected acute myocardial infarction using high-sensitivity cardiac troponin T and copeptin. *Biomarkers*. **2017**, *22(3-4)*, 351-360.
52. Ezekowitz JA, Welsh RC, Weiss D, Chan M, Keeble W, Khadour F, et al. Providing rapid out of hospital acute cardiovascular treatment 4 (PROACT-4). *J Am Heart Assoc.* **2015**, *4(12)*, 1-9.
53. Tideman PA, Tirimacco R, Senior DP, Setchell JJ, Huynh LT, Tavella R. Impact of a regionalised clinical cardiac support network on mortality among rural patients with myocardial infarction. *Med J Aust.* **2014** Feb *17;200(3)*, 157-160.
54. Stengaard C, Thorsted Sørensen J, Terkelsen CJ. Prehospital point of care testing of biomarkers has diagnostic value in relation to acute myocardial infarction. *Ugeskr Laeger*. **2013**, *175(4)*, 186-189.
55. Venturini JM, Stake CE, Cichon ME. Prehospital point-of-care testing for troponin: are the results reliable? *Prehosp Emerg Care.* **2013**, *17(1)*, 88-91.
56. Prosen G, Klemen P, Štrnad M, Grmec S. Combination of lung ultrasound (a comet-tail sign) and N-terminal pro-brain natriuretic peptide in differentiating acute heart failure from chronic obstructive pulmonary disease and asthma as cause of acute dyspnea in prehospital emergency setting. *Crit Care*. **2011**, *15(2)*, R114.
57. Sørensen JT, Terkelsen CJ, Steengaard C, Lassen JF, Trautner S, Christensen EF, et al. Prehospital troponin T testing in the diagnosis and triage of patients with suspected acute myocardial infarction. *Am J Cardiol*. **2011**, *107(10)*, 1436-1440.
58. Kost GJ, Kost LE, Suwanyangyuen A, Cheema SK, Curtis C, Sumner S, et al. Emergency cardiac biomarkers and point-of-care testing: Optimizing acute coronary syndrome care using small-world networks in rural settings. *Point of Care*. **2010**, *9*, 53-64.
59. Di Serio F, Lovero R, Leone M, De Sario R, Ruggieri V, Varraso L, et al. Integration between the tele-cardiology unit and the central laboratory: methodological and clinical evaluation of point-of-care testing cardiac marker in the ambulance. *Clin Chem Lab Med*. **2006**, *44(6)*, 768-773.

60. Owens CG, McClelland AJ, Walsh SJ, Smith BA, Tomlin A, Riddell JW, et al. Prehospital 80-LAD mapping: does it add significantly to the diagnosis of acute coronary syndromes? *J Electrocardiol*. **2004**, *37 Suppl*, 223-232.
61. Schuchert A, Hamm C, Scholz J, Klimmeck S, Goldmann B, Meinertz T. Prehospital testing for troponin T in patients with suspected acute myocardial infarction. *Am Heart J*. **1999**, *138(1 Pt 1)*, 45-48.
62. Collopy KT, Westmoreland A, Powers WF. Patient care alterations after point-of-care laboratory testing during critical care transport. *Air Med J*. **2022**, *41(4)*, 370-375.
63. Morton S, Avery P, Payne J, OMeara M. Arterial blood gases and arterial lines in the prehospital setting: a systematic literature review and survey of current United Kingdom Helicopter Emergency Medical Services. *Air Med J*. **2022**, *41*, 201-208.
64. Murali A, Guyette FX, Martin-Gill C, Jones M, Kravetsky M, Wheeler SE. Implementation and challenges of portable blood gas measurements in air medical transport. *Clin Chem Lab Med.* **2022**, *60(6)*, 859-866.
65. Cini S, Urbanelli A, Montemerani S, Ramacciani Isemann C, Righi L. Point-of-care blood gas analysis as a tool for COVID-19 patients: a prehospital setting experience. *Recenti Prog Med.* **2021**, *112(12)*, 821-823.
