Feasibility Study of Using Uncrewed Aerial Vehicles to Deliver COVID-19 Vaccines in Geographically Inaccessible Areas of Nepal

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Research Article

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Feasibility study of using uncrewed aerial vehicles to deliver COVID-19 vaccines in geographically inaccessible areas of Nepal

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Abstract

Background: The infectious diseases vaccine program started in Nepal. Transportation facilities using uncrewed aerial vehicles (UAVs) will support the COVID 19 vaccine; therefore, remote areas where accessibility is unavailable and takes enormous time to reach the primary health center. However, it can distribute vaccines at standard times with required temperature-sensitive. Moreover, eliminating human contact reduces logistics cost, time, and chances of virus carriers to the frontline workers while delivering vaccines.

Methods: This feasibility study provides one of the possible ways of transporting vaccines using UAVs to the remote areas of Nepal; one approach will be using a customize prototype of drones and deploying it. The following will to studying the research articles on this field for proper guidance to conduct a study. The drone with a vaccine carrier takes the vaccine from Simikot Airport to the Local Mission hospital about a 400-meter journey time of about 11-15 minutes.

Results: The results show that drones can supply medical kits to health centers to reduce delivery time. It has been practicing that literature review on this related field states UAVs' possible implication in transporting vaccines. It reduces the time to deliver by 11-15 minutes with a vaccine carrier box (10-12 kg) that maintains a low temperature for 3-7 days. Furthermore, it minimizes the potential risk of not providing vaccines due to the unavailability of the road in remote areas.

Conclusion: This alternative can support the delivery of vaccines for vulnerable groups deprived of health care. One of the significant ways to deliver the vaccine can be using a drone for remote areas with limited health facilities. In addition, it can support government plans to vaccine people incorporation with emerging technologies.

Keywords: Feasibility; UAVs; Vaccine; COVID 19; Remote places

1. Introduction

The coronavirus threatens millions of lives worldwide; however, vaccines thrive to save and stimulate the body's immune system. This year, at least seven different vaccines intend to access all the countries and their vulnerable groups (*COVAX*, n.d.; *COVID-19 Vaccines*, n.d.). More than 200 additional vaccines will develop in upcoming days, where 56 in clinical and 166 in pre-clinical development (Welle (www.dw.com), n.d.). When administering this vaccine in distant areas, transporting it with an appropriate temperature is a significant problem. One of the eight categories that perform poorly in good vaccination management is the transportation of vaccines within the acceptable temperature range. A feasibility study of vaccine delivery of COVID 19 through uncrewed aerial vehicles will learn the technical aspect of delivering vaccines and their required time. In rural areas, the transportation of vaccines is complex, and need to travel long distances to reach a primary health center. There will be limited resources, human resources, and infrastructure to store, transportation of vaccines. Vaccine development and safe transport are critical issues for the developed and underdeveloped countries. Proper vaccination and transportation will be a game-changer for the world to minimize its spread. Remote and isolated people are among the significant problems in delivering the vaccination to undeveloped countries like Nepal. Many drone-delivery businesses are vying for a logistical role in transporting Covid-19 vaccinations from distribution facilities to health clinics. It expects to be a massive and complex endeavor (*Drone Startups Aim to Carve out Role in Delivery of Potential Covid-19 Vaccine*, 2020; Vartabedian, 2020).

52 To distribute Covid-19 vaccinations, several companies have lately formed medical delivery
53 agreements with drug companies and merchants.

54 Meanwhile, many firms are discussing with governments worldwide about utilizing drones to deliver
55 vaccination doses, especially in isolated areas. In Nepal, for example, individuals must walk for an
56 hour to reach a primary health facility due to dirt roads. Although more than half of Nepal's
57 impoverished live in rural areas where harsh steep terrain prevents millions of people from receiving
58 life-saving medical treatment and roads. The drone will assist in the delivery of vaccinations to
59 remote places. In addition, uncrewed aerial vehicles (UAVs) or drones are being explored almost as a
60 solution to medical product transportation complications, such as emergency blood supplies, vaccines,
61 medicines, diagnostic tests, and even organs, especially for "last mile" delivery. For example, drones
62 were used to diagnose tuberculosis in Nepal, and a last-mile drone delivery system for health drugs
63 and supplies started.

64
65 Innumerable research has discovered that the government does not pay abundant attention to and plan
66 for vaccination in rural areas. Few studies have been conducted in Nepal to recognize the COVID-19
67 epidemic's spread and predictability (Bhandary et al., n.d.; Thapa, 2020, 2021; White et al., n.d.).
68 Vaccine distribution in Nepal's rural areas where road networks have yet to develop. There are places
69 where roads are not there; still, people have to walk days for primary health service. The use of UAVs
70 will provide the vaccine near health centers such as local hospitals, primary health posts from the
71 located domestic airports. The study is designed to test the UAVs will be feasible to deliver vaccines
72 in less time in remote areas than other means of transportation. In this study, a trial will be conducted
73 to find out the feasibility of drones for delivering a vaccine with the objective to save time and
74 provide access to vaccines to remote areas people. One alternative could supply from the nearest
75 airport using drones for transporting to the isolated community health post. Since late 2018, many
76 countries have employed drones to deliver vaccines (*Drones for Social Good | UNICEF Office of*
77 *Innovation*, n.d.; *How Drones Can Help Get Vaccines to Where They Are Needed Most*, n.d.). They
78 are vulnerable in terms of health, this alternative method can play a significant role in minimizing the
79 risk of coronavirus by a quick supply of vaccine dose via UAVs.

