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Which Technologies Should Be Used to Improve Prehospital Emergency Services?

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Abstract
Chief among the barriers to maintaining emergency medical services in rural areas are personnel shortages, long travel times, and austere settings in which clinicians must often provide care. These problems stem from a variety of sources, and some of those stemming from funding shortfalls might be remediable through technological innovation. This article examines how new technologies have recently been implemented and suggests how technology might be further integrated into prehospital emergency care.

One Emergency Medical Services System

There's a well-worn saying in the field of emergency medical services (EMS): *If you know one EMS system, you know one EMS system.* The ubiquity of this sentiment underscores the wide variation in EMS systems and operations domestically and internationally. There are distinct challenges that occur in certain environments, as the infrastructure and protocols that are successful in a densely populated region might not be successful in a sparsely populated region. Financially well-off communities or those with government funding might be able to pay their EMS workforce, while other communities might need to rely on volunteers. In general, guidance on how to navigate regional variation and the infrastructure and workforce issues that arise is often lacking. This lack of guidance is evident, especially in rural settings.

At the root of the problems faced by rural EMS are lack of nearby hospitals, financial instability of EMS agencies or patients, limited resources, and lower call volume, potentially resulting in less experienced EMS personnel.[1,2] Sometimes investment in rural medicine is considered a low-return investment since the communities served are less densely populated. This assumption works against upholding the ethical concept of justice, for it is often easier and more financially viable to provide medical resources across all levels of care—from prehospital to hospital and ambulatory settings—to patients living in urban environments.[1,3] The cost of delivering equitable care to rural patients can be prohibitively high and might sometimes only be feasible when supplemented by the government, as is the case with critical access hospitals.[1,3]

While these problems might be difficult to address, technological innovations can offer a potential alternative solution. From artificial intelligence (AI) to telemedicine and drones, technology has already proven itself in other fields and could now provide much-needed assistance to EMS and the rural communities they serve.

Artificial Intelligence

AI is a broad term for any computer system-based technology that can perform problem-solving and adaptive reasoning tasks typically performed by humans. In the past few years, AI has advanced in leaps and bounds. New uses and applications of this technology are constantly being discovered, and it is clear that AI could become a useful tool in prehospital medicine.

With its combination of data analysis, fast processing, and machine learning, AI could provide cognitive off-loading for EMS personnel and dispatchers.[4] There is already evidence supporting the use of AI in accurately predicting critical care needs in the prehospital setting, which could justify the use of AI to ensure appropriate triage and allocation of resources to the scene.[5] During transport, AI could provide accurate traffic information, rerouting ambulances as needed and updating the receiving hospitals while EMS personnel concentrate on patient care.[4] On the dispatch side, AI can aid in picking up key words in conversations with patients and prompting further questions, in addition to providing interpreter services, for patients with limited English proficiency.[4] A study in Denmark showed that AI speech recognition software could be utilized during a phone call with a patient to detect if the patient was having a stroke.[6,7] While earlier and more accurate detection of stroke patients could decrease morbidity and mortality by ensuring that patients are properly triaged and rapidly transported and treated, this technology also demonstrates how AI can augment the job performance of an EMS dispatcher.[6,7]

For rural EMS systems, which are often short on human manpower, AI could provide much-needed relief. With the help of AI, fewer dispatchers could handle a greater number of calls with more efficient resource utilization. Moreover, response times could also be decreased by utilizing AI's ability to detect pathology even outside of listening in and analyzing a 9-1-1 call. One group of researchers trained a software program to detect agonal breathing, which is commonly heard in patients with cardiac arrest, which they then incorporated into common household smart devices such as Amazon Echo and Apple iPhone with a high degree of fidelity.[8] This innovation could aid early detection of cardiac arrests and thereby decrease response times and, hopefully, mortality.

Other studies have shown the utility of using AI as a prognostication tool in both the prehospital and the hospital setting by helping health care practitioners identify critically ill patients or those who might benefit from early intervention.[6,9,10] In rural areas, where staffing shortages and training challenges might necessitate an advanced life support (ALS) unit having 1 paramedic and 1 basic emergency medical technician (EMT) (as opposed to 2 paramedics), AI could provide key cognitive support.

Another area of study for AI in the prehospital setting is predicting the location of the next 9-1-1 call to better allocate ambulances and personnel to areas of high volume.[6,11,12] Doing so would help streamline efficiency by placing EMS resources in the area where they will likely be most needed.[6,11,12] Although the population sparsity of a rural setting makes it more difficult to apply AI in resource deployment, AI might still be superior to the current models (such as posting ambulances at the same location daily or at the EMS station) and warrants further investigation.