66. Gruebl T, Ploeger B, Wranze-Bielefeld E, Mueller M, Schmidbauer W, Kill C, et al. Point-of-care testing in out-of-hospital cardiac arrest: a retrospective analysis of relevance and consequences. *Scand J Trauma Resusc Emerg Med.* **2021**, *29(128)*, 1-10.
67. Nawrocki J, Furian M, Buergin A, Mayer L, Schneider S, Mademilov M, et al. Validation of a portable blood gas analyzer for use in challenging field conditions at high altitude. *Front Physiol*. **2021** Jan 8, *11*, 600551. doi: 10.3389/fphys.2020.600551.
68. McPherson MD. Point-of-care blood tests in decision-making for people over 65 with acute frailty. *J Paramed Pract*. **2019**, *11(3)*, 106-115.
69. Shin J, Lim YS, Kim K, Lee HJ, Lee SJ, Jung E, et al. Initial blood pH during cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients: a multicenter observational registry-based study. *Crit Care.* **2017**, *21(1)*, 322.
70. Mikkelsen S, Wolsin-Hansen J, Nybo M, Maegaard CU, Jepsen S. Implementation of the ABL-90 blood gas analyzer in a ground-based mobile emergency care unit. *SJTREM*. **2015**, *23*, 54 (letter). doi: 10.1186/s13049-015-0134-y
71. Di Serio F, Petronelli MA, Sammartino E. Laboratory testing during critical care transport: point-of-care testing in air ambulances. *Clin Chem Lab Med*. **2010**, *48(7)*, 955-961.
72. Jousi M, Reitala J, Lund V, Katila A, Leppäniemi A. The role of pre-hospital blood gas analysis in trauma resuscitation. *World J Emerg Surg*. **2010**, *5*, 10.
73. Vos G, Engel M, Ramsay G, van Waardenburg D. Point-of-care blood analyzer during the interhospital transport of critically ill children. *Europ J Emerg Med*. **2006**, *13*, 304-307.
74. Gruszecki AC, Hortin G, Lam J, Kahler D, Smith D, Vines J, et al. Utilization, reliability, and clinical impact of point-of-care testing during critical care transport: six years of experience. *Clin Chem*. **2003**, *49(6)*, 1017-1019.
75. Backer HD, Collins S. Use of a handheld, battery-operated chemistry analyzer for evaluation of heat-related symptoms in the backcountry of Grand Canyon National Park: a brief report. *Ann Emerg Med.* **1999** Apr, *33(4)*, 418-422.
76. Herr DM, Newton NC, Santrach PJ, Hankins DG, Burritt MF. Airborne and rescue point-of-care testing. *Am J Clin Pathol*. **1995** Oct, *104(4 Suppl 1, Kost Ed.)*, S54-S58.
77. Fuzery AK. Airborne point-of-care testing capabilities. [personal communication] August, **2022**.
78. Hill J, Gothard DM, McLean MM. Prehospital blood glucose testing as a predictor of impending hypotension in adult trauma patients. *Air Med J*. **2020**, *39(1)*, 20-23.
79. Remick K, Redgate C, Ostermayer D, Kaji AH, Gausche-Hill M. Prehospital glucose testing for children with seizures: A proposed change in management. *Prehosp Emerg Care*. **2017**, *21(2)*, 216-221.
80. Lerner EB, Billittier IV AJ, Lance DR, Janicke DM, Teuscher JA. Can paramedics safely treat and discharge hypoglycemic patients in the field? *Am J Emerg Med*. **2003**, *21(2)*, 115-120.
81. Novak A, Cherry J, Ali N, Smith I, Bowen J, Ray J, et al. Point-of-care blood testing with secondary care decision support for frail patients. *J Paramed Pract*. **2022**, *14(2)*, 54-62
82. Galvagno SM, Sikorski RA, Floccare DJ, Rock P, Mazzeffi MA, DuBose JJ, et al. Prehospital point of care testing for the early detection of shock and prediction of lifesaving interventions. Shock. **2020**, *54(6)*, 710-716.
