UAV FOR MEDICINE AND HUMANITARIAN PURPOSES: SCOPE OF OPERATION AND CHALLENGES

Martina KOŠČÁKOVÁ*, Peter KOŠČÁK, Peter KORBA, Michaela TIRPÁKOVÁ
Faculty of Aeronautics, Technical University of Košice, Rampová 7, 04121 Košice, Slovakia
*Corresponding author. E-mail: martina.koscakova@tuke.sk

Abstract. The use of drones is no more limited to commercial and environmental purposes. The incorporation of drones into medical and humanitarian actions has witnessed a significant advancement in recent years. The main purpose of drones for medical services is the fast delivery of various medical equipment and materials. Drones seem to be an ideal means for the creation of quick-access links between various medical facilities and people in need of assistance. Drones are ever more frequently deployed at disaster sites to facilitate search and rescue operations. As the drone deployment rate rises, the challenges and problematic issues are more apparent and the need for solutions more pronounced.

Keywords: drones; healthcare; delivery; medical supplies; emergency response

1. INTRODUCTION

UAVs (drones) have already proven their usefulness in various types of human activities and industries. The relatively small size, wide availability, speed and ability to handle various operations using cameras and other sensors make drones handy helpers who can effectively represent a person in several activities. The possibilities for their use continue to expand thanks to technological developments that seek to meet new market requirements. In healthcare, drones are used mainly in the delivery of blood, drugs, vaccines and other medical supplies and in rescue operations. Despite the fact that they have already proved their usefulness during multiple emergency events, their general use in medical logistics is still considerably limited.

There is still a social shadow behind the drones of doubts stemming from their possible misuse of privacy, human rights violations and irresponsible use by hobby pilots, who often do not even respect basic safety recommendations. This societal skepticism, combined with ever-evolving legislation that limits the use of UAVs in many countries, makes it impossible for drones to show their potential in full force. Nevertheless, several projects have emerged that are either already actually using drones for medical purposes or are under development or testing.

There are several countries that are currently involved in health projects using drones for medical services. Most of the projects are taking place in Africa, where the regulations are more flexible compared to Europe or the US and it is therefore much easier to get the approval of local governments to lunch a project or set up a drone network. Moreover, drones for medical purposes are frequently being used in South-East Asia in disaster emergency response after floods, landslides or typhoons.

2. USE OF DRONES FOR MEDICAL AND HUMANITARIAN PURPOSES

As very often, the marginalised communities, especially in developing countries are located in places characterized by difficult terrain and lack infrastructure, drones for medical purposes are used to help get access to appropriate medical care by delivering necessary medical supplies and health services in a timely manner. The drones are particularly effective as they can easily overcome geographic challenges that are problematic for other means of transport and can do so with a speed of up to 60-100 km/h [1].

Currently, UAV begins to fulfil more and more purposes within the field of medicine and humanitarian response, such as delivery (samples, medications, devices, etc.), search and rescue, surveillance and monitoring, response to disasters and mass causality incidents and communication, which we will look at in the following paragraphs.

2.1 Delivery

Delivery of supplies is one of the most frequent uses of drones for medical and humanitarian purposes. In Figure 1, we can see the percentual proportion of the main types of cargo delivered.
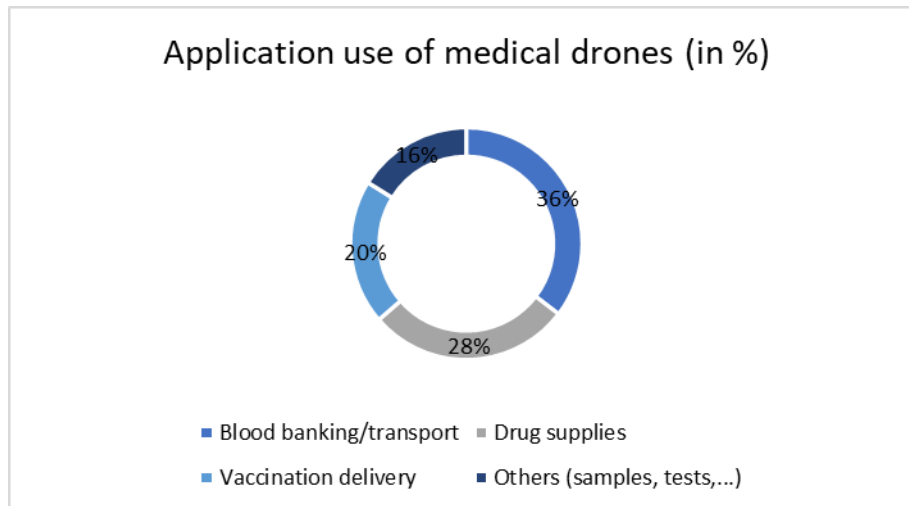

