

Drone Applications in Primary Health Care During Routine and Emergency Conditions: A Rapid Review

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Abstract : Primary Health Care (PHC) faces challenges in service delivery, particularly in rural and hard-to-reach areas. Drones have emerged as a supporting technology for improving healthcare access and logistics; however, their utilisation remains diverse across operational contexts. This study aims to identify and map relevant drone applications in supporting PHC under routine and emergency conditions. A rapid review method was conducted based on the Cochrane Rapid Reviews Methods Guidance. Literature from 2019–2026 was identified through Google Scholar, with the final search conducted in August 2026. From 35 reviewed publications, 9 studies were selected for the final synthesis. Data were analysed descriptively based on the context of utilisation. The findings indicate that drones are used for vaccine distribution, medical product delivery, biological specimen transportation, and emergency response support. In routine conditions, drones support healthcare logistics and diagnostic connectivity, while in emergency situations they facilitate the rapid delivery of medicines, AEDs, naloxone, and other urgent medical supplies. Drones have the potential to improve PHC access and continuity when conventional transportation systems are limited. Future research should examine reliability, safety, cost, regulation, user acceptance, and drone integration within PHC systems.

Keywords : Drones;; Primary Health Care; Healthcare Logistics; Emergency Health Services; Rapid Review

Abstrak : Pelayanan Kesehatan Primer (Primary Health Care/PHC) menghadapi tantangan dalam penyediaan layanan, terutama di wilayah pedesaan dan sulit dijangkau. Drone berkembang sebagai teknologi pendukung akses dan logistik kesehatan, namun pemanfaatannya masih beragam dalam berbagai konteks operasional. Penelitian ini bertujuan mengidentifikasi dan memetakan pemanfaatan drone yang relevan untuk mendukung PHC pada kondisi rutin dan emergency. Penelitian menggunakan metode rapid review berdasarkan Cochrane Rapid Reviews Methods Guidance. Literatur tahun 2019–2026 ditelusuri melalui Google Scholar, dengan pencarian terakhir pada Agustus 2026. Dari 35 publikasi yang ditinjau, sebanyak 9 publikasi dipilih untuk sintesis akhir. Data dianalisis secara deskriptif berdasarkan konteks penggunaan. Hasil penelitian menunjukkan bahwa drone dimanfaatkan untuk distribusi vaksin, pengiriman produk medis, transportasi spesimen biologis, serta dukungan respons darurat. Pada kondisi rutin, drone mendukung logistik kesehatan dan konektivitas diagnostik, sedangkan pada

kondisi emergency digunakan untuk pengiriman obat, AED, nalokson, dan kebutuhan medis cepat. Drone berpotensi meningkatkan akses dan kontinuitas PHC ketika sistem transportasi konvensional terbatas. Penelitian selanjutnya perlu mengkaji aspek keandalan, keselamatan, biaya, regulasi, penerimaan pengguna, dan integrasi drone dalam sistem PHC.

Kata Kunci : Drone; Puskesmas; Logistik Kesehatan; Emergency Health Services; Rapid Review

INTRODUCTION

Primary Health Care (PHC) is an essential component of the health system because it serves as a point of care that is close to communities and forms part of the broader network of health services, referral systems, and health emergency response (Rajan et al., 2024). However, the delivery of primary health care does not always take place under ideal operational conditions. Geographic distance, limited transportation infrastructure, challenging terrain, and the need for time-sensitive health services and supplies may affect the ability of health facilities to provide timely care. These challenges are particularly evident in remote and hard-to-reach areas, highlighting the need for technological approaches that can support connectivity among health facilities, laboratories, logistics centers, and communities (Ernawaty, 2024; Lukito & Gani, 2024).

One technology that has increasingly emerged in this context is the Unmanned Aerial Vehicle (UAV), or drone. The use of drones in healthcare has evolved from experimental applications into an alternative approach for supporting the distribution and accessibility of health services (De Silvestri et al., 2023). Various studies have reported the use of drones to transport medicines, vaccines, blood products, laboratory specimens, and other health commodities. Experiences in Madagascar, Malawi, and Senegal have demonstrated that bidirectional drones can support specimen transportation, health supply chains, medical commodity distribution, and emergency maternal health needs. These applications suggest that drones have the potential to function as a link between health facilities and the medical resources they require.

