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Opinion

Medical Drones for Public Health Emergency Preparedness, Response, and Resilience: Delivering Health for All

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Abstract: Amid a global metacrisis of health, environmental and economic challenges, medical delivery drones (or uncrewed aerial vehicles) offer a promising method to prepare for, and rapidly respond, to future emergencies. This opinion article summarizes the current medical delivery drone landscape, evidence base, and policy implications in the context of public health emergencies, such as pandemics, natural disasters, and humanitarian crises, with a particular emphasis on the region of sub-Saharan Africa. Using a multilateral, international health policy perspective, key challenges and opportunities, such as the development of sustainable funding mechanisms, robust regulatory frameworks, and capacity building, are identified.

Keywords: Medical delivery; Public health; Health policy; Global health; Digital health; Sub-Saharan Africa

1. Introduction

Recent pandemics, upsurges in climate-related disasters and ongoing humanitarian crises have revealed significant weaknesses in the existing global architecture for health emergency preparedness, prevention, response and resilience. In addition to uncovering tremendous global inequities and the continuous threat of future emergencies, the international response to this metacrisis prompted calls for much-needed health systems reforms [1]. The 77th World Health Assembly, which began in May 2024, emphasized the need to improve the accessibility of health services globally through its theme, "All for health, health for all". Despite this, progress towards operationalizing equity and driving health system transformation has been slow due to overlapping political, financial, human resource, and infrastructural constraints [2]. Recent innovations on the African continent have opened the door to "futuristic" technologies capable of leapfrogging structural barriers while providing high-quality, timely healthcare to even the most remote communities [3–5]. This article outlines the tremendous progress of medical delivery drones in Sub-Saharan Africa (SSA) thus far. It identifies barriers to health system integration and key engagements if this technology is to be scaled up to strengthen future global health responses.

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2. The Current Medical Drone Landscape

Much of the recent discourse about improving global health emergency preparedness and response has revolved around adopting high-impact, cost-effective technological solutions [6,7]. During the pandemic, unprecedented pressure on public health systems and significant supply chain disruptions led to the deterioration of health services around the world [8]. In response, many low-, middle-, and high-income countries began experimenting with using uncrewed aerial vehicles (i.e., drones) to support public health supply chains [9]. The use of drones to transport medical supplies, such as medications, vaccines, and blood products, has been a growing area of study in recent years due to their ability to avoid barriers related to ground transportation infrastructure and to deliver health products in a timely, energy-efficient, and cost-effective manner [9,10]. With Sub-Saharan Africa (SSA) leading the way with medical drone technology, this innovative solution also challenges neocolonial norms of knowledge and expertise "diffusing" from the global North to the global South [9,11,12].

Despite the relative novelty of the industry, the use of medical delivery drones has skyrocketed in the last five years, with 39 different countries currently applying the technology in either pilot studies or established delivery networks [10]. In SSA, countries such as Ghana, Madagascar, Rwanda, Malawi, Mozambique, Nigeria and the Democratic Republic of the Congo are already routinely using drones as a part of their public health supply chains [10]. While momentum in the global North has been slower, largely due to regulatory and airspace constraints, countries including Canada, Japan, the United Kingdom, and the United States are engaged in extensive pilot and feasibility testing [10].

3. The Evidence

The expanding interest in medical drone technology is not unwarranted. Following years of research on established drone delivery systems in SSA, the evidence base is steadily growing in support of this technology's efficacy, sustainability and economic viability.

For instance, in 2021, more than 2.5 million doses of COVID-19 vaccines were safely transported to rural regions of Ghana via cold chain-enabled delivery drones, shaving days off the standard transportation time and circumventing the challenges of poor road infrastructure, social distancing policies, and severely under-resourced community health centers [13]. Furthermore, a study across 156 health facilities in Ghana reported a 30% reduction in vaccine stockouts, a 44% reduction in missed vaccination opportunities, and a 42% reduction in the prevalence of infectious diarrhoeal cases among children following the implementation of medical delivery drones [14].

