

Managing Efficiently Future Pandemics

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Áine Carroll
The Future of Healthcare in the Wake of
COVID-19 - Time for a Paradigm Shift

Jodi Keller, Nancy Lehr, Melissa Rose et al.
Surge Operations Call Center: Managing
Capacity Through Innovation and Collaboration

Giuseppe Tortora, Davide Caramella
Autonomous Delivery of Medical Material
Through Drones in a Future Pandemic

Hannah Jackson, Pooja Arora
The Challenges of Being a Locum GP Post
COVID-19

Amit Vaidya
Pharmaceutical Development Trends & Their
Impact on Healthcare Policy Planning & Delivery

Rahul Varshneya
Data Management Challenges in Healthcare
That Need to be Addressed to Improve Efficiency





Autonomous Delivery of Medical Material Through Drones in a Future Pandemic

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An overview of the logistic challenges during the pandemic, the use of drones to trigger logistic advancements both in normal operational conditions and in emergency situations, and the new set of possibilities introduced by autonomous drones to reduce legacy vulnerabilities of healthcare systems.



Key Points

- COVID-19 highlighted the need for improvement in existing logistic methods for the transport of biological samples.
- The drastic restrictions of the movement of people and vehicles implemented to reduce the chances of contagion caused unexpected criticalities in blood donation.
- COVID-19 diagnosis was often slowed down by the uneven workload of the laboratories that read the swabs, causing delay in the communication of the diagnosis to patients.
- A drone-based delivery system could connect mobile clinics and analysis laboratories with hospitals to avoid unnecessary direct contacts and speed up the transport.
- The role of drone systems for the transport of biological samples plays a pivotal role. However, the technological development of drone systems has to be carefully monitored.

A valuable lesson learned during the COVID-19 pandemic is that the existing logistic methods for the transport of biological samples need to be reengineered. In the months during which draconian non-pharmaceutical interventions were implemented worldwide to contain the diffusion of the virus, the disruption of many delivery chains might have been less severe if unmanned aerial vehicles, or drones, had been available to enable efficient and contact-free delivery of medical goods such as blood supplies, organs for transplants, and healthcare products.

The drastic restrictions of the movement of people and vehicles implemented to reduce the chances of contagion caused unexpected criticalities in blood donation. A reduction of blood donors was observed due to the inability of the donors to leave home during the shutdowns. If a drone service had been available, the blood might have been collected directly at the home of the donors by a nurse and the blood samples might have been sent to the hospital by using an automatic and safe

delivery system via drones.

Moreover, during the pandemic, strict policies were introduced to reduce as much as possible the entrance of healthy individuals into hospitals in which the circulation of the virus was rampant. These policies had a negative impact on blood donations, too. If blood collection centres had been established in safe areas outside the hospitals, the logistics might have benefitted from sending blood samples to the collecting centre by means of drones.

Another lesson learned concerns the COVID-19 diagnosis, that was often slowed down by the uneven workload of the laboratories that read the swabs, causing delay in the communication of the diagnosis to patients. This in turn resulted in unnecessary quarantine and loss of working days when a negative result was delayed. Drones might have been employed to efficiently balance the workload by preferentially distributing the swabs to the less active reading centres, thus avoiding backlogs.

Basic Features of a Drone System

In general, a distinct advantage made possible by drones is the improvement of service in remote locations or sparsely populated areas (e.g. islands, mountain villages, etc.). In fact, a drone-based delivery system allows to connect mobile clinics and analysis laboratories with hospitals, to avoid unnecessary direct contacts between people, and to speed up the transport by reducing the time by 80% at a negligible cost for the single delivery.

A drone delivery system can be used in any place, at any time and it works in densely populated urban areas as well as in sparsely populated locations. Drones have the advantage of low overhead costs and are a potential way around traffic delays, the unavailability of passable roads, and when roads are non-existent for large parts of the year.