Figure 1 Application use of medical drones *(Source: Beroe Analysis,marketwatch.com)*

As some of the diagnostic tests are highly time and temperature sensitive and not all hospitals are appropriately equipped for conducting the tests, drones are frequently used to transport specimens, mainly in disconnected communities [8]. The safety of transportation of samples for the laboratory test by drones was proven by the study conducted at Johns Hopkins University which concluded that the quality of these samples are in no way affected by this means of transportation, and thus drones are appropriate for the transport of blood derivatives and pharmaceuticals [1].

Moreover, the timely transfusion of blood has proven to be essential in decreasing the death rate of patients suffering from uncontrolled hemorrhage, the main cause of preventable death in trauma [6]. This is also the case with pregnancy-related complications. For example, Rwanda was among the first to use transport of blood by drones to caregivers in rural areas, to help women that experienced postpartum hemorrhage, and has thus significantly reduced the risk of their death. Building on this, drones later began to be used as a fast, safe and cost-effective tool for the delivery of medicines such as epinephrine or insulin, antivenoms, vaccines and even body parts for transplant. [3, 8] According to some studies, drones are capable of cutting the average delivery time by up to 78.8% [6].

Other medical equipment transported by drones are small medical devices and supplies, which is particularly important in response to events where access by road is compromised, such as natural disasters [1]. One of such devices can be an automated external defibrillator. For example, in the event of a sudden heart attack, it is paramount that first aid is exercised in the shortest possible time, and with the drone delivery of the first aid kit, the bystanders can begin providing the care even before the arrival of the response team [3, 8].

Additionally, in the pandemic situations as we live today, when it is highly necessary to slow down the spread of the virus, some countries are making use of drones for the quick delivery of personal protective equipment, such as gloves, facemasks, but also drugs, tests, to the most affected and emergency sites and health facilities [3].

In case the immediate humanitarian response is necessary, there is no need to rely solely on the road infrastructure, that can be either blocked, damaged or even non-existing. UAV can be a very useful tool for the immediate transportation of the first wave of essential aid to the affected regions, and thus can maximize the relief impact and prevent the spoilage of necessities. At the same time, drones can be instrumental in minimizing the human lives´ loss by providing doctors with the necessary medical supplies, by transporting the medical devices directly to the victims that may be located at places that are difficult to access and can even facilitate the medical treatment by assuring the video connection with the emergency operators [7].

2.2 Disaster relief

In the event of a natural disaster, drones can prove to be highly useful in maximizing the effectiveness of the emergency response and reducing the response time [1]. During disasters, drones can be used as a tool to provide emergency surveillance, improve telecommunication services and facilitate search and rescue operations, as well as deliver the necessary supplies to places that are hard to reach or unsafe for the medical personnel. For example, drones were used for such purposes after the earthquakes in Haiti and Taiwan in 2010 and 2016 respectively, as well as after typhoon in the Philippines in 2013 and are frequently used in Nepal where they experience recurrent landslides, avalanches and floods [6]. In these cases, drones were used for surveillance of the damaged areas, their evaluation and creation of maps of the areas affected, to determine the range of the needed help as well as to establish which routes were still available for emergency use [1].

UAVs can be equipped with micro-radar systems, that weigh only a few hundred grams, and can therefore provide more accurate information compared to more traditional methods. This proved to be highly useful in the events of tornados and storms and can be also used for their detection and warnings before them [1].

2.3 Search and Rescue

During the search and rescue missions, drones are sent to examine the emergency sites and look for potentially injured persons. The search is conducted using special video and photosensors that include thermal imaging. These results are then sent to the software for image recognition that is able to identify and locate human bodies. If any individuals are located within the site, they are sent the necessary medical equipment along with other essential resources, such as food and water [1]. At the same time, the remote sensing system installed in UAVs can ensure safety and reduce the risk for the rescue personnel, as it can provide the surveillance of the dangerous areas that are inaccessible, such as steep slopes and swampy fields. It is also essential for quick assessing of the damages and provides timely and accurate information which leads to the quick location of survivors and causalities [7].

In the mountainous and hard to access areas, drones are implemented in the search for lost hikers or skiers under the avalanche, as their thermal and multispectral imaging makes it possible to detect gases that can be found around the victim. At the same time, in the coastal areas, they serve for surveillance of the sea to detect potential victims of drowning or distress swimmer and can immediately provide him with a floating device [6].

