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ORIGINAL ARTICLE

Bringing revolution through quadcopter technology in the field of supplying medicine in the Himalayan regions of Uttarakhand: Case example of Pithoragarh

D. S. Vohra[1] · **Pradeep K. Garg**[1] · **Sanjay K. Ghosh**[1]

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Abstract

Background Quadcopters are used in various forms in the civil arena, from crop insurance to agricultural drones, as loudspeakers for announcing government guidelines, resilience tools in infrastructure monitoring, real-time vehicle detection, etc. However, the usage of quadcopters and hexacopters in supplying medical aid to inhospitable and far-flung terrains is being studied and researched in less detail throughout the globe.

Aim This paper focuses on the basics of quadcopter technology in supplying medicines and its advantages to the affected patients who get life-saving medicines from earlier inaccessible roads. The efficacy of quadcopters in terms of time, economy, and manpower in supplying essential and inescapable medical supplies is exponentially high, especially in the Pithoragarh Region of Uttarakhand State, where the villages are not connected to the roads.

Methods The road structure of the hilly terrain of Uttarakhand, India, was studied in detail to know the state of people who do not get access to life-saving drugs due to the non-availability of roads near them.

Results The result informs us that the quad/hexacopter if used in abundance can provide a glimmer of hope to people in remote places.

Conclusion The quadcopter can provide hope to the residents of the Pithoragarh district of Uttarakhand, India, located in far-flung places devoid of basic medical facilities.

Keywords Blood supply · Medicines · Patients · Pithoragarh · Quadcopter

Introduction

The applications of rotor drones (usually quadcopter) in the civil sector range from counting the apples in a dense orchard, crop insurance, announcing government guidelines, automating traffic signals by providing real-time vehicle detection, resilience tools in infrastructure monitoring, etc. [1]. In the field of the health sector, quadcopters are used in multifarious situations, e.g., providing live videos of birth procedures where life is at risk, scanning for tumors using infrared cameras without any in-depth medical procedures, performing biopsies which are three-dimensional (3D) in nature where the doctor has to find whether there is any kind of cancerous cell present inside a tumor or cyst using scans by high-end quadcopter cameras (akin to computed tomography) and seeing the aerial imagery of how the organs are connected post completion of surgery. However, out of the various usages above, one most important use of quadcopters to supply life-saving medicines to far-flung places in hilly areas has revolutionized the field of medicine and given it a new paradigm altogether. In Rwanda and Ghana, drone start-up company Zipline started providing medical supplies and personal protective equipment (PPE) during tough coronavirus disease (COVID-19) times to rural communities located in places where there were no roads. In another place named Malawi in Africa, a small quadcopter (called EcoSoar by Local people) made by Malawian College students created history in Jun 2022 by supplying medical supplies to remote places.

✉ D. S. Vohra
ds_vohra@ce.iitr.ac.in

Pradeep K. Garg
p.garg@ce.iitr.ac.in

Sanjay K. Ghosh
sanjay.ghosh@ce.iitr.ac.in

[1] Indian Institute of Technology (IIT), Roorkee, India

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Table 1 Details of hospitals and primary health centers in district Pithoragarh (Courtesy: Health Department Data of State of Uttarakhand, 20 Feb 2023)

Block	Allopathic hospital/dispensary no	Primary health center no	Total no. of beds	Total staff		
				Doctors	Para medical	Others
Munisiari	4	0	66	5	35	14
Dharchula	5	2	82	17	48	18
Berinag	5	1	34	6	35	18
Didihat	5	1	54	10	48	22
Kanalichina	5	4	40	10	44	22
Gangolihat	4	3	64	10	40	24
Pithoragarh	3	2	20	8	42	18
Munakot	2	4	24	11	40	18
Total rural	33	17	384	77	332	154
Total urban	22	0	228	34	73	69
Total in district	**55**	**17**	**612**	**111**	**405**	**223**

The ibid activity in Malawi happened through the collaboration between the Malawi government and the United Nations International Children's Emergency Fund (UNICEF), where the genesis was laid for this project was laid in the year 2017.