However, drones can be used in the transport of potentially lifesaving goods only if there is a guarantee that they do not adversely affect the quality of the payload (Amukele 2019). Therefore, any concern about maintaining the original quality of the payload throughout the duration of the flight must be addressed very carefully, to persuade all stakeholders that drones are indeed a reliable asset for the improvement of healthcare organisational models.

The key component of the drone system is the smart capsule, a container that is primarily designed to ensure preservation of the payload (Amicone et al. 2021). The design of the capsule must be flexible and modular, in order to allow to transport any

- Autonomous flight control, without need for trained ground pilots.
- Ability to fit professional drones compliant with given technical requirements (e.g., 10 kg load capacity, 60 km/h minimum speed, water and wind proof).
- Compliance with the continuous evolution of drones, thanks to a dedicated adjustable interface.
- GPS/GSM/3G/4G connectivity that allows to control and modify the flight according to flight authorisation requirements. The connectivity also guarantees the recovery of the active control by drone operators in case of emergency.
- Temperature and humidity sensors for real-time monitoring and control of storing conditions and quality of the medical freight, as prescribed by blood delivery regulations.

Within the capsule, a certified UN3373 container must be equipped with temperature stabilisers that contribute to maintaining the right temperature. The temperature stabilisers are cooled in order to reach a suitable temperature (4 °C, 22 °C, -25 °C) before being inserted, together with the medical material, in the UN3373 container before every flight. Their action in addition to the thermal-insulated material of the capsule make temperature stabilisation possible for about three hours, which is a more than suitable time for one delivery mission.

In the target application (delivery of highly valuable and perishable medical goods), the capsule must allow the continuous tracking of the payload: to this aim the role of Artificial



medical product (e.g., blood bags, organs, drugs, test samples). The main features of the capsule are the following:

- High mechanical resistance, ensured by the choice of polyurethane material that is available off-the-shelf and can be manufactured according to high-quality standards based on the design of the device. Some parts of the capsule can be manufactured out of metal (aluminum, steel) for structural reasons.

Intelligence (AI) is crucial. The on-board control intelligence must be able to take over the control of the flying vehicles it is mounted on, or to make it redundant, thereby guaranteeing double insurance for successful mission completion, allowing the capsule to make autonomous decisions about distances, route changes, emergency manoeuvres, and landings. Moreover, AI makes it possible to meet the strict regulations of drone flight in urban scenarios by reducing the overall risk of



operations through mandatory specific operation risk assessment, according to JARUS guidelines (2019).

Future Challenges

The COVID-19 pandemic unearthed several criticalities in our healthcare systems that had been underestimated for years: from poor stock management of personal protective equip-

- Thermal and mechanical improvements by using finite element method (FEM) simulations and suitable crash tests.
- Autonomous reaction of the drone-system to undesired events in case of an emergency by further deploying AI inside the control loop in order to implement suitable strategies for risk mitigation in case of emergency.

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ment and insufficient preparedness in intensive care units, to supply chain issues and logistical bottlenecks.

The best way to be prepared to face new healthcare challenges such as a future pandemic is to rethink the current practices and optimise workflows to introduce resilience in the system.

In this context, the role of drone systems for the transport of biological samples plays a pivotal role. However, the technological development of drone systems has to be carefully monitored with particular attention to:

- Safety aspects, including cybersecurity criticalities with implementation of effective countermeasures to prevent the drone system from being tampered with by malicious users (i.e., hackers).

- Labelling for unequivocal identification of the drone system in the medical environment.

In conclusion, the use of drones for healthcare applications holds the promise to trigger logistic advancements both in normal operational conditions and in emergency situations, in which the new set of possibilities introduced by autonomous drones may reduce some legacy vulnerabilities of our healthcare systems.

Conflict of Interest

Giuseppe Tortora is founder and co-owner of ABzero (www.abzero.it), a startup company producing a smart capsule for blood delivery through drones. ■

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