83. Martín-Rodríguez F, López-Izquierdo R, Medina-Lozano E, Ortega Rabbione G, Del Pozo Vegas C, Carbajosa Rodríguez V, et al. Accuracy of prehospital point-of-care lactate in early in-hospital mortality. *Eur J Clin Invest*. **2020** Dec, *50(12)*, e13341. doi: 10.1111/eci.13341.
84. Martín-Rodríguez F, López-Izquierdo R, Castro Villamor MA, Mangas IM, Del Brío Ibáñez P, Delgado Benito JF, et al. Prognostic value of lactate in prehospital care as a predictor of early mortality. *Am J Emerg Med.* **2019**, *37(9)*, 1627-1632.
85. Shephard M, Shephard A, McAteer B, Regnier T, Barancek K. Results from 15 years of quality surveillance for a National Indigenous Point-of-Care Testing Program for diabetes. *Clin Biochem*. **2017**, *50(18)*, 1159-1163.
86. Motta LA, Shephard MDS, Brink J, Lawson S, Rheeder P. Point-of-care testing improves diabetes management in a primary care clinic in South Africa. *Prim Care Diabetes*. **2017**, *11(3)*, 248-253.
87. Kost GJ, Pratumvinit. Diabetes spatial care paths, leading edge HbA1c testing, facilitation thresholds, proactive-preemptive strategic intelligence, and unmanned aerial vehicles in limited-resource countries. *Point of Care.* **2017**, *16*, 12-31.
88. Kost GJ, Kanoksilp A, Mecozzi DM, Sonu R, Curtis C, Yu JN. Point-of-need hemoglobin A1c for evidence-based diabetes care in rural small-world networks: Khumuang Community Hospital, Buriram, Thailand. *Point of Care*. **2011**, *10*, 28-33.
89. Spaeth BA, Shephard MD, Schatz S. Point-of-care testing for haemoglobin A1c in remote Australian Indigenous communities improves timeliness of diabetes care. *Rural Remote Health*. **2014**, *14(4)*, 2849.

90. Martin DD, Shephard MD, Freeman H, Bulsara MK, Jones TW, Davis EA, et al. Point-of-care testing of HbA1c and blood glucose in a remote Aboriginal Australian community. *Med J Aust*. **2005**, *182(10)*, 524-527.
91. Shephard MD, Mazzachi BC, Shephard AK, McLaughlin KJ, Denner B, Barnes G. The impact of point of care testing on diabetes services along Victoria's Mallee Track: results of a community-based diabetes risk assessment and management program. *Rural Remote Health.* **2005**, *5(3)*, 371.
92. Schober P, Bossers SM, Koolwijk J, Terra M, Schwarte LA. Prehospital coagulation measurement by a portable blood analyzer in a helicopter emergency medical service (HEMS). *Am J Emerg Med*. **2021**, *46*, 137-140.
93. Beynon C, Erk AG, Potzy A, Mohr S, Popp E. Point of care coagulometry in prehospital emergency care: an observational study. *Scand J Trauma Resusc Emerg Med*. **2015**, *23*, 58.
94. Rumpf TH, Krizmaric M, Grmec S. Capnometry in suspected pulmonary embolism with positive D-dimer in the field. *Crit Care.* **2009**, *13(6)*, R196
95. Christensen HM, Pietersen PI, Laursen CB, Wittrock D, Nadim G, Jørgensen G, et al. Patients' perspectives on point-of-care diagnostics and treatment by emergency medical technicians in acute COPD exacerbations: A qualitative study. *Scand J Trauma Resusc Emerg Med.* **2022**, *30(1)*, 11.