Health scenario in Pithoragarh District, Uttarakhand, India

The road connectivity in the Pithoragarh district of Uttarakhand, India, is abysmally poor in the current time [2]. As per the latest Public Works Department (PWD) data, more than 800 villages in the above district still need roads. Lack of access to roads leads to dependency on medical supplies to the patients in these villages through long hilly stretches of 7–10 km where many times the people do not get the life-saving medicines quickly as the medical supply through ponies have to pass several ephemeral streams, bridges, and rivers. By the time the life-saving drug reaches the affected person, the patient does not survive due to the non-availability of life-saving medicines on time. Pithoragarh district is the last district in the easternmost part of Uttarakhand and is surrounded by high peaks which stay snow-capped most of the year. Pithoragarh district has 1657 villages, 05 municipalities, and 08 blocks. Only 32.4% of households in the ibid district have access to basic medical facilities as they are situated in remote locations. The expenditure on the day-to-day medical facilities is very high as compared to other districts of Uttarakhand, being a hilly region, and not well-connected by all-weather roads. Table 1 shows the data on allopathic health services in the district.

Table 1 shows that only one doctor is available for every 5000 population or per lakh people; only 22 doctors are available. In comparison of the rest of India, 80 doctors are available for per lakh of population. The medical machinery is poor, and the lack of adequate road facilities has further worsened it. The patients are carried in stretchers or palanquins to the nearest medical facility where life-saving medicines could be available. The blood supplies never reach in time to the affected individual. The COVID-19 has worsened the situation, where several staff working in the health centers returned to their families residing in the plains of Uttarakhand or Uttar Pradesh [3]. As per Fig. 1, available from the Department of Public Works Department, Uttarakhand, it emerges that more than 50% of the villages in Pithoragarh district are not connected to roads, which has severely affected the basic medical facilities to reach ordinary people in time.**Fig. 1** Road connectivity to 1627 villages in the Pithoragarh District (The pink color denotes the roads that were planned as per PWD Uttarakhand, August 20043)

Supply of essential medicines and blood made possible using drones

The problem mentioned in the "Health scenario in Pithoragarh district, Uttarakhand, India" section can be obviated with the use of quadcopters or drones. Quadcopters can be used to provide quick blood supplies, life-saving drugs for the older ones, and small oxygen cylinders for pregnant ladies in the remote village locations of the Pithoragarh district. Once such supplies reach the destination using a rotor copter, as depicted in Fig. 2, one of the basic facilities for humans (i.e., right to medical facilities) lacking in the hilly terrain of Pithoragarh can be met to a great extent. Moreover, patients can get medicines delivered to their homes, in the future if drones are to be used for providing essential medicines. This will remove the infrastructure required for the dispensary in the hospitals. The health center staff will be able to interact with the patients more, and the diagnosis will become faster. The drones can also collect blood

Fig. 1 Road connectivity to 1627 villages in the Pithoragarh District ▶ (The pink color denotes the roads that were planned as per PWD Uttarakhand, August 20043)

