Leveraging Unmanned Aerial Vehicle Technology to Improve Public Health Practice: Prospects and Barriers

Sudip Bhattacharya, Md. Mahbub Hossain[1], Kyle Hoedebecke[2], Madonna Bacorro[3], Özden Gökdemir[4], Amarjeet Singh[5]

Department of Community Medicine, Himalayan Institute of Medical Sciences, Dehradun, Uttarakhand, India, [1]Department of Health Promotion and Community Health Sciences, School of Public Health, Texas A & M University, [2]Medical Director, Oscar Health, Dallas, USA, [3]Department of Family Medicine, University of Sto. Tomas Hospital, Espana, Manila, Philippines, [4]PhD Izmir University of Economics, Faculty of Medicine, Izmir, Turkey, [5]Department of Community Medicine and School of Public Health, PGIMER, Chandigarh, India

Abstract

Unmanned aerial vehicle (UAV) is increasingly being used in different sectors, including public health. Common applications of UAVs in public health are delivering logistics in remote areas, transporting biomedical samples, providing community-based health care, and public health surveillance. UAVs have contributed to efficient public health ensuring better health services activities at a lower cost. Across diverse health-care settings, UAVs are used to minimize human labor and physical barriers such as distance or hazards associated with different tasks. This technology has shown notable success in advancing public health in resource-constrained countries. In Rwanda, the use of UAVs has resulted in robust logistic support and improved vaccine coverage. Faster transportation and coordination between points of health services have facilitated the overall health service delivery. Despite these advancements, there are several challenges in using UAVs in public health, which include technical difficulties in operating UAVs, maintenance of devices and systems, regulatory challenges, safety concerns, air traffic congestion, and cost of using UAVs. These challenges should be addressed with empirical research and innovative interventions to leverage UAVs in preventing health-care problems and saving lives around the world.

Keywords: Drones, interventions, public health, unmanned aerial vehicle

"Patients frequently die because of lack of access to a basic medical product that exists in a central warehouse 75 km away but can't make it out that final mile to the person who needs it." (Rinaudo)

Introduction

An unmanned aerial vehicle (UAV) is defined as a "powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload."[1] During the 19th century, UAV was first used in war through a balloon carrier by the Navy in Italy.[2-4] Till then, many scientific innovations in aerospace engineering have advanced the structure and functions of UAVs. While they were previously limited to the battlefield, now their implementation is rapidly expanding. Such modern UAV uses include aerial air quality sampling, monitoring harmful gases in the atmosphere, industrial hygiene, safety management, road traffic accident study, flora and fauna monitoring, and in landscape ecology (e.g. the study of malaria associated with rubber plantations).[5] However, UAV application in public health is less explored compared to that of other fields. In this article, we discuss the prospects of using UAVs/drones in different areas of public health. In addition, we describe various advantages and potential barriers for successful use of UAVs in public health.

Application of unmanned aerial vehicles in public health

In the era of the 4th industrial revolution, it is very likely that UAVs/drones, robots, and artificial intelligence (AI) may replace many human tasks, reduce variability in processes, reduce errors, improve outcomes, and lower the cost of care.[6,7] In this way, UAVs can help overcome challenges faced by

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Address for correspondence: Dr. Sudip Bhattacharya, Jolly Grant, Dehradun, Uttarakhand, India. E-mail: drsudip81@gmail.com

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overburdened health systems.[6] A few examples of using UAVs for improving public health are highlighted below.

Delivering health-care logistics in remote locations

In many low- and middle-income countries as well as in isolated areas (e.g. mountainous and islands), it is challenging to deliver medical supplies including vaccines, drugs, food, and water to the disaster-affected populations. To date, air ambulances or helicopters are employed for such purposes. However, these platforms prove extremely expensive for most health-care systems. To bridge the distance and time gap for providing essential supplies to the affected population, UAVs should be considered as a viable solution.[5] Beyond the cheaper cost, UAV operations are much less complex than flying conventional helicopters for these services.[7-8] Recently, the Johns Hopkins University School of Medicine and the non-profit Field Innovation Team documented that UAVs can transport aid during disaster situations successfully.[9] After such promising findings, the former Director-General of the World Health Organization Dr. Margaret Chan remarked stated, "The use of drones UAVs to deliver lifesaving medical products can overcome the lack of infrastructure. We need to let our imaginations soar when looking for ways to get quality medical products to those in greatest need."[10]

Transportation of blood, medicines, and biologicals

In addition to routine logistics, UAVs can be used to transport blood, biological samples, diagnostic and therapeutic agents from one location to another facilitating better health service delivery. Recently, the UPS Foundation, Zipline, and Global Alliance for Vaccine Initiative have collaborated with the Rwandan government to transport blood and vaccines to rural areas in Rwanda.[5] Currently in Rwanda, UAVs deliver anti-rabies vaccines to dog bite patients in <15 min where previously access to treatment took over 2 h. The collaborative project is capable of delivering 150 packets of blood daily to the blood banks in the western half of the countries with UAVs specially designed for long-distance delivery.[5] In addition, these platforms are being implemented in trauma situations when the golden hour is important to intervene and save lives. Future implementation of UAVs includes sending organs for transplant swiftly to the recipient, bypassing the challenges of making a green corridor or airlift.[11] Studies had shown that kidneys transported in UAVs/drones did not experience damage related to extrinsic forces.[11] Furthermore, UAVs can be useful in hospital settings.[11] Indoor drones will be capable of dispensing medicines to the bedside of the patients without the help of pharmacists and nurses.[5]