96. Ienghong K, Cheung LW, Tiamkao S, Bhudhisawasdi V, Apiratwarakul K. The utilization of handheld ultrasound devices in a prehospital setting. *Prehosp Disaster Med.* **2022**, *37(3)*, 355-359. doi: 10.1017/s1049023x22000644.
97. Dubecq C, Dubourg O, Morand G, Montagnon R, Travers S, Mahe P. Point-of-care ultrasound for treatment and triage in austere military environments. *J Trauma Acute Care Surg*. **2021**, *91(2S Suppl 2)*, S124-129.
98. Nadim G, Laursen CB, Pietersen PI, Wittrock D, Sørensen MK, Nielsen LB, et al. Prehospital emergency medical technicians can perform ultrasonography and blood analysis in prehospital evaluation of patients with chronic obstructive pulmonary disease: a feasibility study. *BMC Health Serv Res.* **2021**, *21(1)*, 290.
99. Schoeneck JH, Coughlin RF, Baloescu C, Cone DC, Liu RB, Kalam S, et al. Paramedic-performed prehospital point-of-care ultrasound for patients with undifferentiated dyspnea: A pilot study. *West J Emerg Med*. **2021**, *22(3)*, 750-755.
100. Sabatino V, Caramia MR, Curatola A, Vassallo F, Deidda A, Cinicola B, et al. Point-of-care ultrasound (POCUS) in a remote area of Sierra Leone: impact on patient management and training program for community health officers. *J Ultrasound*. **2020**, *23(4)*, 521-527.
101. Bobbia X, Abou-Badra M, Hansel N, Pes P, Petrovic T, Claret PG, et al. Changes in the availability of bedside ultrasound practice in emergency rooms and prehospital settings in France. *Anaesth Crit Care Pain Med.* **2018**, *37(3)*, 201-205.
102. Chin EJ, Chan CH, Mortazavi R, Anderson CL, Kahn CA, Summers S, et al. A pilot study examining the viability of a prehospital assessment with ultrasound for emergencies (PAUSE) protocol. *J Emerg Med.* **2013**, *44(1)*, 142-149.
103. Advance Health Services Cooperative. Mobile Diagnostic Clinic. Philippine Cooperative Central Fund Federation Bldg, 20 Gov. M. Roa St, Cebu City, 6000 Cebu. **2022**.
104. Söderqvist M, Virta J, Kämäräinen A. Substance abuse among emergency medical services patients. A pilot study on the clinical impact of an on-site oral fluid screening test. *Point of Care* **2018**, *17(2)*, 47-49.
105. Beeman A, Gonzalez Marques C, Tang OY, Uwamahoro C, Jarmale S, Mutabazi Z, et al. Factors associated with HIV testing among patients seeking emergent injury care in Kigali, Rwanda. *Afr J Emerg Med.* **2022** Sep, *12(3)*, 281-286.
106. Zadran A, Ho AVD, Zadran L, Ventura-Curiel IJ, Pham T-T, Kost GJ. Optimizing public health preparedness for highly infectious diseases in Central Vietnam. *Diagnostics.* 2022, *12*, 2047. doi.org/10.3390/diagnostics120920
107. World Health Organization. *Consolidated Guidelines on HIV Prevention, Testing, Treatment, Service Delivery and Monitoring: Recommendations for a Public Health Approach.* Geneva: WHO. **2021**, 592 pages. https://www.who.int/publications/i/item/9789240031593 [Accessed August 31, 2022.]
108. Vallely AJ, Pomat WS, Homer C, Guy R, Luchters S, Mola GDL, et al. Point-of-care testing and treatment of sexually transmitted infections to improve birth outcomes in high-burden, low-income settings: Study protocol for a cluster randomized crossover trial (the WANTAIM Trial, Papua New Guinea). *Welcome Open Res*. **2019**, *4*, 53. doi: 10.12688/wellcomeopenres.15173.2.