The strategic value of drones in healthcare is primarily associated with their ability to overcome certain geographic barriers and accelerate transportation (De Silvestri et al., 2023). These characteristics are particularly important when health services require time-sensitive interventions. Evidence on drone-based emergency medical services has demonstrated various applications, including the delivery of Automated External Defibrillators (AEDs), naloxone, emergency medications, and blood products. In several studies, drone-based naloxone delivery demonstrated faster response times than ground-based emergency medical services (EMS), although much of the available evidence remains based on simulations or feasibility studies and therefore requires further validation under real-world conditions (Folasade Taiwo et al., 2022). Accordingly, the use of drones in healthcare should not be understood solely as a transportation innovation, but also as an enabling technology for improving the timeliness of access to health interventions.

The use of drones has also gained new relevance in emergency and biological emergency conditions, including the experience of the COVID-19 pandemic (Hodgins et al., 2022a). The pandemic demonstrated that health systems may face the need to rapidly distribute medicines and vaccines to hard-to-reach areas while the mobility of health workers and conventional transportation systems may be subject to various limitations. A study by Sham et al., (2022) examining the use of drones to deliver medicines and vaccines during the COVID-19 pandemic indicated that this technology was considered as an alternative distribution approach for health facilities in rural areas. The study involved health workers from district health clinics and district hospitals and highlighted the importance of health workers' acceptance of the technology. Thus, the pandemic provides an important context for understanding the potential use of drones to maintain essential health service functions when routine operational patterns are disrupted (Filip et al., 2022).

From a health defense perspective, the ability of a health system to maintain essential functions when the operational environment changes represents an important component of preparedness. Drones can be viewed as an enabling technology with the potential to support access, logistics, and emergency response without replacing health workers or health facilities. Experience with drone integration into the health system in Malawi, for example, has been associated with improved equity and access, responsiveness to urgent needs, and potential applications during emergencies and disasters (Knoblauch et al., 2019a). In the mountainous region of Uttarakhand, the use of drones has also been explored to support the delivery of medicines for conditions such as tuberculosis, stroke, myocardial infarction, and other emergencies, while highlighting the need for coordination with health authorities and adequate technical personnel (Gairolla et al., 2024).

Nevertheless, evidence regarding the use of drones in healthcare remains dispersed across different contexts and levels of care. De Silvestri et al., (2023) through a scoping review, identified a wide range of drone applications in healthcare, including the transportation of biomedical products, AED delivery, healthcare logistics, air ambulance services, and other medical applications. The review also highlighted technological, regulatory, public acceptance, safety, and real-world validation challenges associated with drone implementation. Although this broad body of evidence provides an important foundation for understanding the development of drone technology in healthcare, it also indicates the need for a more specific mapping based on health service functions and operational contexts (Taiwo et al., 2022) .

This gap is particularly relevant from a PHC perspective because not all drone applications in healthcare can be directly applied to primary health care facilities. Some evidence has originated from hospitals, prehospital emergency services, or healthcare logistics networks. PHC, meanwhile, has distinct characteristics, particularly its proximity to communities, provision of essential health services, referral networks, resource constraints, and the need to maintain services under both routine conditions and disruptions (Gairolla et al., 2024). Therefore, an evidence mapping approach is needed that specifically places primary health care as the analytical perspective and distinguishes drone functions according to routine and emergency conditions (Omam et al., 2023).

Such mapping is also important for understanding the potential dual-use of drone technology. Under routine conditions, drones may support the distribution of medicines and vaccines, specimen transportation, and other health logistics functions. Under emergency conditions, the same capabilities may be directed toward the delivery of urgent medical supplies, emergency response support, and access to areas where transportation has been disrupted (Roberts et al., 2023). In the context of a biological emergency, experiences from the pandemic may provide lessons on how such technology could support health services when mobility and supply chains are under pressure. However, this relationship should be positioned as a health defense implication, rather than assuming that all uses of drones during a pandemic constitute responses to CBRNE threats (Folasade Taiwo et al., 2022; Hodgins et al., 2022a).

