Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Short communication

Aerial Bots in the Supply Chain: A New Ally to Combat COVID-19

Nitin Koshta *, Yashoda Devi, Sabyasachi Patra

Indian Institute of Management Kashipur, Kashipur, Udham Singh Nagar, Uttarakhand, 244713, India

A R T I C L E   I N F O

Keywords:
COVID-19
Drone technology
Pandemic
Supply chain management

A B S T R A C T

The rapid global spread of COVID-19 has caused disruptions in various supply chains and people’s lives. At the same time, it has paved the way for drone technology (Aerial bots). With the countries gone into lockdown for an unspecified time, it is self-evident that people will run out of food, medicine, and other essentials because of the middleman’s unavailability to move products from supply to demand point. Lack of medical infrastructure and distant testing laboratories is another challenge faced by the countries, which result in a delayed testing report leading to delay in medical treatment—such critical problems arising in the fight against COVID-19 highlight the need for improving the efficiency of supply chains. Recently used for commercial purposes, drone technology has already proved its utility in inventory and logistics management. Therefore, we argue that drones could be a viable option to improve the efficiency and effectiveness of the supply chains working for humanitarian aid to combat COVID-19. Specifically, the focus is on food, administrative, and healthcare supply chains that are the core to combat the pandemic. Moreover, in this article, we highlight various present and future application areas for drone technology, which could pave the way for future research and industry applications.

1. Introduction

The science of supply chain management for humanitarian aid has become critical because of hundreds of natural and human-made disasters that affect millions of people every year across the globe [32]. According to the Centre for Research on the Epidemiology Disaster, a total of 6457 weather-related disasters occurred between 1995 and 2015, claiming 606,000 lives and 4.1 billion left injured [8]. Moreover, between 2011 and 2018, 1438 epidemics outbreaks were recorded by World Health Organization [10]. The present COVID-19 pandemic, however, is unique. It has had a global impact and caused a more severe and dynamic impact on peoples’ lives than any other epidemic outbreak or weather-related disaster [7,14]. For example, till May 2021, COVID-19 has already claimed approximately 3.8 million lives, and almost 176 million are suffering from it, while the pandemic is still ongoing [33]. Moreover, unlike other epidemic viruses, the COVID-19 molecules can remain suspended in air or rest on material surfaces for hours and transmitted through them to other people. In other words, air and the material surface can serve as a mode of transmission for COVID-19 [23].

The medical practitioners’ highlight that the level and intensity of social contact are crucial determinants of COVID-19 spread and suggest that social distancing is the best option to confine its spread [18,21]. Considering these suggestions, countries worldwide have gone under either complete or partial lockdown [16,20]. For example, travel between and within the country by any means, including air, rail, and road, is prohibited. Educational institutions have been kept closed, industrial and commercial activities have stopped, supermarkets, malls, and theatres are shut, people are not allowed to visit worship places to avoid social contact [22]. However, these measures are likely to make it difficult for people to meet their daily food, medicine, and other essentials requirements if they run out of stock [19]. Moreover, lack of awareness and misinformation among people may result in lockdown violations and increase the risk of virus spread. To this end, aerial bots (or Drone), because of their various advantages such as remote operations, aerial view, and lack of dependence on road infrastructure, could be a viable option for various supply chains [17].

Since the COVID-19 outbreak, scholars have actively been engaged in assessing its impact on people, supply chain, and society as a whole to support the policymakers and practitioners in decision making. For example, Usher et al. [28] highlighted how the pandemic had impacted peoples’ mental health and a proposed a framework for recovery from mental health. Ivanov and Dolgui [11] reported the impact of the pandemic on the supply chain and highlighted the strategies to improve supply chain resilience. Moreover, Singh et al. [23] suggested how three-dimensional printing technology could be leveraged to...
manufacture essential products to support society during pandemic outbreaks. However, to the best of our knowledge, there are no studies on the application of aerial bots to combat COVID-19. Therefore, the purpose of this article is to not only highlight the applications of drones in various supply chains during the COVID-19 outbreak but also to inspire future research in this direction. Specifically, the implications of drones in healthcare supply chains, food supply chain, and administrative purposes have been considered in this study.

### 1. Aerial bots and their industry applications

Drones are no more a future thing but a present-day reality. Aerial bots or drones are unmanned aerial vehicles (UAVs) that can be operated either autonomously or remotely by humans. Different classifications of drones exist; based on engine type, weight carrying capacity, range, flying altitude etc. These days, aerial bots can carry a weight of more than 500 kg and can have a flight range of more than 1000 km. The drones initially found their use in military operations [4], such as rescue operations, surveillance, reconnaissance etc. [6]. In recent years, the advancement in technology has enabled the commercial use of drones. For example, in December 2016, Amazon, with permission from U.S. Federal Aviation Administration, successfully tested its first last-mile delivery using aerial bots. Its aerial bot named MK27 can carry up to 5 pounds of weight and deliver the product in less than 30 min.