109. West K. Rapid HIV testing: a new standard of care to protect prehospital providers. *J Emer Med Serv*. **2007** May, *32(5)*, 40-41. doi: 10.1016/S0197-2510(07)72192-7.
110. West K. HIV: test results in minutes: reviewing the prehospital occupational risk of acquiring HIV & the availability & value of rapid post-exposure testing. *J Emer Med Serv*. **2004** Jul, *29(7)*, 68-73.
111. Metelmann C, Metelmann B, Scheer C, Gründling M, Henkel B, Hahnenkamp K, et al. Sepsis detection in emergency medicine: Results of an interprofessional survey on sepsis detection in prehospital emergency medicine and emergency departments. *Anaesthesist.* **2018**, *67(8)*, 584-591.
112. Ebinger M, Siegerink B, Kunz A, Wendt M, Weber JE, Schwabauer E, et al. Association between dispatch of mobile stroke units and functional outcomes among patients with acute ischemic stroke in Berlin. *JAMA*. **2021**, *325(5)*, 454-466.
113. Wendt M, Ebinger M, Kunz A, Rozanski M, Waldschmidt C, Weber JE, et al. Improved prehospital triage of patients with stroke in a specialized stroke ambulance. Results of the pre-hospital acute neurological therapy and optimization of medical care in stroke study. *Stroke* **2015**, *46*, 740-745.
114. Ebinger M, Winter B, Wendt M, Weber JE, Waldschmidt C, Rozanksi M, et al. Effect of the use of ambulance-based thrombolysis on time to thrombolysis in acute ischemic stroke. *JAMA* **2014** Apr, *311(16)*, 1622-1631.
115. Walter S, Kostopoulos P, Haas A, Keller I, Lesmeister M, Schlechtriemen T, et al. Diagnosis and treatment of patients with stroke in a mobile stroke unit versus in hospital: a randomized controlled trial. *Lancet Neurol.* **2012**, *11*, 397-404.

116. Chan J, Griffith LE, Costa AP, Leyenaar MS, Agarwal G. Community paramedicine: a systematic review of program descriptions and training. *CJEM*. **2019**, *21*, 749-761.
117. Van Vuuren J, Thomas B, Agarwal G, MacDermott S, Kinsman L, O'Meara P, et al. Reshaping healthcare delivery for elderly patients: the role of community paramedicine; a systematic review. *BMC Health Services Research.* **2021**, *21*, 29.
118. Thirumalai M, Zengul AG, Evans E. Challenges and lessons learned from a telehealth community paramedicine program for the prevention of hypoglycemia: pre-post pilot feasibility study. *JMIR Diabetes.* **2021**, *6*, e26941.
119. Rural Health Information Hub. Community Paramedicine. https://www.ruralhealthinfo.org/topics/community-paramedicine **2022**. [Accessed August 31, 2022.]
120. Paramedic Real-world Example 1: https://www.albertahealthservices.ca/ems/Page16487.aspx **2022**. [Accessed August 31, 2022.]
121. Paramedic Real-world Example 2: http://www.bcehs.ca/our-services/programs-services/community-paramedicine **2022**. [Accessed July 21, 2022.]
122. Leff B, Burton L, Guido S., Greenough WB, Steinwachs D, Burton JR. Home hospital program: a pilot study. *J Am Geriatr Soc*. **1999**, *47*, 697-702.
123. Leff B, Burton L, Mader SL, Naughton B, Burl J, Inouye SK, et al. Hospital at home: feasibility and outcomes of a program to provide hospital-level care at home for acutely ill older patients. *Ann Intern Med.* **2005**, *143*, 798-808.
124. Leong MQ, Lim CW, Lai YF. Comparison of hospital-at-home models: a systematic review of reviews. *BMJ Open*. **2021**, *11*, e043285.
