Text Message-based Prehospital Emergency Dispatching for Resource-limited Communities

Executive Summary
Lack of access to health care services has been identified as a major contributor to health disparities between developed and developing nations. Often times, access can be significantly improved by increasing the efficient deployment of available personnel and transport through better communications systems, thus reducing the time interval between an event’s onset and the patient’s transfer to definitive care. Injury, childbirth, disease outbreak and disaster are examples of public health risks where time can be a critical determinant of patient outcomes. In developed countries, emergency medical services are supported by robust telecommunications systems to provide both urban and rural populations with improved access through early detection; rapid response; and expedited transport. In developing countries, a weak telecommunications infrastructure precludes trained first responders from providing basic prehospital care and transport where and when it is needed. As a result, low- and middle-income countries (LMICs) have substantially higher mortality rates for what would otherwise be considered preventable deaths, including deaths from traffic accidents, out-of-hospital childbirth, and cholera, among many others. However, by equipping resource-poor communities with low-cost, reliable telecommunications capabilities, community-based prehospital care systems can be organized to improve care and transportation for emergency patients, thus reducing preventable deaths.

To address the near-universal lack of coordinated emergency services, Trek Medics has developed Beacon, a text message-based emergency dispatching software designed specifically for communities where advanced "911" dispatching technologies are inappropriate or unaffordable. Beacon works by relaying requests for emergency assistance from the scene of an emergency to nearby trained community responders via text message, and then automates the coordination of these resources to ensure that patients are quickly located, stabilized, and transported promptly to appropriate facilities.

At its core, Beacon ensures end-to-end coordination of emergency resources, ultimately eliminating the need for and dependence on expensive and inappropriate EMS technologies that have been developed for the public infrastructure of Westerns nations. The platform achieves this by opening accessibility to all of the people and resources that can be used to provide medical care and transport – and not just traditional ambulances with outdated dispatching technologies. This enables communities to strengthen and integrate both the formal and informal EMS systems that exist – including, young adults using the vehicles already on the road and the phones in their pockets.

Using the Beacon platform, communities with limited resources will be able to match the standards of the most advanced ambulance services, guaranteeing that 90% of patients requesting emergency assistance will be attended to by trained emergency responders with access to appropriate transport within 10 minutes in urban centers and within 30 minutes in outlying communities.
A Failure to Communicate: The Centrality of Dispatch to Effective Emergency Communications

Emergency response dispatch has been defined as “‘Sending the right thing to the right person at the right time in the right way and doing the right things until help arrives’”[^2]. While it’s hard to believe that societies have ever functioned without formal emergency services to locate and evacuate persons with critical medical needs, historical tradition tends to mark the Napoleonic wars as the advent of the contemporary ambulance service, with the American Civil War and locomotion providing the proving grounds for the world’s first scalable model of organized treatment and mechanized transport for the critically injured. Despite these rich histories, outside times of war little other attention was paid to managing routine calamity until the mid-twentieth century, when, in the U.S., three important societal forces merged:

1. Widespread consumer access to automobiles, telephones and radios
2. The publication of “Accidental Death and Disability: the neglected disease of modern society” by the National Academy of Sciences (US) a white paper prescribing a national approach to emergency trauma systems development in order to reduce road traffic fatalities, and
3. The return of American combat medics to the US from the Korean and Viet Nam wars with basic, life-saving trauma skills and experience that could be taught to the public at large

From these three factors - an influx of available resources, widespread political will, and trained personnel - emerged the modern ambulance system, now a staple of most communities in North America, Western Europe and Australia, among a smattering of other countries. Yet the apparent sophistication and advanced technologies used today in the most well-funded systems (or movie sets) can be misleading because they fail to acknowledge the context in which the majority of emergency medical dispatching technologies have been developed and continue to operate today: through the efforts of amateur hobbyists and tinkerers patching together systems that work using the resources at hand.

This is because dispatching has always been central to any response network: It does not matter how many ambulances a community has, nor how advanced the training of their responders; Without effective communications to alert available responders when and where their assistance is required, emergency resources will only be used incidentally. And this is precisely why the majority of communities in low- and middle-income countries have gone so long without formalized emergency response systems providing comprehensive coverage: few of them had access to telephones or radios to the extent needed.

However, things have clearly changed drastically over the past 10 years with mobile phone penetration in LMICs now upwards of 80%[^3]. Where robust, landline-based infrastructure was once the foundation for advanced emergency communications systems, today telephone cords and handsets are their biggest liability, holding back true innovation like a literal ball and chain. Today, mobile-only communities across the developing communities have a very real opportunity to build truly innovative solutions from scratch to meet their specific needs, on their terms.