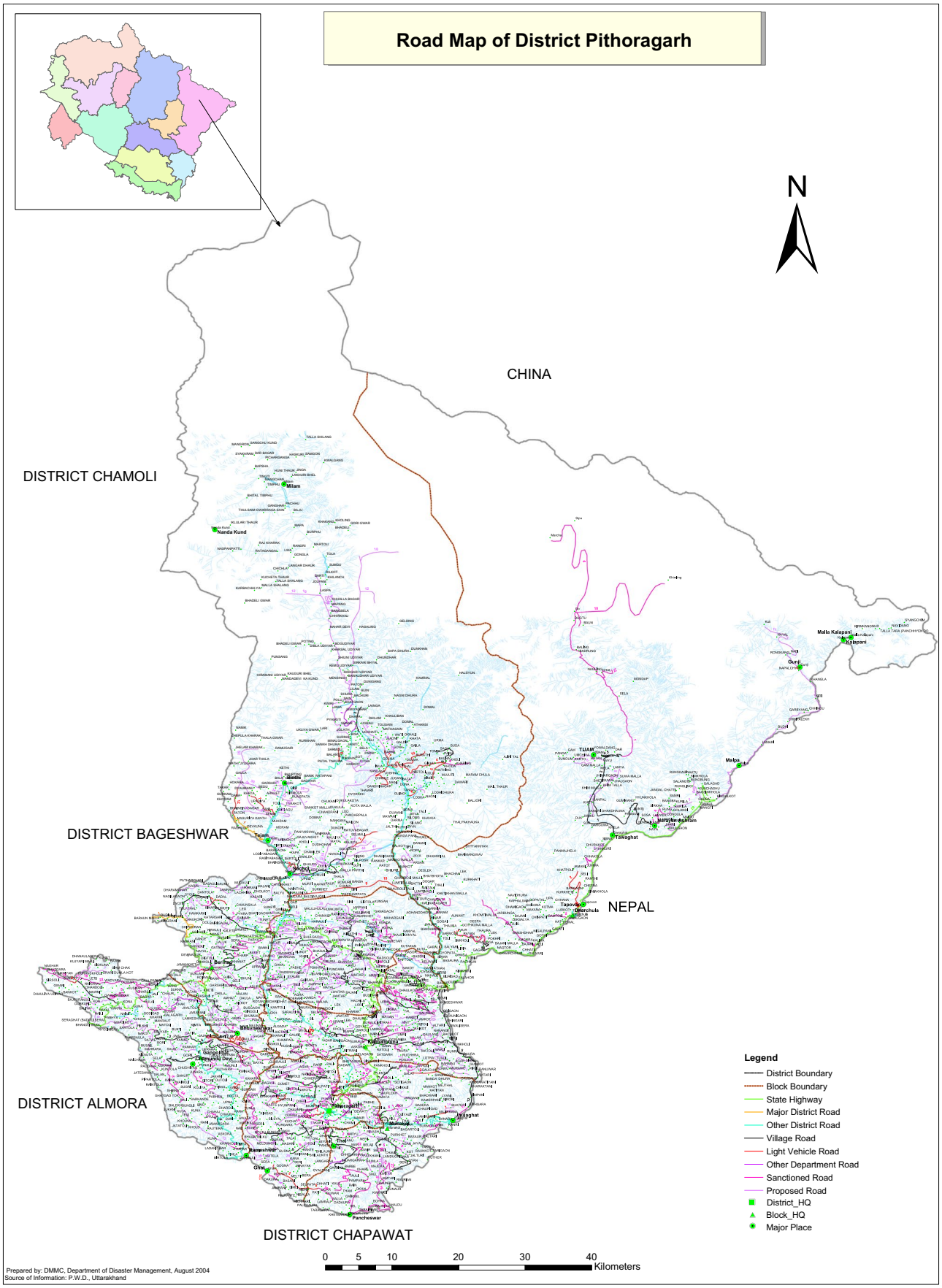
Road Map of District Pithoragarh
N
CHINA
DISTRICT CHAMOLI
DISTRICT BAGESHWAR
NEPAL
DISTRICT ALMORA
DISTRICT CHAPAWAT
Legend
District Boundary
Block Boundary
State Highway
Major District Road
Other District Road
Village Road
Light Vehicle Road
Other Department Road
Sanctioned Road
Proposed Road
District_HQ
Block_HQ
Major Place
0 5 10 20 30 40
Kilometers
Prepared by: DMMC, Department of Disaster Management, August 2004
Source of Information: P.W.D., Uttarakhand

Fig. 2 Hexa-copter carrying blood sample

samples directly from the patient's homes and supply the required medicines to their homes [1].

The supply of medicines in remote places of Uttarakhand through quadcopters will reduce considerable time, vis-a-vis, the traditional delivery methods. It will also be economical in terms of finances. In addition, it will reduce the manpower which would have been involved in reaching the lifesaving drugs to the affected individuals [4]. Various waypoints can be established via the quadcopter controlling software (Mission Planner) so that the drone takes the exact path as defined for the drone. Even places beyond the visual line of sight (BVLOS) can be supported using quadcopters/drones.

Transportation of patients takes a long-time to shift them to nearby hospitals as the density of hospitals in the region is very low [5]. It happens most of the time that the transfusion of concentrates of red blood cells (RBC) and transfer of plasma to patients with unembellished bleeding becomes an impossible task within the available time. Consequently, the quadcopters may be employed in such contingencies to provide urgent medical facilities to the patient [6]. The blood supply, when reach in time to the patient, reduces the prehospital transfusion and further reduces the exsanguination and prolonged hemorrhagic shock. To keep the blood quality intact, a special box with the requisite temperature-controlled mechanism is also carried by the quadcopter. The temperature is maintained between 2 and 6° inside the ibid box. The vibration, which occurs during quadcopter flying, does not impair the blood quality.