125. Balatbat C, Kadakia KT, Dzau VJ, Offodile AC. No place like home: Hospital at home as a post-pandemic frontier for care delivery innovation. *NEJM Catalyst*. August 23, **2021**. https://catalyst.nejm.org/doi/pdf/10.1056/CAT.21.0237 [Accessed July 21, 2022.]
126. Lippert M, Semmens S, Tacey L, Rent T, Defoe K, Bucsis M, et al. The Hospital at home program: no place like home. *Curr Oncol.* **2017**, *24*, 23-27.
127. Johns Hopkins Hospital at Home online resource: https://www.hospitalathome.org/ [Accessed July 21, 2022.]
128. Home Hospital Real-world Example 1: https://www.islandhealth.ca/our-services/hospital-home-services/hospital-home **2022.** [Accessed August 31, 2022.]
129. Home Hospital Real-world Example 2: https://www.ualberta.ca/folio/2020/02/virtual-hospital-cuts-ems-calls-er-visits-and-hospital-admissions-for-high-use-patients.html **2022.** [Accessed August 31, 2022.]
130. Flemons K, Baylis B, Khan AZ, Kirkpatrick AW, Whitehead K, Moeini S. The use of drones for the delivery of diagnostic test kits and medical supplies to remote First Nations communities during Covid-19. *Am J Infect Control.* **2022** Aug, *50(8)*, 849-856.
131. Katariya M, Chung DCK, Minife T, Gupta H, Zahidi AAA, Liew OW, et al. Drone inflight mixing of biochemical samples. *Anal Biochem*. **2018** Mar 15, *545*, 1-3.
132. Amukele TK, Hernandez J, Snozek CLH, Wyatt RG, Douglas M, Amini R, et al. Drone transport of chemistry and hematology samples over long distances. *Am J Clin Pathol.* **2017** Nov 2, *148(5)*, 427-435.
133. Amukele T, Ness PM, Tobian AA, Boyd J, Street J. Drone transportation of blood products. *Transfusion.* **2017** Mar, *57(3)*, 582-588.
134. Amukele TK, Street J, Carroll K, Miller H, Zhang SX. Drone transport of microbes in blood and sputum laboratory specimens. *J Clin Microbiol*. **2016** Oct, *54(10)*, 2622-2625.
135. Claesson A, Fredman D, Svensson L, Ringh M, Hollenberg J, Nordberg P, et al. Unmanned aerial vehicles (drones) in out-of-hospital-cardiac-arrest. *Scand J Trauma Resusc Emerg Med*. **2016** Oct 12, *24(1)*, 124.
136. Priye A, Wong S, Bi Y, Carpio M, Chang J, Coen M, et al. Lab-on-a-drone: Toward pinpoint deployment of smartphone-enabled nucleic acid-based diagnostics for mobile health care. *Anal Chem*. **2016** May 3, *88(9)*, 4651-4660.
137. Amukele TK, Sokoll LJ, Pepper D, Howard DP, Street J. Can unmanned aerial systems (drones) be used for the routine transport of chemistry, hematology, and coagulation laboratory specimens? *PLoS One*. **2015** Jul 29, *10(7)*, e0134020. doi: 10.1371/journal.pone.0134020
138. Lindsey R. Climate change: Global sea level. NOAA Climate.gov. **2022**. https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level# [Accessed August 31, 2022.]
139. The United Nations Refugee Agency (UNHCR), Philippines. Super Typhoon Rai (local name Odette). **2021**. https://www.unhcr.org/ph/typhoon-rai-odette [Accessed August 31, 2022.]
140. Kost GJ, Ehrmeyer SS, Chernow B, Winkelman JW, Zaloga GP, Dellinger RP, et al. The laboratory-clinical interface: point-of-care testing. *Chest.* **1999** Apr, *115(4)*, 1140-54.
141. Kost GJ. Using small-world networks to optimize preparedness, response, and resilience. In Kost GJ, Ed., Curtis CM, Assoc. Ed. *Global Point of Care: Strategies for Disasters, Emergencies, and Public Health Resilience*. Washington DC: AACC Press-Elsevier, **2015,** *49*, 539-568.