Based on these considerations, an evidence synthesis is needed to determine which functions of drones have been reported in primary health care and how these functions have been used under routine and emergency conditions. Therefore, this study employed a rapid review approach to identify and map reported drone functions in Primary Health Care under routine and emergency conditions. The findings are expected to provide an evidence base for the further development of drones as a supporting technology for primary health care and serve as an initial foundation for future research on health-system preparedness and adaptation to changing operational environments.

METHODS

This study employed a rapid review approach to identify and map reported drone applications relevant to Primary Health Care (PHC) under routine and emergency conditions. The review was informed by the Cochrane Rapid Reviews Methods Guidance (Garritty et al., 2024). The review process was streamlined by focusing the search on Google Scholar. The primary criterion for selection was direct relevance to the review question, particularly evidence describing a healthcare function performed or supported by drones, and using descriptive evidence synthesis rather than

quantitative pooling. Literature was identified through searches focusing on publications relevant to drones or Unmanned Aerial Vehicles (UAVs), primary healthcare, rural or remote health services, healthcare logistics, and emergency health services. Publications published between 2019 and 2026 were considered. The final literature search was conducted in August 2026.

Approximately 35 publications identified through the search were reviewed for relevance to the research question. Publications were considered for inclusion when they reported the use or potential use of drones for healthcare functions applicable to PHC, primary care, rural or remote health facilities, or services supporting access to primary healthcare. Evidence addressing routine services, emergency situations, disasters, outbreaks, or pandemics was considered. Publications focusing exclusively on technical drone development without a healthcare application, non-healthcare applications, or applications without relevance to primary or community-level healthcare were excluded. Following the relevance assessment, 9 publications that most directly addressed the review question and had accessible full-text information were selected for the final evidence synthesis.

Data were extracted into a structured evidence table covering author and year, country, healthcare setting, drone function, operational condition, health service supported, and key findings. The reported applications were organized according to operational condition as routine or emergency, while pandemic-related applications were examined separately as a contextual category. The evidence was synthesized descriptively to identify recurring drone functions and their relevance to PHC. Due to the heterogeneity of the identified publications in terms of healthcare settings, applications, and types of evidence, no quantitative synthesis or meta-analysis was performed.

RESULTS AND DISCUSSION

Results

The identified evidence covered a range of geographical settings and healthcare contexts, including rural and remote health facilities, primary healthcare networks, prehospital emergency services, and healthcare logistics systems.

Table 1. Characteristics of Publications Included in the Rapid Review

Author, Year	Country	Publication Type	Drone Function	Operational Condition	Health Service Supported	Key Finding
(Taiwo et al., 2022)	Rwanda, Nigeria	Original Research / Case Study	Medical logistics delivery (consumables, blood, vaccines) using IoT-enabled drones	BVLOS; centrally operated from a logistics warehouse	Emergency services, risk management, and delivery to remote areas	Rwanda successfully integrated drones, improving access and efficiency. Adoption of the technology was recommended for Nigeria.
(Roberts et al., 2023)	Global (USA, Canada, Sweden, etc.)	Systematic Review	Delivery of emergency equipment: AEDs, naloxone, anti-epileptic medication,	Simulation and real-world trials; often under ideal conditions	Out-of-hospital cardiac arrest (OHCA), opioid overdose, status	Drones demonstrated faster delivery of emergency equipment and medicines than

