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Barriers to Implementing Drone-Based Telemedicine: A Mini Review

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Abstract:

Background: *Drones (Unmanned Aerial Vehicles, UAVs) are proposed as a transformative solution to extend the reach of telemedicine, particularly to remote, rural, and geographically isolated communities. While technical feasibility has been demonstrated in numerous pilot studies, widespread integration into routine healthcare delivery remains limited.*

Objective: *This scoping review aims to systematically identify, categorize, and analyse the barriers hindering the real-world implementation of drone-based telemedicine systems.*

Methods: *A search of literature from 2021 to 2026 was conducted in PubMed and Google scholar. Studies describing the implementation of drones for telemedicine-related applications were included and analysed.*

Results: *Twenty-one studies were retrieved and filtered after title search and full text review. Five studies were included in the review. Analysis reveals key obstacles categorized into three interdependent tiers: Strategic (Regulatory, Economic), Operational (Technical Integration, Human Factors), and Contextual (Social, Environmental). Foundational challenges include restrictive aviation and medical regulations, unclear financial sustainability, technical interoperability issues, and a lack of standardized training.*

Conclusion: *The path to operationalizing drone-telemedicine is impeded more by non-technical barriers than by technical capability. Future research must move from proof-of-concept studies to practical implementation research, addressing these systemic hurdles to enable scalable healthcare delivery.*

Keywords: *Drone integration in healthcare, Drone-based telemedicine, Remote healthcare delivery, Rural telemedicine challenges, Telemedicine implementation barriers.*

1. Introduction:

Telemedicine has emerged as a vital tool for delivering healthcare across distances, yet its effectiveness is fundamentally constrained by the physical gap between digital consultation and the delivery of care, medications, or diagnostics in remote, rural, or disaster-stricken areas [1]. This access gap is a well-documented barrier to equitable care, even as telemedicine adoption grows

[2]. Unmanned Aerial Vehicles (UAVs), or drones, present a promising technological bridge for this gap. Their potential applications are twofold: as logistics enablers for delivering medical supplies (e.g., medications, lab kits, Automated External Defibrillators) prescribed via teleconsultation, and as mobile telemedicine platforms carrying diagnostic equipment to establish remote consultations [3]. Recent reviews have documented the diverse applications and general benefits of drones in healthcare and emergency services [4], [5]. However, a significant gap remains between successful pilot projects and routine clinical use. While studies from various global contexts demonstrate technical viability—such as delivering medications to remote islands [6] or providing drone-delivered tele-ultrasound [7]—these initiatives often remain as short-term demonstrations [8]**.** The primary bottlenecks appear to be systemic rather than purely technical. Although existing reviews list general challenges [4], [5], [9], a focused analysis of the specific barriers to *implementing* drone-telemedicine is needed.

Therefore, this review aims to answer the question: What are the key barriers preventing the operational integration of drone technology with telemedicine services? By analysing recent implementation-focused literature, this work provides a structured framework to guide future development and policy.

2. Methods:

This review follows a narrative synthesis approach to map and analyse the literature on implementation barriers. The goal was to identify common themes and categorize the challenges.

2.1. Search Strategy:

A preliminary search was conducted in PubMed using the search string: ("Unmanned Aerial Vehicles"[Title/Abstract] OR Drone*[Title/Abstract]) AND ("Telemedicine"[Title/Abstract]). This identified a set of 21 articles. To ensure comprehensiveness and capture the most salient implementation studies, a targeted search of Google Scholar was performed for recent (2021-2026), studies and reviews explicitly discussing drone telemedicine operations. The date range was selected to focus on the most current evidence, as the regulatory and technological systems for drones has evolved rapidly in the past five years.

2.2. Study Selection:

Articles were included if they: (i) described a real-world case study, pilot project, or feasibility study involving drones for telemedicine or direct healthcare delivery; (ii) explicitly discussed challenges, barriers, or limitations to implementation; (iii) were published in English between 2021-2026. Articles were excluded if they were purely technical specifications, simulation-only studies without real-world context, or focused solely on non-telemedicine drone applications (e.g., agricultural spraying).

2.3. Data Extraction and Synthesis:

Data from included studies were recorded using a standardized template focusing on: study

design, context, described implementation, and reported barriers. An analysis was performed. Studies describing barriers were grouped into categories, which were then refined and organized into a coherent framework.

3. Results:

3.1. Overview of Included Evidence:

The analysis focused on five primary studies that illustrate implementation in detail. These include medication delivery to remote Japanese islands [6], a national survey on telemedicine and drone readiness in Japanese island clinics [10], the use of drones in mountain search-and-rescue [11], a proof-of-concept for drone-delivered tele-ultrasound [7], and a study on telepresence robots for hospital ward rounds [12]. This final study on ground-based robotics was included because it directly investigates the integration of a mobile platform into hospital workflows. The barriers it identifies, including technical connectivity issues, staff training needs, and patient preference for in-person interaction, are highly relevant to the challenges of integrating aerial telepresence drones into similar clinical environments [12].