142. Kost GJ, Louie RF, Truong A-T, Curtis CM. Needs assessment for rapid decision making in pandemics, complex emergencies, and disasters: A global perspective. In Kost GJ, Ed., Curtis CM, Assoc. Ed. *Global Point of Care: Strategies for Disasters, Emergencies, and Public Health Resilience*. Washington DC: AACC Press-Elsevier, **2015,** *1*, 3-22.
143. Open Sea Map — The Free Nautical Map. **2022.** https://map.openseamap.org/ [Accessed August 31, 2022.]
144. Tinsay S, Chin E, Gilbuena NB. Matrix Population Mapping and Assigning Tool. Bantayan, Santa Fe, and Madridejos Barangay Local Government Units. **2022.** https://docs.google.com/spreadsheets/d/1EuIhbH6VCGzLzjTPH8RWunyAQ8t5R-gq09XPmMvJmQ/edit?usp=sharing [Accessed August 31, 2022.]

145. Genrui (Shenzhen, China). Electrolyte Analyzer GE 300. Ion-selective instrument that measures ionized calcium (Ca++), potassium, sodium, and chloride. https://www.genrui-bio.com/products/electrolyte-analyzer-ge300.html [Accessed August 17, 2022.]
146. InTec (Fujian, China). Qualitative One-step (15-20 minutes) Troponin I Test Card (sensitivity not specified; whole blood, plasma, or serum). https://www.intecasi.com/rapid-troponin-i-test_p67.html. [Accessed August 17, 2022.]
147. Genrui (Shenzhen, China). Quantitative Immunoassay Analyzer FA50. https://www.genrui-bio.com/products/quantitative-immunoassay-analyzer-fa50.html [Accessed August 17, 2022.]
148. Cepheid. GeneXpert Systems. https://www.cepheid.com/en_PH/systems/GeneXpert-Family-of-Systems/GeneXpert-System **2022**. [Accessed August 31, 2020.]
149. Kost GJ, Tran NK, Abad VJ, Louie RF. Evaluation of point-of-care glucose testing accuracy using locally-smoothed median absolute difference curves. *Clin Chim Acta*. **2008**, *389(1-2)*, 31-39.
150. Kost GJ, Tran NK, Louie RF, Gentile NL, Abad VJ. Assessing the performance of handheld glucose testing for critical care. *Diabetes Technol Ther*. **2008**, *10(6)*, 445-451.
151. Kost GJ, Tran NK, Singh H. Mapping point-of-care performance using locally-smoothed median and maximum absolute difference curves. *Clin Chem Lab Med*. **2011**, *49(10)*, 1637-1646.
152. Waggoner JJ, Vos MB, Tyburski EA, Nguyen PV, Ingersoll JM, Miller C, et al. Concordance of SARS-CoV-2 results in self-collected nasal swabs vs swabs collected by health care workers in children and adolescents. *JAMA*. **2022** Aug 26. doi: 10.1001/jama.2022.14877. [online ahead of print]
153. Youngster I. Self-sampling for SARS-CoV-2 detection in children [Editorial]. *JAMA*. **2022** Aug 26. doi: 10.1001/jama.2022.15225. [online ahead of print]
154. Stop TB Partnership. Rapid molecular diagnostics for use at peripheral level. The introducing New Tools Project. https://www.stoptb.org/introducing-new-tools-project/rapid-molecular-diagnostics-use-peripheral-level [Accessed September 15, 2022.]
155. Department of Health, Philippines. USAID to expedite patients' access to TB care. https://www.pna.gov.ph/articles/1174445 [Accessed September 15, 2022.]
156. Stop TB Partnership. *Practical Guide to Implementation of Truenat Tests for the detection of TB and Rifampicin Resistance*. https://www.stoptb.org/sites/default/files/Truenat_Implementation_Guide_0.pdf [Accessed September 15, 2022.]