Furthermore, many drones are able to accurately and reliably identify a wide range of gestures, even from a distance, and can therefore facilitate and assure a constant line of communication among the search and rescue personnel [6].

3. CHALLENGES

As all the new technologies, drones' usage for medical and humanitarian purposes is facing many new challenges that need to be resolved on several levels, including advancements in technology, widening of resources, improvement of the legal environment and supporting social acceptance. Throughout the next paragraphs, we will present the most daunting challenges that need to be addressed, such as lack

of regulations and guidelines, privacy and security issues, technological problems and concerns about safety.

3.1 Regulations

One of the main challenges faced by drones for medical and humanitarian purposes is the lack of appropriate regulations. While, according to FAA estimates, more than 7 million drones are currently flying worldwide, only 57 countries have established official regulations and a great part of them is focused on bans of drones rather than on guidelines for their safe and legal use. Furthermore, the problem arises mainly for the marginalized and isolated communities living along the borders, that are most in need of the use of drones, as there is practically no harmonization of the regulations on a cross-border basis [2].

Due to this lack of regulations and guidelines in some of the countries, many of the health projects that would like to establish the use of drones cannot move forward. Moreover, frequently, even if there are regulations, these do not cover health-related safety and privacy issues, transportation of medical supplies or samples and therefore do not apply to the medical use of drones. Providers of health projects are facing also another problem related to the limitations to the radiofrequency, altitude, distance covered and cargo weight are implemented in some of the regulations that do not support the use of drones for medical purposes [4].

As a result of this inappropriate legal environment, most of the usage of drones for medical services is currently limited to African countries, such as Rwanda or Ghana, where the regulations are not so rigorously set and more flexible and where airspace is less congested compared to, for example, Europe or the US [6].

3.2 Privacy and Security

As the main purpose of drones used in medical services is saving more lives by efficient delivery of medical supplies, it should be kept in mind, that this can in no way result in an invasion of people´s privacy and violation of basic human rights [3]. Due to the fact, that in providing remote medical attention protected health information are transmitted, drones for medical purposes, unlike the ones used for commercial or environmental purposes, must comply with the regulations concerning the protection of confidential and private information [6]. Another concern, during the disaster response, is that information shared with first responders through the drone may be made public and so compromise privacy and create panic [7].

Likewise, concerns of the public over their privacy and issue of consent are arising, when the drones are flown above their heads. A great number of people is skeptical towards this and see the use of drones as a violation of their privacy, more so, as the use of drones is in minds of many related to the military and thus perceived as a tool for control or spying [7].

3.3 Technical issues

The main technical challenge faced by drone operators is climate-induced operational limitations. The bad weather can result in the complete loss of control over the drone and equipment and systematic failure. However, the most daunting issue is related to battery performance, which is influenced by both low and high temperatures. Low temperatures result in decreased efficiency of the battery, while high temperatures can cause higher consumption. Therefore, there are considerable constraints related to the possible distance flown as well as altitude [7].

Another challenge is related to the network. If the constant medical drone operation should be provided, there rises a need for the establishment and maintenance of the network of drones and pilots along with the development of physical operational infrastructure, as well as radiofrequency for the command and control of the fleet [6].

3.4 Safety

Drones are no exception among the new modern technologies when it comes to concerns about safety and potential malfunctions. They may arise some errors during the flight, but more dangerously, drones are more prone to hacking or crashing into obstacles. Therefore, to prevent such events, it is necessary to further incorporate drones into the already existing flight paths and communication. Further safety issues are related to the right packaging of the deliveries, which can also include dangerous materials, or the possibility of an injury from the direct contact with a person during takeoff, landing or unloading of the delivered materials. Furthermore, the communities, where the drones are operating, are often concerned that the drones may be misused for other than medical purposes in the future, such as biological warfare, which would put them at higher risk [6, 4].

4. DISCUSSION

In the following table, we identify the most pronounced benefits as well as shortcomings of the usage of drones for medical and humanitarian purposes that were identified during the research. The table suggests that the use of drones has become instrumental for medical purposes as well in achieving fast, safe and effective humanitarian response, however, as it is a new field of use, therefore, there are considerable shortcomings that need to be addressed in a timely manner in order to achieve the best possible results.