3.2. Implementation Barriers:

The analysis revealed that barriers are interconnected obstacles operating at different levels. We propose a three-tiered framework

3.2.1. Tier 1: Strategic Barriers (System-Level):

These are high-level hurdles that determine whether an initiative can be legally and economically launched.

- **Regulatory and Policy Hurdles:** This was the most cited barrier. Aviation regulations are a primary constraint. For example, Japan's laws restrict drones to flights over the sea for delivery, requiring shore-based drop-offs and staff retrieval [6]. Operations beyond the pilot's visual line-of-sight (BVLOS) over populated areas often require special certification, a common hurdle noted in other regions [13]. Medical and pharmaceutical regulations also pose problems; drones may not be authorized to transport controlled substances or temperature-sensitive items [6].
- **Economic and Business Model Viability:** The financial sustainability of drone telemedicine is unproven. A major barrier is the absence of clear reimbursement pathways; drone delivery costs are often not covered by health insurance [6]. High upfront costs for drones, maintenance, and infrastructure are compounded in low-population areas, raising the cost per delivery [10], [14]. The high cost is driven not just by drone hardware, but by the need for certified pilots, maintenance infrastructure, insurance, and integration with secure health IT systems. These costs become high when spread across the small number of deliveries in remote areas [13]. To gain insurance reimbursement, drone services must transition from pilots to proven clinical programs. This requires generating robust health-economic data that demonstrates time

savings, improved patient outcomes and reduced total system costs (e.g., fewer hospitalizations through timely medication delivery) [15]. Public and professional acceptance relies on transparent safety records, clear privacy protocols, and designing drone operations as a seamless support for existing healthcare staff, and not as a disruptive replacement [11]

3.2.2. Tier 2: Operational Barriers (Organization-Level):

These barriers pertain to integrating the technology into healthcare workflows.

- **Technical Integration Challenges:** Connecting drone operations with hospital systems remains difficult. Issues include limited bandwidth for real-time data transmission (e.g., for ultrasound video) [7], cybersecurity concerns [16], and payload limitations. Operational reliability is also weather-dependent; strong winds or heavy rain can ground fleets [6], [11].
- **Human Factors and Training Gaps:** Successful implementation requires new skills. This includes training drone pilots, but also training healthcare staff and patients. Clinicians must adapt workflows, and end-users (e.g., bystanders receiving a drone-delivered AED) require intuitive interfaces [7]. Resistance to change and a preference for in-person care can slow adoption [10], [12].

3.2.3. Tier 3: Contextual Barriers (Environment-Level):

These are external factors related to the physical and social environment where implementation occurs.

- **Social Acceptance and Ethical Concerns:** Public perception is crucial. Concerns include noise, privacy, and safety [11], [15].
- **Geographical and Environmental Constraints:** The remote areas that would benefit most from drone telemedicine—islands, mountains—pose significant challenges. Rugged terrain and a lack of clear landing zones complicate operations [11]. Furthermore, these areas often have aging populations [6], [10] who may find new technologies difficult to use.

4. Discussion:

4.1. Principal Findings: Interconnected Challenges

This review finds that barriers form a network of interconnected challenges, where a problem in one tier exacerbates problems in another. This interconnectedness helps explain why promising pilot projects frequently fail to scale [8], [17].

4.2. Beyond Technical Feasibility: A Needed Shift in Focus

This framework aligns with and extends the high-level challenge categories noted in broader reviews [4], [5], [9] by detailing their practical manifestations in telemedicine contexts.

4.3. Future Directions for Research and Development

To bridge the implementation gap, a concerted shift in focus is required:

- For Research: The focus must shift from isolated pilot studies to implementation research. Priority areas include: (i) developing cost-benefit and business case models for different

healthcare settings; (ii) creating technical standards for interoperability with electronic health records; (iii) designing effective training programs; and (iv) conducting studies on long-term clinical outcomes.

- For Technology Development: Design must focus on human-centered factors: reliability in bad weather, intuitive interfaces for non-expert users, and cybersecurity, alongside improving aerial performance.

4.4. Limitations:

This review is limited by the emerging nature of the literature, which is dominated by pilot studies and expert opinions rather than large-scale implementation data. The search, while targeted, may not have captured all relevant grey literature or studies in non-English languages.

5. Conclusion:

Drones hold significant potential to bridge the physical gap in telemedicine delivery. However, this review shows that the path from pilot project to standard practice is blocked by a multi-layered array of strategic, operational, and contextual barriers. These are largely non-technical challenges involving policy, economics, human behavior, and social trust. Moving forward requires a coordinated effort focused on enabling policies, sustainable business models, and designs that meet the needs of both healthcare systems and the communities they serve. The future of drone-based telemedicine depends on solving these system-level problems.

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