Where, however, do we draw the line of what we permit AI to do? Technology that can recognize agonal breathing in a cardiac arrest needs to be listening in at all times in order to catch the agonal breathing—which might constitute an invasion of privacy, especially if the data are stored and used by the AI company for other purposes. While using AI to help prognosticate and diagnose may be helpful, it could also potentially be problematic in the same way that facial recognition technology has been recognized as problematic in recent years.[13] That is to say, AI algorithms are currently only as good as the data they were trained on, which introduces the potential for bias and racism.[13]

Moreover, solutions provided by AI do not always come with reasoning, resulting in a "black box" problem wherein AI generates decisions without humans knowing why.[14] In the prehospital setting, this lack of transparency can be ethically questionable since, from a patient quality and safety perspective, the reasoning behind potentially life-changing decisions is important to understand. There is an additional concern about overreliance,[14] which, in the context of EMS, means that systems become overly reliant on AI technology and fail to invest in human capabilities and the training necessary for their upkeep, causing people's skills to deteriorate.

Although these ethical questions are still being explored and many of these technologies are still in early phases of development and implementation, for rural communities, the alternative might be substandard care or no care at all. Therefore, it would be prudent to continue to invest in and utilize AI in a thoughtful manner.

Telehealth

Advances in video call technology and sharing of electronic health information, in conjunction with concentration of many subspecialties in urban areas, have created a niche and a need for telehealth. Telehealth is, broadly speaking, health care delivered remotely rather than in person.[15,16] Telehealth and its ability to increase accessibility to specialists is especially useful when transfer of the patient is not feasible due to environmental conditions or the time-sensitive nature of the intervention required.[15,16] In conjunction with EMS, telehealth can also be used to provide physician services to patients in the field, with paramedics or EMTs providing assessment and interventions in person, such as taking vital signs, performing physical exam maneuvers,[17] and administering medication. With this type of remote consultation, paramedics could be able to provide more advanced and immediate care to patients in the field or, similar to the guiding principles behind community paramedicine, could be able to prevent a patient from being transported to the emergency department unnecessarily.[17]

Telehealth consults, whether with an EMS physician or a physician of a different specialty, have already been implemented by multiple EMS systems.[18,19,20] These consultations can be used to treat and discharge a patient in place, treat and then transport a patient, and triage where a patient should be transported.[18,19,20] Telehealth consults are especially important in rural communities, where tertiary hospitals might be few and far between. For example, a patient with symptoms concerning for stroke might need a different (and further) hospital destination than a patient with symptoms concerning for Bell's palsy or altered mental status due to sepsis. A consultation with a physician might be crucial in differentiating between these presentations and helping route the patient to the appropriate hospital. Moreover, physicians can also be used to educate patients or EMS personnel about the case at hand. While educating EMS personnel would enhance their knowledge and their clinical practice, educating patients could prevent unnecessary transportation to the hospital in certain cases. Telehealth therefore has the potential to improve patients' experiences, increase access to care, and reduce costs.

Wearable smart technology, also known as wearable Internet of Things (IoT) devices, combines the advantages of AI and telehealth and could prove crucial to the advancement of prehospital medicine.[6] These technologies most commonly come in the form of smart watches, which include features such as photoplethysmography to measure heart rate, sensors to measure respiration rate, and single-lead electrocardiogram (ECG) for detecting atrial fibrillation.[21] Smart watches have been shown to be non-inferior to traditional methods of monitoring, such as ECG, Holter, and patch monitoring, for diagnosing atrial fibrillation.[21] Wearable IoT devices could therefore be utilized to supplement telehealth visits by providing the remote physician with longitudinal data or with acute data that a basic EMT might not be able to acquire (since, for example, obtaining an ECG is considered in most places to be a paramedic skill but not an EMT skill). This technology could be especially useful in rural settings where a paramedic might be a scarce resource.

A counterargument, though, is that telehealth in this sense might result in doctors directing paramedics to function and practice outside of their protocols. As long as paramedics are still within their scope of practice, it should be permissible for them to work outside of their protocol under the guidance of a physician, but to do so would mean that the physician takes responsibility—both legally and ethically—for the actions of the paramedic, which some physicians might be reluctant to do. Telehealth also necessitates that physicians make decisions based on information supplied to them by the EMS personnel. Remote physicians are not able to do a physical exam with their own hands and must rely on video and audio as a stand-in. These technologies are reliant on a strong internet connection, which in some rural locations might not be available.

Some could also argue that, at least right now, telehealth is not equivalent to in-person medicine with respect to patient care. There is much that can be seen or discovered through an in-person history and physical and through interventions that can only be provided in person. Therefore, are we doing our patients a disservice by encouraging them to utilize telehealth or by only giving them a telehealth option? A patient who could benefit from in-person physician services might be encouraged not to seek higher care if telehealth provides a more financially feasible and easier alternative. However, patients might place high value on the ease, comfort, and affordability of getting care delivered at home, which for many might outweigh the often only incremental gains they would obtain from visiting a tertiary hospital. Our job as ethical health care professionals is to ensure that patients understand their options and the risks and benefits that accompany those options so that they—and their communities—can make informed decisions on how best to integrate telehealth into health care.