81 **2. Materials and Methods**

82 **2.1. Study Area**

83
84 More than half of the Nepalese population are still away from access to road facilities that impact
85 million to get safe, nutritious food and health care (A Closer Look at Hunger and Undernutrition in
86 Nepal - Country Case Studies, n.d.; Why roads matter in Nepal, 2013). It is one of the world's worst
87 places for children, women, and old-aged people to fall ill. Almost half of its population lives in high
88 mountains and rugged hills. People living in such places have the weakest infrastructure, such as
89 roads, hospitals(Nepal: Nutrition Profile, 2018). Humla is disconnecting from the rest of the world via
90 a road that runs through the isolated northwestern region. Nearly every local units build a road in the
91 name of development; however, this cannot fully operate most of the time due to a lack of appropriate
92 technical feasibility study. Simikot is at least four days' walk from the nearest road. A small district
93 hospital in Simikot is not always fully staffed, and there are twelve health posts. Vaccine delivers in
94 the rural, remote, and no-road access areas through UAV quadcopter drones to these health posts. It is
95 a feasible option to support COVID 19 vaccine delivery to reach people in isolated areas.

97 **2.2. Data Collection**

98
99 The datasets acquired from the UAV quadcopter drone carry a heavy load up to 10-12 kg with a
100 vaccine carrier box that maintains a low temperature for 3-7 days. The dimension of carrier is 40 cm x
101 30 cm x 30 cm. The total weight of the carrier was around 8-9 kg and held 400 x 0.5 ml vials.

103 **2.3. Uncrewed Aerial Vehicles (UAVs)**

A drone, also known as an uncrewed aerial vehicle (UAV), is a plane that does not have a pilot and consists of a ground-based controller and a communications system. Thematic mapping for agriculture, forestry, archeology and architecture, environment, emergency management, and traffic monitoring, as well as projects, regulations, classifications, and UAV applications in the mapping domain, began in the 2006s. In terms of applications, UAV drones have been used for thematic mapping in the disciplines of ecology, crop productivity, LULC mapping, plant disease detection, and medical applications steadily since 2018. A quadcopter, sometimes known as a quad-rotor, is a four-rotor crewless aerial vehicle that can fly without a pilot. Each rotor in a quadcopter is crucial to the vehicle's intended orientation and optimal balance when lifting payloads. Two counter-rotating propellers serve each side's pitch and roll axes in the cross arrangement.

2.4. Methods

This study chose a more miniature village Humla, remote and isolated, only connected by the Simikot Airport. From that airport to the local Mission Hospital, the Simikot distance is around 2 km with rugged terrain and snow cover. The drone with a vaccine carrier takes about a 400-meter journey time of about 11-15 minutes. Therefore, it might take approximately one hour to reach the destinations.

3. Results

The Mission hospital Simikot has situated around 2 km from the Simikot Airport. It locates 2983 meters above mean sea level (MSL) and is one of the steeper terrains. . There is no road. However, there is only a walking trail available to access the hospital. Heavy rainfall and snow during the rainy season make the track full of snow and slippery.

Figure 3.1: Landscape, terrain, and elevation between Simikot Airport and Mission Hospital Simikot

The transporting vaccine cooler box by walking trail approximately requires one hour from the Simikot Airport (Figure 3.1). At the same time, the walking path was not in smooth and flat routes since the village situates in rugged terrain near high mountains. Therefore, the walker must face many obstacles while delivering the vaccine using a foot trail takes time, cost, and chances of damaging it.

Figure 3.2: Walking and Drone routes to access from Simikot Airport to Mission Hospital Simikot

Drone transport uses a straight-line route of 400 m, whereas a walking trail of 2 km (Figure 3.2). Therefore, it will reduce time, cost and increase efficient delivery. Around eight heavy-lift drones are available for commercial use. UAV quadcopters with load capacity range from 3 to 20 kg, and the scope for flight time was 16-50 minutes is used to test on the study area.

Figure 3.3: Drone payload, flight time (minutes), and occurrence

The box plot shows cargo (Kilogram), flight time (minutes), and occurrence (Figure 3.3). For 40-60 kg, cargo requires 20-50 minutes, whereas 5-30 kg load needs 10-30 minutes. Higher load rises flight time and minor occurrence. Less flight time will increase by two or three shifts of flight with the same battery.