Author, Year	Country	Publication Type	Drone Function	Operational Condition	Health Service Supported	Key Finding
			and blood products		epilepticus, and trauma	ambulances in reported studies.
(Hiebert et al., 2020)	USA, Canada	Scoping Review	Delivery of medical supplies and samples, AED delivery, and search-and-rescue support	Outdoor operations in remote and hard-to-reach areas	Emergency services and delivery to remote areas, including Indigenous communities	Studies focused primarily on technological aspects, with limited involvement of communities and healthcare workers. Attitudes among rural healthcare workers were mixed (50% positive). Key factors included innovative leadership and risk perception. Major barriers included technology-related factors (weather, battery life, and payload capacity), regulation, and public acceptance.
(Sham et al., 2022a)	Malaysia	Original Research (Cross-Sectional)	Delivery of medicines and vaccines to rural areas	BVLOS concept; survey conducted during the COVID-19 pandemic	Routine and emergency delivery to remote areas	
(De Silvestri et al., 2023)	Global (Focus: Europe, USA)	Scoping Review	Review of biomedical goods transportation, AED delivery, hospital logistics, and air ambulance applications	Various conditions, including simulations and field trials	Cardiac arrest response, organ delivery, and emergency logistics	

Author, Year	Country	Publication Type	Drone Function	Operational Condition	Health Service Supported	Key Finding
(Campbell et al., 2024)	Global	Systematic Review with Topic Modelling	Review of critical medical item delivery (AEDs, blood products) and non-critical medical item delivery	Thematic distinction: emergency (ad hoc) versus planned (scheduled) delivery	Supply chain management and emergency response	The literature was divided into two themes: emergency (time-critical) delivery and non-emergency delivery focused on supply-chain optimization.
(Knoblau et al., 2019a)	Madagascar, Malawi, Senegal	Practice / Experience Report	Bidirectional delivery of specimens (TB, HIV) and medicines (oxytocin)	Pilot projects in areas with limited infrastructure	TB diagnosis and treatment, early HIV diagnosis, and maternal emergencies	Regulation, local technical capacity, and community acceptance were key determinants of successful implementation.
(Aggarwal et al., 2024)	India (Himalayas)	Original Research (Feasibility Study)	Delivery of emergency medicines and transportation of clinical samples (blood, sputum)	Altitude >10,000 feet, temperatures as low as -10°C, BVLOS	Healthcare services in isolated areas and TB diagnosis	Drones were feasible and particularly useful for transporting diagnostic samples during winter.
(Tetteh et al., 2025)	Ghana	Original Research (Cross-Sectional Survey)	Delivery of health products (blood, vaccines, medicines) by Zipline	Operations from distribution centres to rural health facilities	Routine and emergency delivery to remote areas	Benefits included cost efficiency, inventory management, and accessibility; barriers included payload capacity and a shortage of trained personnel.

As shown in Table 1, the included publications represented heterogeneous types of evidence and reported diverse applications of drones in healthcare. The reported functions included medical

logistics, medicine and vaccine delivery, biological specimen transportation, blood and medical-product delivery, and emergency-response support. The evidence was reported across different operational environments, ranging from routine healthcare delivery in rural and remote areas to emergency, humanitarian, and pandemic contexts. This heterogeneity supported the use of a descriptive synthesis to organize the reported applications according to routine and emergency conditions.

DISCUSSIONS

Characteristics of the Identified Evidence

The identified evidence showed that drone applications in healthcare have been reported across diverse geographical and operational contexts. The included evidence covered rural and hard-to-reach health facilities, primary healthcare networks, laboratories, healthcare logistics systems, and prehospital emergency services. Reported drone functions included the transportation of medicines and vaccines, blood and other medical products, biological specimens, and emergency equipment, as well as support for emergency response and healthcare logistics (Aggarwal *et al.*, 2024). Evidence from Madagascar, Malawi, and Senegal demonstrated the use of bidirectional drones to support specimen transportation, medical commodity distribution, and health supply chains, including applications related to maternal emergencies (Knoblauch *et al.*, 2019b). These findings indicate that drones can function as a link between peripheral health facilities and laboratories or medical supply sources rather than merely serving as an independent transportation technology.