157. Embassy of the Republic of Indonesia. Facts and figures. **2022**. https://www.embassyofindonesia.org/basic-facts/ [Accessed August 31, 2022.]
158. Kost GJ, Ed., Curtis CM, Assoc. Ed. *Global Point of Care: Strategies for Disasters, Emergencies, and Public Health Resilience*. Washington DC: AACC Press-Elsevier, **2015,** 701 pages.
159. Fernando D, Thota P, Semege S, Booso R, Bell D, de A W Gunasekera KT, et al. Evaluation of a haemozoin-based rapid diagnostic test for diagnosis of imported malaria during the phase of prevention of reestablishment in Sri Lanka. Malar J. **2022** Sep 10, *21(1)*, 263.
160. Oviedo A, Knipes A, Worrell C, Fox LM, Desir L, Fayette C, et al. Combination of serological, antigen detection, and DNA data for Plasmodium falciparum provides robust geospatial estimates for malaria transmission in Haiti. Sci Rep. **2020** May 21, *10(1)*, 8443.
161. Rogier E, Hamre KES, Joseph V, Plucinski MM, Presume J, Romnilus I, et al. Conventional and high-sensitivity malaria rapid diagnostic test performance in 2 transmission settings: Haiti 2017. J Infect Dis. **2020**, 221(5), 786-795.
162. Ventura IJ, Zadran A, Ho AVD, Zadran L, Thuan DTB, Pham TT, et al. Rapid diagnosis and effective monitoring of diabetes in Central Vietnam: Point-of-care needs, improved patient access, and spatial care paths for enhanced public health. Point of Care. **2019**, *28*, 1-8.
163. Nguyen TLC, Kost GJ. The status of point-of-care testing and coordinators in Vietnam: Needs assessment, education, technologies, exchange, and future mission. Point of Care. **2020**, *19(1)*, 19-24.
164. Hengel B, Causer L, Matthews S, Smith K, Andrewartha K, Badman S, et al. A decentralised point-of-care testing model to address inequities in the COVID-19 response. Lancet Infect Dis. **2021** Jul, *21(7)*, e183-e190.
165. Herd GCE, Musaad SMA. Point-of-care testing in rural and remote settings to improve access and improve outcomes: A snapshot of the New Zealand experience. Arch Pathol Lab Med. **2021**, Mar 1, *145(3)*, 327-335.
166. Kost GJ. Geospatial science and point-of-care testing: Creating solutions for population access, emergencies, outbreaks, and disasters. *Front Public Health*. **2019** Nov 26, *7:329*, 1-15. doi: 10.3389/fpubh.2019.00329.
167. Kost GJ. Geospatial hotspots need point-of-care strategies to stop highly infectious outbreaks. *Arch Pathol Lab Med*. **2020** Oct 1, *144(10)*, 1166-1190.
168. Joung SY, Ebinger JE, Sun N, Liu Y, Wu M, Tang AB, et al. Awareness of SARS-CoV-2 Omicron variant infection among adults with recent COVID-19 seropositivity. *JAMA Netw Open*. **2022** Aug 1, *5(8)*, e2227241. doi: 10.1001/jamanetworkopen.2022.27241.
169. National Institutes of Health. NIH seeks he next generation of COVID-19 diagnostics. https://www.nih.gov/news-events/news-releases/nih-seeks-next-generation-covid-19-diagnostics [Accessed September 15, 2022.]
170. Kost GJ. Geospatial spread of antimicrobial resistance, bacterial and fungal threats to Coronavirus Infectious Disease 2019 (COVID-19) survival, and point-of-care solutions. *Arch Pathol Lab Med*. **2021** Feb 1, *145(2)*, 145-167.
171. Kamp J. Covid still a leading killer, especially among seniors. *Wall Street Journal*. **2022** September 12, *280*, A1, A3.