Similarly, Walgreens and FedEx are using drone technology for last-mile delivery. Walgreen, along with Wings, a drone service provider owned by Alphabet, pilot-tested their first last-mile delivery by delivering facial tissue, cough drops, water bottle, Tylenol, and Emergen-C [5]. Another example of the use of aerial bots is by Walmart in their warehouses for inventory management. Their inventory drones perform activities such as the movement of items, locating specific inventory, surveying large areas, inspecting labels etc. These machines have an advantage over human beings as they can perform inventory management tasks in a day that would take weeks for them to perform. Furthermore, the chances of error are significantly less, making the supply chain efficient [1].

An example of the use of drones in healthcare supply chains is by Zipline. In Rwanda, the company uses its fixed-wing drones to deliver blood, medicines, and vaccines to remote areas. The use of drones in Rwanda’s healthcare supply chain has reduced the delivery time from 4 h to 30 min in some cases [2]. Similarly, Flirtey delivers medical essentials to healthcare facilities in Virginia, and Matternet is distributing medical supplies to remote healthcare facilities in Lesotho [17].

#### 1.1. Aerial bots and their industry applications

With the global lockdown extending to an uncertain period, the people will likely run out of essential items. Moreover, the need for social distancing has created room for the new application of aerial bots. Therefore, in this section, we highlight how aerial bots can be used, by various supply chains, to respond to the pandemic outbreak.

#### 1.2. Aerial bots to combat COVID-19

Testing samples for COVID-19 within a short window of time is vital as it helps identify infected individuals, isolate them, and provide medical treatment. Further, it could also assist in the efficient allocation of staff and resources. Setting multiple testing laboratories can be a solution to achieve this, given the number of testing kits and time required to test the sample are constant. For example, in a densely populated country like India, there were only 52 coronavirus testing laboratories, which were increased to 1300 by July 2020 [24]. However, due to a lack of infrastructure and funds, many countries are often unable to establish a large number of testing laboratories. Under such circumstances, aerial bots could be deployed to ensure timely delivery of test sample to the testing laboratories. For example, with only two testing labs in the entire country, Ghana has conducted approximately 70,000 tests, having one of the highest testing rates in Africa. It was made possible by flying samples to the testing labs using drones [3], spotlighting the utilisation of drone technology in the fight against COVID-19.

Given the severity and contagiousness of COVID-19, the medical staff engaged in the treatment of infected individuals are not safe. As many as 3300 health workers in China got infected while treating COVID-19 patients, and 22 died. In Italy, nearly 20% of health workers got infected, and some lost their lives [15]. Using personal protective equipment (PPE) does not eliminate the need for sanitisation after visiting an infected individual. Moreover, using the aerial bots for spraying sanitisers will help the healthcare workers eliminate any physical contact with any person or thing before being sanitised if they have visited an infected individual. Further, utilising the aerial bots for disinfecting used PPE and load them in the trucks for safe disposal will eliminate human contact with the used PPE.

Due to limited supply and limitation in increasing the production of PPE, freighters carrying PPE are moving across national boundaries to fulfill the demand. These PPE need to be disinfected before being used [30]. With its capability of eliminating direct human contact, drone technology can be used to unload and disinfect the imported PPE. Additionally, the aerial bots have their application in the last-mile delivery of medicines, i.e., delivery of required medication to customer doorstep.

#### 1.3. Healthcare supply chain

For the success of large-scale lockdown, it is crucial to ensure that peoples’ need for food, grocery, and other essential items are fulfilled on time. At times, in areas of high density or huge population within an administrative boundary, catering to the needs of the people could be very complicated and time-consuming. These challenges highlight the need to effectively and efficiently maintain the logistics for the last-mile delivery of food and other essentials. Deriving motivation from the last-mile delivery by Amazon and Walgreen, the drones could be employed to complete this highly cumbersome and time-consuming task of last-mile delivery with ease. The advantages of using drones in last-mile delivery include low-cost operation, fast delivery, and is environment friendly [31]. Last-mile delivery will enable on-demand delivery of food, groceries, vegetables, or fruits and help the mom-and-pop store and restaurants acquire the business and maintain income. Moreover, the pandemic outbreak has resulted in job and income loss of rural households and disrupted the local food supply chain. Thus, affecting the quality and quantity of diet of the people living in those areas [19]. As a result, large drones should be used to transport food supplies in bulk in these areas to improve access to healthy food.