Other studies reported broader applications in medical logistics, including the delivery of vaccines, blood products, medicines, specimens, and medical consumables to geographically difficult-to-reach areas. Evidence from emergency and prehospital settings further demonstrated the use of drones to deliver Automated External Defibrillators (AEDs), naloxone, emergency medicines, and blood products. Studies conducted in rural and high-altitude settings also reported the use of drones for medicine delivery and clinical specimen transportation, highlighting their potential to support healthcare access where conventional transportation is constrained (Hiebert *et al.*, 2020; Sham *et al.*, 2022b; Tetteh *et al.*, 2025). Evidence from the COVID-19 pandemic added a biological-emergency context, particularly regarding the potential delivery of medicines and vaccines to rural health facilities. These studies also highlighted organizational factors, including healthcare workers' acceptance, leadership, perceived risk, and operational readiness. Overall, the identified evidence demonstrated that drone applications extend across both routine healthcare logistics and time-sensitive emergency functions, providing the basis for further classification according to operational condition (Chemali *et al.*, 2022; Hodgins *et al.*, 2022b).

Drone Applications During Routine Conditions

Under routine conditions, the reported applications of drones were primarily related to healthcare logistics and the distribution of essential medical resources (De Silvestri *et al.*, 2023). These applications included the delivery of medicines, vaccines, blood products, and other medical supplies, as well as the transportation of laboratory specimens from peripheral or rural health facilities. The evidence suggests that drones were particularly relevant in settings where geographical distance, limited road infrastructure, or difficult terrain could delay conventional transportation (Gairolla *et al.*, 2024; Sham *et al.*, 2022b). The transportation of medicines and vaccines represented one of the most frequently reported applications. Studies from rural and remote settings indicated that drones could support scheduled delivery from centralized distribution points to peripheral health facilities. In addition, bidirectional drone systems enabled the movement of biological specimens from peripheral facilities to laboratories while allowing medicines and other health commodities to be transported in the opposite direction. This function suggests that drones can support connectivity within healthcare supply and diagnostic networks rather than functioning solely as one-way delivery systems (Tetteh *et al.*, 2025).

Specimen transportation was another important routine application. Evidence from remote and geographically challenging areas demonstrated the use of drones to transport clinical samples to diagnostic facilities, potentially reducing delays associated with conventional ground

transportation. In the Himalayan setting, for example, drone operations included the transportation of clinical samples and essential medicines under difficult environmental conditions. These findings indicate that drone applications in routine PHC may extend beyond commodity delivery to include diagnostic logistics and inter-facility connectivity (Aggarwal et al., 2024).

Drone Applications During Emergency Conditions

Under emergency conditions, drone applications were predominantly associated with time-sensitive medical needs and rapid access to essential health resources. Reported applications included the delivery of emergency medicines, Automated External Defibrillators (AEDs), naloxone, blood products, and other emergency medical supplies. Compared with routine logistics, these applications placed greater emphasis on reducing transportation time and maintaining access when conventional ground-based transportation was constrained or potentially too slow (De Silvestri et al., 2023). Evidence from prehospital emergency medical services demonstrated the use of drones for selected time-critical interventions, including AED and naloxone delivery. Some studies reported shorter delivery or response times compared with conventional ground-based emergency services. However, the evidence included simulations, feasibility studies, and real-world trials conducted under varying operational conditions. Therefore, these findings demonstrate reported operational potential rather than definitive evidence of improved clinical outcomes (Yapa, 2019).

Emergency applications were also reported in geographically challenging environments. In remote and high-altitude settings, drones were used or evaluated for the delivery of emergency medicines and transportation of clinical specimens when conventional transportation could be affected by terrain, weather, or seasonal access limitations . These findings suggest that the value of drones during emergencies may be particularly relevant when the combination of geographical barriers and time-sensitive health needs creates a gap that conventional transportation cannot readily address (Aggarwal et al., 2024). The COVID-19 pandemic provided an additional emergency context in which drone delivery of medicines and vaccines was explored for rural health facilities (Tetteh et al., 2025). In this context, the reported application was not limited to transportation speed but also involved maintaining access to essential health commodities when mobility and conventional supply chains were affected. However, the available evidence also highlighted the importance of healthcare-worker acceptance, perceived risk, leadership, and operational readiness for successful implementation. Healthcare logistics and supply-chain connectivity were treated as synthesized cross-study functions rather than single delivery activities.