Drones

Innovation in emergency medicine often comes first from battlefield medicine, and drones (also known as unmanned aerial vehicles) might prove to be another such instance. Lack of air superiority in recent conflicts has changed battlefield medicine from fast evacuations to prolonged field care.[22] While combat medics increasingly use drones to deliver medical supplies to the front lines for immediate care, the Ukraine-Russia war saw the first use of a cargo drone for a medical evacuation.[22] Being unmanned and airborne, drones have the capability to access places that humans cannot, either due to safety reasons or difficult terrain, which makes them a great asset in battlefield medicine.[23] These same advantages lend themselves to rural prehospital medicine and other similarly austere environments. Austere environments, which generally mean a setting with limited access to resources, can include post-disaster regions, military outposts or combat zones, or communities without easy access to medical services or other necessities.

Drones can be used to deliver blood products, supplies such as oxygen canisters, medications, or vaccines.[23,24] Drone delivery can meet critical needs of rural patients in a timely manner, and, if utilized appropriately, can save lives and resources. For example, imagine a rural patient who has a cardiac arrest witnessed by his wife. A drone could likely reach the patient faster than an ambulance to deliver an automatic external defibrillator (AED) for his wife to use, with verbal guidance from either the AED, drone, or live dispatcher over the phone.[24] Faster time to defibrillation means higher likelihood of return to spontaneous circulation and reduced mortality.[24]

However, there are distinct disadvantages to drone use in prehospital settings. Drones are expensive, require skilled operators,[23,25] and are limited in how much weight they can bear and by weather conditions.[23,25] Even with correct and timely delivery of supplies, humans are still needed to retrieve and use the delivered items. A question then arises: How should we weigh rapid health care delivered by civilians, with only verbal instructions from a drone or via phone, against a patient's suffering while awaiting the arrival of EMS personnel? Should allowing bystanders to give lifesaving care be considered an undue burden of responsibility for these civilians? How to best integrate drones into an EMS system is still being investigated, and it might be difficult to justify their high costs when benefits are yet unproven.

Yet drone use potential goes beyond the military and rural EMS. Already, drones have proven themselves by helping to map out hazards and topography in disasters and hazmat incidences.[26] For example, as early as 2013, drones surveyed the areas affected by Typhoon Haiyon in the Philippines, which aided in relief efforts.[26] Not only can drones alert EMS and disaster relief personnel to environmental dangers, but, by reporting on the locations and conditions of patients, drones can assist in directing and prioritizing relief efforts.

As AI gets incorporated in drone technology, drones have the potential to become autonomous, which means that we will need to ensure that their decision-making skills fall along ethical lines. For example, in a mass casualty incident (MCI) with 3 equally critically injured patients, a drone that is the first on scene may have to decide to whom to offer treatment first. In MCIs and disaster scenarios, the needs outweigh the resources, and decisions have to be made about how best to allocate those resources.[27] Although guidelines and a framework have been created by the Institute of Medicine,[27] there are no definitive rules on how or when to instigate crisis standards of care and how to make decisions within this framework. Recognition of how to handle complex medical and ethical decisions in disasters remains as much an art as a science. In the hypothetical MCI with 3 patients and only 1 drone on scene, should the drone make a decision based on which patient it encountered first, which patient is the youngest with the fewest comorbidities, or which patient has insurance?

Yet the needs of rural communities are great, and drone technology has much to offer in terms of lowering barriers to accessing care, increasing efficiency of health care delivery, and aiding in difficult situations. Although implementation of drones in EMS should be monitored and regulated, the advancement of technology should not be hampered by fear.

Guidelines for Integration

In rural communities, calls are often dispersed over a larger area due to the lower density of populations, which might make it more difficult to provide timely care. However, patients in rural areas are just as deserving of the standard of care provided in urban areas. While technological advances have clear advantages for and uses in rural EMS, investments in this technology must also be weighed against other shortcomings and challenges faced by EMS systems. Even with the assistance of drones or AI, the practice of prehospital medicine needs health care personnel on the ground, taking care of patients. It needs roads to reach patients, vehicles that can endure the rough environment, and community or critical access hospitals. Other initiatives, such as ameliorating overreliance on EMS volunteers, financing infrastructure projects, and creating a community paramedicine program, can add much value to rural communities.

That being said, the technological innovations in EMS should be embraced, as they offer improvement in the patient experience, easier access to care, and potentially lower costs for the patient. AI can decrease the cognitive burden of EMS personnel by streamlining dispatch and assisting them with prognostication. With telemedicine, a hospital admission or even a hospital transport can sometimes be avoided because EMS, in conjunction with telemedicine, can provide medical services to a patient in the comfort of their home. Meanwhile, drones can bring supplies to places that humans might not be able to access as quickly and provide key topographical data after natural disasters. The next step in incorporating these technologies in EMS systems is to develop guidelines for their safe and ethical use. Creating guidelines should be done with all stakeholders at the table, which means including not only technology experts, physicians, and EMS personnel but also communities and the patients these EMS systems serve. For, in a rural community, just as in any community, EMS and health care professionals should focus on serving patients, and a thoughtful use of new technologies can help achieve just that.

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