Table 1: Benefits and shortcomings of drones used for medical and humanitarian purposes

Benefits	Shortcomings
- Delivery of test samples, medications, anti-venoms, vaccines	- Lack of regulations and network
- Reduction of travel time for diagnosis	- Lack of training and experience
- Transport of transplant organs, AED	- Issues of medical supplies storage
- Support of medical facilities´ network	- Short battery life – distance reduction
- Wider availability of vaccines and drugs	- Small cargo load
- Telehealth – medical assessment through video	- Vulnerable to weather
- Ensures higher safety in disaster-affected areas	- Limited bandwidth
- Cost-efficient alternative for actions in complicated terrain	- Location inaccuracy
- Provision of accurate, timely, first-hand information	- Technological and design issues
- Enhancement of better communication lines	- Privacy and safety issues
- Mobility and reliability of the wireless network	- Negative public perception
- Operational flexibility and effectiveness	- Accountability and responsibility issues
- Environmentally friendly	- Lack of financial resources – need for big investments
- Low energy consumption	

From the previously stated facts, we can conclude, that medical and humanitarian drones began their incorporation into the system and began to be essential in saving lives. Drones have proven themselves to be the fast link connecting first responders with the victims, as well as medical facilities with patients and among themselves. They can be used to create a link between the medical facilities in the rural areas, with limited resources and diagnostic abilities, with the nearest hospital or laboratory and thus bring a higher level of medical care to the remote communities.

Probably the greatest strength of drones is their possible quick use. In a very short time, drones can deliver samples for the diagnosis or body parts for transplantation. They are becoming essential in the delivery of medicines, antivenoms and vaccines and thus making them more accessible. The unique feature of the drone is the possibility to use them for telehealth – the medical assessment through the video transmitted by a drone which can bring basic medical care nearer to the marginalized population.

Within the humanitarian use, the most pronounced benefit to the usage of drones is their quick deployment and the possibility to use them in the hard to access areas so that the safety of the rescue personnel is maximized. Moreover, they become essential in search and rescue operations, due to their ability to detect human bodies as well as their great use in improving communication, and what's important, the possibility to maintain the communication network despite the possible destruction of ground communication lines.

On the other hand, it is important to state the challenges of this field that need to be resolved. In the following paragraphs, we will address some of these challenges and provide recommendations for the direction of further research in the field.

First and foremost, it is important to focus on the creation of regulations and guidelines for the use of drones in humanitarian and medical services, as most of the countries lack the legislative for their use, and even if the regulations are present, they are often not relevant for the use in medicine. Many of the developers of the humanitarian projects using drones call for guidelines specific for this type of use. Moreover, it is highly essential to create regulations on the international level and harmonize the rules at the cross-border level, as the communities most in need of help by drones are very often located along the border.

Secondly, it is necessary to focus on the specific design of the drone for medical purposes, as currently there is not a model developed specifically for this type of use. It is important to look for ways to strengthen its cargo capacity while keeping in mind that the cargo space must be appropriate for transportation of either dangerous materials or fragile delivery. In the matter of design, engineers should also look at the possibilities of equipping the drones for search and rescue missions with other new technologies such as different kinds of sensors, cameras or electronic sniffers. Furthermore, the most daunting task is to find a way how to prolong the lifecycle of the drone batteries, as this is essential in prolonging their flight distance. In this regard, a solution of powering the drones through solar energy is offering itself. Another solution could be the equipment of the drones with a return-to-safe location system in the case of low battery levels, which would prevent the crash.

Thirdly, there is a need to resolve the problem with the lack of human resources in the development of medical drone projects in developing countries. This is associated with a lack of training and experience. This matter could be resolved only by the greater number of organizations engaging in the training the drone operators and by the higher level of cooperation and coordination on an international level and better sharing of knowledge.

Moreover, if we want to establish a working and permanent network of the drones for medical services that would be used for the response to the emergencies, it is necessary to incorporate this network first into the existing flightpaths but also into the real data system for their accurate location and EMS system of the emergency dispatching. Then, the types of emergencies to which drones could be automatically dispatched should be identified. What´s important is also taking into account the position of the general population and practical implementation of the system, as its effectiveness would be compromised if, for example, bystanders were not able or not willing to use the first aid kit delivered by drone before the arrival of first responders.

Finally, it is necessary to get the consent and support of the general public for medical and humanitarian drones, as many of the humanitarian projects fail because of the negative public perception. Many people still see drones as the tool of the governments for warfare, surveillance and control. Thus it is important to incorporate into legislation also privacy and security provisions related to data storage.

5. CONCLUSION

Although the use of drones for medical purposes is a relatively new phenomenon, drones have already proven their place within medical and humanitarian actions. They are undoubtedly fast and effective tools used for emergency response as well as for the delivery of medical supplies. It is its ability to create quick connections between the facilities and person in need, as well as their ability to reach the places impossible or dangerous for other means of transport.