Table 2. Summary of Reported Drone Functions by Operational Condition

Drone function	Routine	Emergency	Relevance to Primary Health Care	Supporting evidence
Medicine delivery	✓	✓	Supports access to essential medicines, particularly in rural and hard-to-reach areas	(Aggarwal et al., 2024; Taiwo et al., 2022; Knoblauch et al., 2019a; Sham et al., 2022a)
Vaccine delivery	✓	✓	Supports immunization and access to vaccines in remote settings	(Taiwo et al., 2022; Sham et al., 2022a)
Medical supply delivery	✓	✓	Supports healthcare supply chains and last-mile delivery	(Taiwo et al., 2022; Knoblauch et al., 2019a; Tetteh et al., 2025)
Specimen transportation	✓	✓	Supports diagnostic connectivity between peripheral facilities and laboratories	(Aggarwal et al., 2024; Knoblauch et al., 2019a)

Drone function	Routine	Emergency	Relevance to Primary Health Care	Supporting evidence
Blood/blood-product delivery	✓	✓	Supports time-sensitive medical and emergency services	(Folasade Taiwo et al., 2022; Roberts et al., 2023)
Emergency medicine delivery	—	✓	Supports rapid access to time-sensitive interventions	(Aggarwal et al., 2024; Roberts et al., 2023)
AED delivery	—	✓	May support PHC-linked emergency access and referral pathways	(Roberts et al., 2023)
Naloxone delivery	—	✓	May support time-sensitive emergency access within community-linked health systems	(Roberts et al., 2023)
Emergency response / scene support	—	✓	May support rapid assessment, access, and emergency response in difficult environments	(Campbell et al., 2024; Roberts et al., 2023)
Healthcare logistics / supply-chain connectivity	✓	✓	Connects peripheral facilities with centralized medical resources	(Campbell et al., 2024; Folasade Taiwo et al., 2022; Knoblauch et al., 2019a; Tetteh et al., 2025)

Overall, the evidence indicates that drone applications extend from routine healthcare logistics to time-sensitive emergency support. This pattern suggests that the same drone capabilities developed for routine service delivery may provide additional value when conventional transportation and supply chains are disrupted. From a health-defense perspective, drones may therefore serve as an enabling technology to support access, connectivity, and continuity of essential PHC functions under changing operational conditions.

Drone Applications in Pandemic/Biological Emergency Contexts

Evidence from the COVID-19 pandemic indicates that drones have been considered or used to support the delivery of medicines, vaccines, and other health-related supplies during the pandemic. The study by Sham et al. showed that healthcare workers' acceptance and organizational readiness were important considerations in the use of drones for medicine and vaccine delivery to rural health facilities (Hodgins et al., 2022a; Saulnier et al., 2023; Sham et al., 2022a). In this rapid review, the pandemic is positioned as one context of a biological emergency, rather than as synonymous with all biological threats or as an operational definition of CBRNE. This context is used to examine how drone functions already available in routine healthcare services may acquire additional value when mobility, supply chains, or access to healthcare services are disrupted.

CONCLUSIONS

Overall, this rapid review indicates that drone applications in healthcare extend from routine logistical support to broader emergency-response functions. Under routine conditions, the most commonly reported applications involved medical logistics, specimen transportation, and the distribution of medicines and vaccines. Under emergency conditions, these capabilities may support time-sensitive medical delivery, emergency response, and rapid diagnostic transportation. Evidence from the COVID-19 pandemic further suggests that drone capabilities developed to support

healthcare access and logistics may provide additional operational value when health systems experience disruptions. Further research should assess the feasibility of integrating drone-based services into primary healthcare systems, particularly in geographically difficult-to-reach areas. Priority should be given to pilot implementation studies evaluating delivery time, operational reliability, safety, regulatory requirements, cost, payload integrity, healthcare-worker acceptance, and integration with existing health logistics and referral systems. Such studies could determine whether drone-supported services improve the timeliness and continuity of primary healthcare delivery under routine and emergency conditions. The use of Google Scholar as the primary search source may have limited the comprehensiveness and reproducibility of the literature search compared with searches across multiple bibliographic databases. Drones should therefore be considered an enabling technology that complements, rather than replaces, health workers and existing healthcare facilities. Further development should focus on context-specific integration into primary healthcare systems rather than technology deployment alone.

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