Challenges in the supply of medicines/ blood through drones

The challenges associated with the supply of medicines to the doorsteps at a remote village include the power supply limitations of the quadcopter, meeting with some obstacles in between, and supplying the essential drugs at the wrong doorstep due to the loss of the Global Positioning System (GPS) signals [1, 7, 8]. However, the ibid challenges can be significantly minimized if the drone is self-aware using the deep learning concepts of reinforcement learning of artificial intelligence [9, 10]. Some people might not let quadcopters deliver the medicines as it might erode their jobs. But that is not true, as automation and speed are necessary to improve the overall medical system. The other challenge is to balance the payload capacity and the battery to be used in drones [11]. The higher payload in quadcopter means lesser battery life and vice versa. In addition, the number of sensors required for specific kinds of delivery also needs to be well estimated. Generally, LiPO batteries are used in such cases with the voltage reading labeled at the top [12, 13]. Other challenges are covered in the "Health workforce," "Financing," "Logistics," and "Leadership and governance" sections. Many times, the unacceptable organism may be supplied, which includes bacteria, viruses, prions, and parasites, which has irreparable consequences. The storage of blood and safe supply is a great challenge. The entire health system machinery needs to be deployed in such a manner that the blood stays in a refrigerated condition. Quality control services need to be developed so that the blood reaches to the correct patient in the required time frame.

Health workforce

The job profiles of the health force will be changed once quadcopters are used in abundance to supply medicines. The health professionals, as per their technical aptitude, must be adequately trained on flying or landing a quadcopter, dropping a packet to the needed ones. The process of training and authorizing health professionals to fly a quadcopter will take proper methodologies that need to be formulated [14]. A good operating model for using quadcopters for the supply of medicines is, therefore, the need of the hour. Identifying a specific home or location to deliver the medicine package requires a good knowledge of images and coordinates (location), and the concept of contextual awareness will also come into play. It will attain a more significant role in times to come.

Financing

A cost-effective, innovative model must be planned to decide the cost of dropping the medical supplies through quadcopter. In the present scenario, the cost is directly proportional to the payload taken by the quadcopter beyond visual line of sight (BVLOS) conditions, weather conditions, battery conditions, distance covered, etc. There is a tendency for the cost to become unreasonably high as, maximum times, the companies providing such facilities increase the cost in leaps and bounds once they find that the patient is in dire

need. Such practices need to be curbed, and optimum cost needs to be homed on depending upon parameters that are acceptable to the ordinary public of the region.

Logistics

Logistics information systems will be changed in entirety once quadcopters become part of the supply chain for supplying life-saving medicines [15]. A new warehousing system needs to be developed, which will take care of the new variables emerging out of the new system of transporting. New routing algorithms need to be developed, which will help drop the medical with more accuracy [16]. The blood samples collected from a patient must be identified correctly with the correct blood group so that the same blood sample is supplied. Supervising and assessment systems must also be changed to ensure proper and adequate integration of all the components. The performance of the supply chain system will change with the introduction of this new mode of transport using quadcopters/drones.

Leadership and governance

New regulations must be employed at a regional and national level to push this medical supply methodology through quadcopters. Air authorities must play an instrumental role in implementing such methodologies at the regional level to ensure safe operations [1]. As quadcopter technology has progressed, there is a challenge to meet the users' requirements by the stakeholders. In India, the practice of using quadcopters for supplying medicines involves civil companies (who will develop such quadcopters), health organizations for implementing the technology on the ground, and at regional/national level authorities/leaders that will make regulations for prolific usage of the ibid methodology of supplying the medical supplies through quadcopters.

Conclusion

The quadcopter can provide hope to the residents of the Pithoragarh district of Uttarakhand, located in far-flung places devoid of basic medical facilities. COVID-19 has further worsened life in primary health centers as staff strength has reduced considerably due to their return to families residing in the plains. Consequently, the quadcopters, if used in abundance for supplying medicines in remote areas, will surely compensate for the lack of basic medical supplies for all the individuals living in such harsh and inhospitable terrains. This will also increase the life expectancy of people in the Pithoragarh district of Uttarakhand to more than the present life expectancy rate.

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Author contribution All authors have contributed to ensuring that sound conclusions may be reached.

Availability of data and materials Data supporting the findings are part of the manuscript only.

Declarations

Ethics approval No result has been misrepresented, which could damage any journal's trust, scientific authorship's professionalism, and ultimately, the entire scientific endeavor. The integrity of the research was maintained, and good scientific rules were adhered to while writing the research article.

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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