On the other hand, there is still a bunch of issues that need to be resolved, mainly regarding regulations, safety, privacy and security and design. However, the advancement in the field is swift and therefore it is expected that the necessary solutions will be brought out soon.

In the recent two years, we could witness the widened scope of use of drones for medical services during the COVID-19 pandemic. The pandemic has helped to boost some of the aspects of the drone delivered healthcare. Drones were used for the delivery of drugs, vaccines, food and goods, as well as for surveillance, warnings, thermal monitoring and disinfection of places.

Finally, it can be said that given all the benefits of the drones for medical purposes and their low environmental impacts, that is highly important now, when we need to significantly cut the CO_2 emissions, it can be assumed that drones will play an important role in the future healthcare.

Acknowledgements

References

[1]   Wulfovich, S., Rivas, H., Matabuena, P. *Digital Health: Scaling Healthcare to the World. Chapter 11: Drones in Healthcare*. Springer International Publishing AG. 2018. 372 p.

[2]   Amukele, T.K. Current State of Drones in Healthcare: Challenges and Opportunities. *The Journal of Applied Laboratory Medicine.* 2019 4(2):296-298

[3]   Nyaaba, A.A., Ayamga, M. Intricacies of medical drones in healthcare delivery: Implications for Africa. *Technology in Society*. 2021. Vol. 66

[4]   Jeyabalan, V., Nouvet, E., Meier, P., Donelle, L. Context-Specific Challenges, Opportunities, and Ethics of Drones for Healthcare Delivery in the Eyes of Program Managers and Field Staff: A Multi-Site Qualitative Study. *Drones.* 2020. 4,44

[5]   Euchi, J. Do drones have a realistic place in a pandemic fight for delivering medical supplies in healthcare systems problems? *Chinese Journal of Aeronautics.* 2021. 34(2):182-190

[6]   Johnson, A., Cunningham, Ch.J., Arnold, E., Rosamond, W.D., Zègre-Hemsey, J.K. Impact of Using Drones in Emergency Medicine: What Does the Future Hold? *Open Access Emergency Medicine*. 2021. 13 487-498

[7]   Rejeb, A., Rejeb, K., Simske, S., Treiblmaier, H. Humanitarian Drones: A Review and Research Agenda. *Internet of Things*. 2021. Vol. 16

[8]   *Drones in healthcare: Blood transportation and beyond. 2021.* HealthcareTransformers. 2021. Available at: https://healthcaretransformers.com/healthcare-business/drones-healthcare/

[9]   Grote, M.. Cherrett, T., Oakey, A., Royall, A.G., Whalley, S., Dickinson, J. How Do Dangerous Goods Regulations Apply to Uncrewed Aerial Vehicles Transporting Medical Cargos? *Drones*. 2021. 5, 38

[10]   Zubin, I., Van Duin, J., Wiegmans, B., van Arem, B., Using Drones in the Last-Mile Logistics Process of Medical Product Delivery: A Feasibility Case Study in Rotterdam. In: *The 99th Annual Meeting Transportation Research Board 2020.* Washington D.C.

[11]   Ghelichi, Z., Gentili, M., Mirchandani, P.B. Logistics for a fleet of drones for medical item delivery: A case study for Louisville, KY. *Computers and Operations Research*. 2021. Vol. 135

[12] Rosser, J.C. et al. Surgical and Medical Applications of Drones: A Comprehensive Review. *Journal of Society of Laparoscopic &Robotic Surgeons*. 2018. Vol 22(3)

[13] Tin, D., et al. Rise of the Unmanned Aerial Vehicles: An Imminent Public Health Threat Mandating Counter-Terrorism Medicine Preparedness for Potential Mass-Casualty Attacks. *Prehospital and Disaster Medicine*. 2021. 00(00):1-3

[14] Poljak, M., Šterbenc, A. Use of drones in clinical microbiology and infectious diseases: current status, challenges and barriers. *Clinical Microbiology and Infection*. 2020. Vol 26:425-430

[15] *Medical Drones Market Size By Application (Blood transfer, Drugs/Pharmaceutical Transfer, Vaccination Program), End-Use (Emergency Medical Services, Blood Banks), Industry Analysis Report, Country Outlook, Application Potential, Competitive Market Share & Forecast, 2019 – 2025*. 2019. Global Market Insights. Available at: https://www.gminsights.com/industry-analysis/medical-drones-market