The use of unmanned aerial vehicle in home-based and community level care

Recently, most of the operational researches regarding UAVs revolve around the delivery to remote areas or within health-care organizations, but UAVs/drones have the potential to deliver medications to patients in their homes. For example, in chronic diseases, like diabetes, many patients travel to hospitals merely to give blood samples or take routine medications. This imposes direct and indirect costs to both the patients and their providers. With a decision support system, such samples or medication can be delivered by UAVs at the individual patient level.[5] Research is also being conducted regarding how UAVs/drones can benefit the growing geriatric population. Recent advances have shown that small drones with special arms can be used to bring medicines, take hold of a glass of water, pick up spectacles from the table or even sort clothes.[12] Thanks to UAV technology, now, automated external defibrillators can reach to the patients in no time to provide rapid emergency interventions.[13,14] In this way, UAVs can be used for both acute and chronic health conditions and improve health services delivery in noninstitutional settings.

Public health surveillance

Surveillance can be performed in difficult areas or situations in public health with the help of UAVs. This technology proves helpful in finding the exact location of the survivors of collapsed buildings or boulders.[5]

Gamma-spectrometer attached to UAVs were used to measure nuclear contamination and assist in the creation of resolution maps of contamination following the earthquake (2011) and tsunami in Japan.[8]

Challenges of Unmanned Aerial Vehicles in Public Health

It is observed from the above discussions, UAVs/drones make it possible to deliver medical supplies to difficult areas, have the ability to reach victims in emergency situations, and save lives. They can play the role of a courier between hospital buildings, as well as in the community. UAV offers a range of exciting potential to the health-care industry, a potential that helps to save man-hours as well as money.[5]

However, there are some issues of deploying drones in public health. They are as follows:

Operation and maintenance

It requires trained staff and continuous monitoring from the ground. After some time, it can be overcome by gradual training.

There is a possibility of job loss for those who are currently involved in the transport of medical products, but they can be used in other important tasks such as care giving to the patients, surveys, and home visits for palliative care.[5]

Technical

UAVs/drones cannot carry heavier payloads or deliver goods to long distances, unlike helicopters. The payload of a usual UAV varies between 2 and 4 kg.[15,16] Now testing of UAV is in a pilot phase; the safety and efficiency of UAVs are yet to be fully established. Biological samples are delicate and need a proper package to prevent spilling during transit. Proper maintenance of temperature is also important for carrying biologicals and blood. The charge of the UAV battery is a big concern, which can be overcome using solar-powered UAV.[17] Alternatively, UAVs can be programmed in such a way that it can return-to-safe zone if the battery is suboptimal or in communication problem. Outdoor drones can fly with the help of GPS signals and radio frequencies to complete their tasks, but the reception of the signal is suboptimal in indoors.[5] This challenge can be overcome by Wi-Fi technology. Researchers also need to devise a way to completely automate UAVs/drones by embedding AI technology, so that, they can recognize their environment and remember their location.[5]

Regulations and legality

A major obstacle in the use of medical UAVs drones is the legal permission from aviation authorities. Till now, the use of UAVs/drones for a commercial purpose is not legal in India and in many other countries. Although in the United States, under the Federal Aviation Administration rules, license to fly UAV is granted and provided, the drone must weigh <25 kg, must not carry hazardous material, must remain within the visual line-of-sight with a maximum ground speed of <100 miles/h, must yield right of way to other aircraft and a maximum altitude of 400 ft above ground level.[18]

Safety of the public

A UAV can fall due to accident and injure public. It is observed that military UAVs have crashed and caused huge damage.[19] Studies found that a 13-year-old boy got skull fracture and a 9-year-old boy suffered a traumatic ocular injury during the use of commercial UAV.[19] Anxiety among the public exists due to fear of military drones in disturbed/extremist provinces. One study found that frequent attacks by military drones have increased mental health problems such as general anxiety disorder in Pakistan.[20] Civilian drones may be misused by extremists or terrorist groups during a terror attack. As a security measure, a tracker can be assembled with medical UAV.[5]

Safety of the unmanned aerial vehicle

Medical drones may be destroyed by armed forces due to nonrecognition. Hackers can hijack a drone using GPS jammers and loot the drone or its payload. In this case, hacking resistant software has to be developed.[5]

Air traffic congestion

UAVs may obstruct air traffic and cause confusion to commercial planes as it was seen in the United States.[21]

The cost

The initial cost of UAVs may be high. However, it may eventually decline with large-scale adoption across health services organizations where the benefits may outweigh the costs.

Conclusion

Initial results regarding the use of UAVs in public health are quite promising. However, assessment of public safety and privacy has to be done before scaling up of UAVs/drones in public health globally. More studies are needed regarding the safety issues. There is also a need for public health education program to alleviate the potential apprehension and anxiety about drones.

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Conflicts of interest

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