Using Geographic Information Systems (GIS) to assess Response Intervals for Diffuse Community Bystander-Driven (Tier-1) Emergency Medical Services Integrated with Emergency Medical Dispatch for Musculoskeletal Trauma in Mwanza, Tanzania

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INTRODUCTION:
The global trauma and musculoskeletal injury burden disproportionately affects low- and middle-income countries (LMICs), which lack robust emergency medical services (EMS). The Global Prehospital Consortium determined EMS system response intervals are a priority for investigation in LMICs. On-scene response intervals for professionally staffed, ambulance-driven Tier-2 systems are known to vary by density of centralized ambulance dispatch sites per population, requiring additional costly infrastructure to improve response times. Community bystander-driven (Tier-1) systems are less costly with diffuse, mobile, and non-centrally dispatched responders and unknown response intervals. Therefore, we hypothesized Tier-1 EMS response intervals to geographically dispersed emergencies would not be distance-related, due to the inherent diffusion of Tier-1 community bystander first responders, suggesting rapid response times to trauma may be achieved without additional costly dispatch planning or infrastructure.

METHODS: Data from a Tier-1 emergency medical dispatch (EMD)-enabled LFR program in Tanzania were prospectively collected and analyzed to assess response intervals from 2017 to December 2022. In 2015, the Tanzania Rural Health Movement launched a Tier-1 lay first responder (LFR) program integrated with Beacon, a mobile EMD platform for responder coordination in Mwanza, Tanzania. Seven rotating dispatchers were hired and underwent formal training with Beacon after a toll-free emergency hotline was established and linked to the EMD system. Ten local instructors trained 148 total LFRs, who were equipped with locally-sourced first aid kits. LFRs were provided with a two-day training course on airway, respiration, circulation, massive hemorrhage, and fracture management. Chief complaint characteristics, diurnal emergency variation, and response intervals (for emergencies with ≥67% data compliance) were prospectively recorded for descriptive analysis. GIS software (ArcGIS Pro 2.8) used latitude/longitude recorded for compliant entries for analysis of response interval (time between notification to arrival) and distance from Mwanza city, plotted on a logarithmic distribution for correlation in the statistical software R (version 4.2).

RESULTS: 1,397 data entries were catalogued (2017-2022). 192 simulated test incidents and 701 data entries lacking ≥67% data compliance were filtered, leaving 504 entries for analysis. Of chief complaints, 77.6% were road traffic injury-related, 5.23% were fall-related, 5.12% were burn-related, and 11.98% were miscellaneous. Median on-scene response interval was 1 minute 47 seconds (mean = 7 minutes 50 seconds) (n=497) (Figure 1). 61.0% (n=303/497) of emergencies have response intervals less than 3 minutes, while 53.1% (n=264/497) of emergencies have response intervals less than 2 minutes. 49% of emergencies occur between Friday-Sunday, with 66.3% between 6am-6pm (Figure 2). There was no correlation between response interval and distance from Mwanza (r=0.0053957) (n=355) (Figure 3).

DISCUSSION AND CONCLUSION: A community bystander-driven Tier-1 EMS system with integrated mobile EMD demonstrates relatively short on-scene response intervals. Response intervals were not associated with distance, suggesting intervals are not geographically dependent in a Tier-1 model, which may be a result of inherent Tier-1 responder diffusion and EMD coordination. Whether Tier-1 EMS expansion may facilitate rapid on-scene response intervals in certain austere settings more cost-effectively than traditional Tier-2 systems merits further study.

Figure 1: Tanzanian Tier-1 EMS System Response Intervals

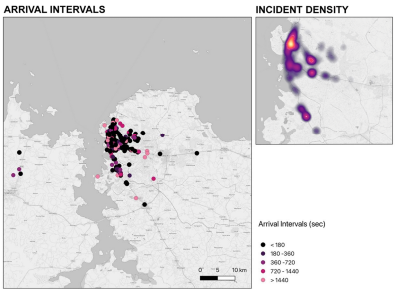


Figure 2:

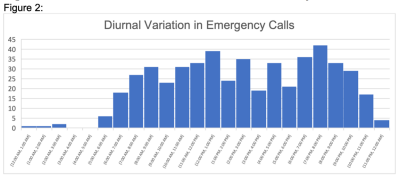
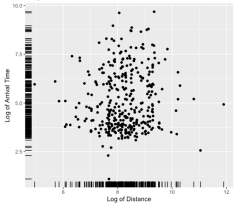


Figure 3: Distribution of Response Interval (time between notification to arrival) and Distance from Mwanza City



*No correlation between response interval and distance from Mwanza (r=0.0053957), suggesting response intervals may not be geographically dependent in a diffuse, community responder-based Tier-1 EMS model