Crossed Phone Lines: Pre-Mobile dispatch solutions

With more than a decade’s worth of experience working with EMS systems in more than twenty five countries, we’ve found myriad communications technologies deployed to coordinate emergency response personnel and vehicles in resource-limited settings, including legacy air sirens, pagers, radios, landline-based phone trees, computer-aided dispatch (CAD) consoles, and more recently, mobile
phone messaging apps. While each represents, in principle, a potentially effective dispatching technology with clear utility, they similarly have their own unique weaknesses. In the end, however, they are plagued by the same problem which Beacon has been designed to address specifically: they do not scale well in communities with limited resources. Included below is a table which describes the primary advantages and disadvantages of each technology, as they relate to deployment in LMICs:

<table>
<thead>
<tr>
<th>Communications Type</th>
<th>Primary Advantages</th>
<th>Primary Disadvantages</th>
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<tbody>
<tr>
<td>Air sirens</td>
<td>Loud, distinct, far-reaching, inexpensive</td>
<td>Non-descript; provide limited information regarding location or emergency nature</td>
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<tr>
<td>Pagers</td>
<td>Small and easy-to-carry, convenient</td>
<td>Provide limited information; one-way communications; increasingly obsolete</td>
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<td>Radios</td>
<td>Real-time, two-way communications; can broadcast among large groups; ability to communicate across multiple channels</td>
<td>Require accessory parts and replacements which are often unique to make and model and difficult to obtain; are not necessarily interoperable; can have very limited range</td>
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<tr>
<td>Landlines</td>
<td>Fixed location; easily replaced</td>
<td>Inefficient – can only call one person at a time; comparatively rare in LMICs and dependent on wide user base to be efficient (“network effect”; dependent on larger infrastructure that’s difficult to repair when damaged</td>
</tr>
<tr>
<td>CAD</td>
<td>Multi-functional platform for multiple agencies and services; designed specifically for</td>
<td>Expensive; overwrought; built from legacy standards; overburdened by architecture design originally based on landline-based; fixed location; require mobile data terminals in vehicles to ensure two-way communications</td>
</tr>
<tr>
<td>Mobile messaging apps</td>
<td>Wide broadcast reach; inexpensive; may have cross-platform interoperability</td>
<td>Require smartphones with internet connection; Not built for emergency dispatching, resulting in uncoordinated resource allocation (i.e., a free-for-all)</td>
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Of the solutions mentioned above, the CAD solution has proven the most effective - in wealthy countries with the money, resources and infrastructure to handle. As we’ll discuss further in the following section, what works in wealthy countries doesn’t work nearly as well in less wealthy countries who have neither the finances nor the infrastructure to make them anything more than a “sometimes solution.”

**Mobile Solutions for Sustainable EMS Development**

In affluent countries, the underlying philosophy for emergency medical response is to find the quickest way to send the nearest ambulance to a patient requesting emergency assistance and to bring them back to the hospital. For low-volume EMS systems with limited vehicles (commonly found in rural areas), the prevailing model is akin to a yo-yo, where the ambulance is parked at a fire or ambulance station, is sent out when needed, and returns to the station when the response is complete. For high-volume EMS systems with large ambulance fleets, the prevailing ambulance dispatching model is often referred to as a “System Status” model, where a number of variables and predictive analytics are used to strategically
position a finite number of designated emergency vehicles across the catchment area in order to ensure the shortest possible response times to any given location. As the number of available vehicles increases or decreases, the vehicles are moved to, from and between pre-determined locations to maintain the most optimal response times. While effective in reducing mortality rates for a host of emergency conditions, such models assume that: 1) an ambulance is the only acceptable form of emergency response and transport; 2) these ambulances can reach nearly all patients by road, and; 3) can be sustained financially.

**System Status Model of EMS Transport Access**

**Approach:** Get ambulances to emergency patients as quickly as possible

**Strategy:**
- Ambulances positioned using algorithms based on population density, call volume patterns, response history, etc.
- As call volume increases, remaining ambulances relocate to locations with higher call probability

**Assumptions:**
- Accessible roads
- Accurate maps
- Street names
- House numbers
- Affordable fuel
- Uniform ambulance fleet
- Excess spare parts
- Expert mechanics

A mobile phone-based emergency response system essentially inverts this approach by re-framing the problem: as opposed to asking remote dispatchers to micromanage the ambulance pool and seek the nearest ambulance and direct it to the scene of an emergency, the focus becomes about expanding the pool of available responders and allowing multiple resources (with or without ambulances) to self-dispatch. Thus, instead of calling for a single ambulance and waiting until it arrives, a mobile phone-based dispatching system could remove the need for puppet master-type dispatching and essentially crowd-source emergency medical response by drastically increasing the number of available first responders within a given geographic area, and then notifying all of them by text message when someone in the community sends requests emergency assistance – an approach we’ve named “System Saturation.” By relaying text messages from the scene of an emergency to the nearest first responder, the Beacon dispatching platform bridges the communications gap that commonly prevents communities with limited means from providing rapid and reliable emergency medical care and transport.
The following sequence details the *Emergency Response Cycle*, adapted to operate in coordination with text message-based dispatching:

1. **Emergency Event** - Someone falls from a moving vehicle and is lying in the street  
2. **Alert & Notification** - A witness sends a SMS to a server or dispatcher or voice call to a dispatcher  
3. **Response** - The server or dispatcher relays the patient's location to the nearest trained responders  
4. **On-Scene Care** - Trained responders locate the patient(s) to provide triage and basic medical care  
5. **Transport** - Responders provide safe emergency transport to receiving facilities (e.g. hospitals) that have advanced notification  
6. **Definitive Care** - Patients are transferred to clinical providers at appropriate healthcare facilities.

Using this approach, communities are able to leverage existing resources to improve access to quality emergency care when and where it is needed by increasing the availability of prehospital care providers and reducing delays in transport to definitive care.

**BEACON: Comprehensive text message-based Emergency Dispatching Software Platform**

Trek Medics International has developed the BEACON software to provide dispatching systems for communities that do not have access to reliable emergency transport and communications, and similarly lack the funding to acquire them. In short, Beacon improves access to trained emergency medical care and transport through SMS that are relayed from the scene of an emergency to the nearest available first responders. The software functions without an Internet connection, and provides an innovative and cost-effective platform for emergency medical care across a wide range of resource-limited settings. We
believe that the minimal human, physical and financial resources required by Beacon makes effective emergency medical system development feasible wherever mobile phones are used. We are currently seeking partners to expand field-testing and development.

Trek Medics International has been working since 2009 to develop emergency medical systems across a range of settings in LMICs, including for both formal and informal systems, and in urban and rural locations. Our work is focused on developing emergency medical response that leverages local resources to address local healthcare realities, with an emphasis on four core programmatic areas: emergency medical care training; transport; communications; and, coordination.

Additionally, Beacon offers countries with limited-resources the ability to collect, analyze and disseminate detailed data regarding each and every emergency incident that is reported through local dispatch centers, providing a level of data collection in the pre-hospital setting that is not uniformly recorded in even the wealthiest nations. According to a 2016 New York Times article, “[In the U.S.] Data on the quality of an ambulance company’s performance is scarce at the national level and difficult to compare town-to-town or company-to-company.” [Citation Needed]

Through Beacon, we’re avoiding the debilitating fragmentation common to EMS in wealthy countries by “leapfrogging” outdated landline systems and creating an open source platform that will drastically increase the availability of high-quality, timely, and reliable data captured through crowd-sourced emergency response at the local level. The platform allows communities to assess performance metrics and gain unprecedented insight into the frequency and type of emergencies occurring, and enables them to more efficiently allocate emergency personnel and resources.

Examples of key data that Beacon currently records include:

- Detailed maps of emergency incident locations and times, including:
  - Spatial mapping of traffic incidents and “hot spots”
  - Passive epidemiological and syndromic surveillance for infectious disease outbreak (e.g., cholera, Ebola and Zika et al)
  - Standardization of emergency access and evacuation corridors
- Real-time analysis of available resources and peak-load (“surge”) demands
- Prehospital response intervals to improve efficiency in resource distribution and allocation, including:
  - Activation Time - How long it takes the system to send out the alerts
o Assignment Time - How long it takes responders to reply to an alert and be assigned to and incident
o Dispatch Time - How long it takes Beacon to meet the quota for assigned responders set by the dispatcher
o Arrival Time - How long it takes from activation to the responder arriving at the patient’s side
o Triage Time - How long it takes the first responder on-scene to determine if additional resources are needed
o Total Scene Time - The length of time spent at the scene of an emergency (from Arrival Time to Transport)

Fully implemented at scale, Beacon’s varied data sets will allow policymakers and community leaders to monitor the incidence and prevalence of acute life-threatening events at the local level, while integrating these data sources at the regional and/or national level under centralized monitoring points. Beacon also enables local agencies to evaluate the performance of their pre-hospital care services and adapt the platform to the local context by allowing further enhancements to its open source code.

Other Functions:

- **Low-tech set-up** – A single internet connected-device is required to launch
- **Scalable operations** – Ability to handle simultaneous events, multi-victim incidents, and complex emergencies; short- vs. long-term deployments
- **Automated control** – After creating the initial alert, all resource coordination is automated, eliminating the need for dispatchers to micromanage individual resources
- **Advanced notification** – Can send status updates and notifications to receiving facilities and online medical direction upon transport confirmation
- **Multi-Agency Platform** – Ability to be utilized by multiple providers and facilities in same catchment area collectively and/or independently
- **Modular architecture for easy customization** – Beacon v2.0 has been re-built using a modular architecture to enable custom changes to message content and response sequence workflow

Features:

- **Easy-to-use interface** – Text message interactions require minimal input, are easily followed and predictable; responsive Admin and Dispatch interface makes platform accessible from any smartphone
- **Low-maintenance operations** – No need to download apps or worry about updates; just register the Responder’s mobile phone number and they’re ready to go
- **Universal accessibility** – Can be used on any mobile phone, whether smartphone or feature phone, with or without internet connectivity for daily operations
- **Remote access or local installation** – The Beacon platform is open source and freely available. However, not everyone has software programmers on staff, so we can make Beacon available to you at a nominal cost via access to our remote servers. For installation on local servers, we’re also available to discuss more
Case Study: Sun City
The following hypothetical scenario will help to illustrate an example of target communities:

Program Setting - Sun City is an impoverished coastal fishing village with high fatality rates for preventable causes, including deaths from road traffic injuries, complicated childbirth, drownings, diseases in the childhood cluster, cholera, and the annual threat of hurricanes. Sun City has a population of 90,000 residents, including a small urban center with 20,000 inhabitants, with the remaining 70,000 scattered sparsely among numerous hard-to-access communities. Several indigenous communities, numbering a few hundred inhabitants each, are living on several islands a few miles offshore. The map above provides some examples of the communities scattered throughout Sun City’s borders, with the traffic light-style coloring depicting a given community’s accessibility by road.

Environmental Assessment - Sun City’s geography is diverse, lying between the sea to the south, and steep mountains to the north, with a single road connecting it to the nearest major cities, running northeast to west. St. Peter’s Hospital, the region’s only public facility, also lies along this main road, making it easily accessible and, therefore, prone to being overwhelmed. This is particularly true during regular storms, flooding and mudslides, when the main road is cut-off in either or both directions, preventing assistance from other parts of the region.

Prehospital Emergency Care - Sun City has a fledgling community emergency response team (CERT), consisting of 20-30 first responders with varying levels of training, received through sporadic programs provided by local and international non-governmental organizations (NGOs), including the national Civil Protection and the Red Cross.

There are two ambulances in Sun City: a Toyota Landcruiser ambulance provided to St. Peter’s by the Ministry of Health, and a Ford F450 TraumaHawk donated by a North American EMS agency. Neither are in service. The CERT team utilizes their own transportation to provide medical care, including motorcycles, pick-up trucks, and other available vehicles. Their work, however, is largely relegated to standby medical care at cultural events, disaster response, and public outreach and education.

They are unable to provide reliable response services, as Sun City lacks a public emergency access number, leaving community members reliant on neighbors and family to provide transport to the hospital for patients with even the most critical conditions. When CERT members do respond to single-event emergencies, it is usually the result of incidental timing or because of a prolonged multi-casualty event that requires significant additional resources – for example, a commercial transport vehicle roll-over.
Implementation - “System Saturation”
Listed here is a generic outline of the SMS-based dispatching process based on our System Saturation model:

- Emergency response capacity is strengthened in both the prehospital and clinical settings by training adequate numbers\(^4\) of personnel to provide an accepted minimum standard of quality emergency care.
- Training for first responders is focused on basic life-saving skills and interventions for laypersons, and seeks a proportionate distribution throughout the catchment area according to population and availability of appropriate vehicles for safe transport; additional training specifically for SMS-based dispatching utilization by first responders is conducted, running live simulations throughout the community to familiarize prehospital and clinical staff and other key stakeholders with the dispatching system.
- Upon successful completion of the training program, first responders have their phone numbers entered into the SMS-based dispatching software, which is housed at the most appropriate healthcare facility within the catchment area.
- A multi-faceted public outreach and education campaign is launched to educate the community about emergency medical conditions, and how to appropriately access emergency medical care via SMS. The awareness campaign is led by trained CERT members, and is reinforced through a range of mediums, including public service announcements on the radio, TV, mobile phones, public events, literature, and live demonstrations, among others.
- Once prehospital training has reached adequate levels, and after key stakeholders are confident that the community has received adequate education, the new system goes live in a public ceremony.

Join Our Efforts - Become Involved and Benefit
Beacon represents a veritable sea change in how prehospital care systems are developed in LMICs, and we are eager to find strong partners willing to work with us as we continue to develop what promises to be a venture with huge potential for impact. If you’re interested in learning more about the Beacon software feel free to contact us by phone or email using the information below:

About the Software
The Beacon platform was designed by Trek Medics International and developed in partnership with Vision Point Systems (Blacksburg, VA).

Trek Medics International is dedicated to reducing the global burden of premature death and disability in vulnerable communities through the development of prehospital and emergency care services. We are a 501(c)(3)-registered, non-profit, non-governmental organization. Contact: info@trekmedics.org

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\(^4\) For emergency care, training includes all personnel regularly treating emergency medical conditions in the clinical setting, as well as 1% of the population in the prehospital setting.