Figure 3.4: Delivery time of vaccine through available two modes of transportation

The drone with a load capacity of 8-10 kg is appropriate for the one-way delivery of 400 vials of the coronavirus vaccine (Figure 3.4). The bar chart depicts less flight time, safe than the walking mode for transporting the vaccine. By walking, it will approximately take 40-45 minutes for the delivery of 400 vials. Using a drone for the same items will deliver around 20-25 minutes.

4. Discussion

This study focuses on the potential of drone delivery of coronavirus vaccines for remote and isolated areas. It finds that it is feasible, safe, quick, and cost-effective. It can be helpful in the places where the mode of transportation, such as road, is unavailable or its rugged terrain. This platform will

deliver one or multi-time which support the medical system and communities. The limited research has tested the possibility of drone transportation on vaccine delivery (Adwibowo, 2021; Benham & Health, n.d.; Kundu, 2021). One of the projects operating collects tuberculosis samples with a drone in remote and road-less areas of Nepal (Times, n.d.). For transporting, this method is convenient and cheaper in high mountains and rugged terrain. Similar studies found a vast prospective for a drone to support importing and exporting medical and daily goods in isolated regions (Laksham, 2019; Rosser et al., 2018). The major problem will be weather, landing points, and electricity to charge its batteries. At the same time, these challenges can be minimized by proper planning like spare batteries if there is no electricity and landing on the roof of the health post. The cost required for drone-assisted vaccine delivery is less for logistics, administration. It reduces time and improves vaccine availability. It will lower the distance and make access to rugged terrain and isolated areas. As stated, this study was fit for vaccine transportation between rural health facilities to the nearest airport but isolated tribal villages. This technology is recommended for decision-makers to improve effective and efficient COVID 19 vaccines in remote places.

This feasibility study is merely a demonstration of the technology; it did not compare the costs of payload delivery by drone against walking. Take into account the time it takes to deliver the cargo and the likelihood of being unable to reach specific health institutions via road due to heavy rainfall. In this case, the benefits of using drones were most readily apparent in terms of delivery time. For the first time in India, drone vaccination delivery will undergo feasibility testing and field trials in Karnataka. Ghana is one of the first countries in the world to deploy a drone to distribute COVID-19 vaccines. Drones use by Zipline, an American medical delivery company, transport approximately 25,000 doses of life-saving vaccines. Ghana's health ministry partnered with Zipline and UPS to distribute vaccines to remote, rural villages that would otherwise be difficult and costly to reach by car. Unmanned aerial vehicles (UAVs) are still transferred medical supplies daily. Until recently, there had only been one incidence of routine medical supplies being delivered by UAVs. Zipline has been operating drones for the Rwandan government since 2016, delivering up to 3 liters of blood on demand to health facilities in under 30 minutes. Several other companies, on the other hand, have been granted authorization to fly regularly in 2019. Matternet, a Swiss firm with hundreds of test flights under its belt, regularly transports laboratory goods within a North Carolina health system. After a year and a half of testing, Alphabet's Wing will soon be distributing over-the-counter medications via UAV in Canberra, Australia.

To yet, none of these initiatives have released any information on their decision to use UAVs for delivery and whether they integrated UAVs into existing health systems or the impact the shift had on health care operations. There are a limited number of resources available to help with the implementation of UAV delivery initiatives. None of the research delves into the feasibility and impact of integrating this technology into the more extensive healthcare system. There are currently no tools available to examine the viability and impact of unmanned aerial vehicles (UAVs) in health care systems. Although the use of UAVs for the public good is generally welcome, stakeholders have highlighted concerns regarding cost, privacy, and security. In addition, it is still difficult to verify that implementations of this technology are carried out by teams who are familiar with both local circumstances and the technology's characteristics.

5. Conclusions

The study shows the UAVs' potential to deliver vaccines in remote areas than other means of transportation. Recently, there has been a surge in interest in employing a drone to carry medicines to outreach areas instead of walking or driving. In contrast, just a few studies have conduct on drones' practicality and impact must, particularly large-scale COVID 19 vaccine administration, which necessitates the use of heavy-lift drones. This study indicates that drone transportation of the COVID 19 vaccine is both practical and efficient, showing that drone viability in aiding COVID 19 vaccine delivery has significant potential. Then, utilizing different drones, this study can be used as a model for future studies to broaden and boost COVID 19 vaccine coverage and delivery.

6. Declaration

• Consent for publication

Not applicable.

• Ethics approval and consent to participant

This research ensures ethical approval of the study from health facilities to transport the vaccine and consent of the participant with local guidelines considering the world health organization COVID 19 procedures.

• Availability of data and materials

Therefore, the data used are cited conducted, the on drones' practicality and impact with their sources; if data used in the manuscript are not precise, the author agrees to send a dataset on request.

• Competing interests

There are no competing interests.

• Funding

No funding.

• Authors' contributions

The author performed analysis, evaluation, writing, editing of the paper, methods, and result.

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• Authors' information (optional)

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