#### 1.5. Administrative purpose

For administrative purposes, the aerial bots could assist in monitoring and enforcement of the law. In a recent incident in India, named the Tabligi Jamaat incident, around 9000 people took part in the religious reconciliation despite the warnings to maintain social distancing and avoid public gatherings [9,27]. This incident resulted in a sudden increase in the number of COVID-19 cases in the country [26]. In another incident, thieves stole Lentetuin, a painting by Dutch master Vincent van Gogh, from a museum in the Netherlands that was closed due to COVID-19 [29]. In Hong Kong, armed robbers stole 600 toilet rolls from a supermarket delivery man [25]. These examples show that despite the pandemic outbreak, unlawful acts have not stopped. With empty roads all around, police staff is overburdened for maintaining law and order. However, with overburden comes human limitations to handle it. Hence, drone technology could be a solution to this problem. Aerial bots fitted with cameras could be used for patrolling purposes, as used by the military for surveillance. These drones could also be
The aim is to utilise drone technology to its full potential and revolutionise the supply chains to make them future-ready. Finally, the future research directions aim to instigate new research on the topic.

2. Conclusion

The COVID-19 pandemic has brought numerous challenges affecting every aspect of society. As the countries enter different pandemic stages, it is essential to have stringent regulations to confine its spread. In this regard, efficient food and healthcare supply chains will ensure food and medical essentials availability at consumers’ doorsteps to limit their visits to retail stores. While effective administration should ensure there are no public gatherings and crimes, and people strictly follow social distancing. We argue that drones are a viable option to improve the resilience and efficiency of these supply chains. Specifically, in this article, we propose various applications of aerial bots or drones in retail stores and restaurants due to lockdown restrictions and market visits to retail stores. While effective administration should ensure there is medical essentials availability at consumers’ eyes view of places.

2. Conclusion

The COVID-19 pandemic has brought numerous challenges affecting every aspect of society. As the countries enter different pandemic stages, it is essential to have stringent regulations to confine its spread. In this regard, efficient food and healthcare supply chains will ensure food and medical essentials availability at consumers’ doorsteps to limit their visits to retail stores. While effective administration should ensure there are no public gatherings and crimes, and people strictly follow social distancing. We argue that drones are a viable option to improve the resilience and efficiency of these supply chains. Specifically, in this article, we propose various applications of aerial bots or drones in retail stores and restaurants due to lockdown restrictions and market visits to retail stores. While effective administration should ensure there is medical essentials availability at consumers’ eyes view of places.

2. Conclusion

The COVID-19 pandemic has brought numerous challenges affecting every aspect of society. As the countries enter different pandemic stages, it is essential to have stringent regulations to confine its spread. In this regard, efficient food and healthcare supply chains will ensure food and medical essentials availability at consumers’ doorsteps to limit their visits to retail stores. While effective administration should ensure there are no public gatherings and crimes, and people strictly follow social distancing. We argue that drones are a viable option to improve the resilience and efficiency of these supply chains. Specifically, in this article, we propose various applications of aerial bots or drones in retail stores and restaurants due to lockdown restrictions and market visits to retail stores. While effective administration should ensure there is medical essentials availability at consumers’ eyes view of places.

2. Conclusion

The COVID-19 pandemic has brought numerous challenges affecting every aspect of society. As the countries enter different pandemic stages, it is essential to have stringent regulations to confine its spread. In this regard, efficient food and healthcare supply chains will ensure food and medical essentials availability at consumers’ doorsteps to limit their visits to retail stores. While effective administration should ensure there are no public gatherings and crimes, and people strictly follow social distancing. We argue that drones are a viable option to improve the resilience and efficiency of these supply chains. Specifically, in this article, we propose various applications of aerial bots or drones in retail stores and restaurants due to lockdown restrictions and market visits to retail stores. While effective administration should ensure there is medical essentials availability at consumers’ eyes view of places.
[28] K. Usher, J. Durkin, N. Bhullar, The COVID-19 pandemic and mental health impacts, Int. J. Ment. Health Nurs. 29 (2020) 315, https://doi.org/10.1111/inm.12726.

[29] H. Verweij, Van Gogh Painting Stolen from Dutch Museum Closed by Coronavirus, REUTERS, 2020 (accessed June 13, 2021), https://www.reuters.com/article/us-netherlands-museum-van-gogh-idUSKBN21H23M.

[30] WHO, Rational Use of Personal Protective Equipment (PPE) for Coronavirus Disease (COVID-19), World Health Organization, 2020. https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE-use-2020.2-eng.pdf. (Accessed 29 April 2020).

[31] Z. Wang, J.B. Sheu, Vehicle routing problem with drones, Transp. Res. Part B Methodol. 122 (2019) 350–364, https://doi.org/10.1016/j.trb.2019.03.005.

[32] L.N. van Wassenhove, Blackett memorial lecture humanitarian aid logistics: supply chain management in high gear, J. Oper. Res. Soc. 57 (2006) 475–489, https://doi.org/10.1057/palgrave.jors.2602125.

[33] Worldometers, COVID-19 Coronavirus Pandemic, Worldometer, 2020 accessed June 12, 2021, https://www.worldometers.info/coronavirus/.