Drone delivery has also been shown to reduce product wastage caused by short shelf lives and fluctuating demand—a critical consideration for resource-limited settings. A study of Rwanda's nationally integrated medical delivery drone network reported a 67% decrease in blood product wastage after 12 months of routine drone transportation [15]. Additionally, a sensitivity analysis on the use of delivery drones for vaccine distribution showed an increase in vaccine availability and an average logistics cost saving of $0.08-$0.20 USD per dose when compared to standard ground transportation [16].

In addition to its routine applications in public health supply chains, drone technology has also been used for emergency medical response, particularly for rapidly transporting blood products. For example, between March 2017 and December 2019, over 5500 emergency blood products were delivered to remote health facilities in Rwanda by drone, reducing the average response time by approximately 79 min [15]. Furthermore, a consensus statement from the Blood Delivery via Emerging Strategies for Emergency Remote Transfusion (Blood DESERT) Coalition identified drone-based blood delivery as a promising and reliable systems-level intervention to address rural blood deserts globally [17]. In two regions of rural Madagascar, where poor road infrastructure significantly delays delivery of health products to remote communities, medical delivery drones have helped reduce response time for emergency medications from four days to one day and have virtually eliminated stockouts of routine health products, including routine immunizations, malaria drugs, and malaria test kits [18].

Outside of the African continent, other applications of delivery drones for emergency response are being studied, including rapid delivery of automated external defibrillators [19], naloxone [20], antiepileptic medications [21], and even human organs for transplant [22,23]. However, it is important to note that most of these additional applications are still experimental or in the early stages of implementation.

4. Key Challenges and Moving Forward

Innovative technologies, including drones, remain an underutilized tool within the field of global health. This gap is increasingly being acknowledged and acted upon. For example, drones are a featured technology in the Africa Center

for Disease Control's recently launched Digital Transformation Strategy [24], which aims to accelerate digital technologies in African health systems and identifies medical delivery drones as a transformative innovation for digital supply chains and emergency response. Additionally, agencies like USAID and UNICEF [25,26], as well as international non-governmental organizations (NGOs), including Gavi [27], the Global Fund [28], and the World Food Programme [29] are increasingly funding and partnering on new medical delivery drone projects in Africa and around the world. Notably, UNICEF, a leader in the drone innovation ecosystem, launched their "Drones for SDGs Toolkit" in 2021 [30]. This collaborative repository shares data, software, analytics, and other resources focused on drone delivery, imagery, and connectivity for advancing progress toward the United Nations' Sustainable Development Goals, with an emphasis on drone delivery of medical products and SDG 3: Good Health and Wellbeing.

The conviction that technological innovations have a key role in addressing global health inequities is not new. The World Health Organization (WHO) Global Strategy on Digital Health 2020–2025 was adopted at the 73rd WHA in May 2020 [31] with a vision to "improve health for everyone, everywhere" through accessible, scalable, and sustainable digital health technologies. The implementation of drone systems within this global strategy framework could support all four of its strategic objectives, which include (i) promoting collaboration and knowledge transfer, (ii) advancing national digital health strategies, (iii) strengthening digital health governance, and (iv) advocating for people-centred health systems supported by digital health. Furthermore, the WHO's more recent Global Initiative on Digital Health [32], introduced in February 2024, aims to accelerate the 2020–2025 Strategy's objective and further support funding and capacity building for digital transformation.

Key challenges remain, despite the growing evidence base and interest in operationalizing medical drone technology from global health agencies, non-profits and NGOs. To fully realize the potential of medical delivery drones, concerted efforts will be required across multiple areas:

1. *Regulatory Frameworks:* International agencies, such as the WHO and International Civil Aviation Organization, should collaboratively consider the role of drone technology in health emergency response and resilience and further prioritize the development of robust regulatory frameworks at the national and international levels in cooperation with Member States.
2. *Multi-Sectoral Collaboration:* Collaboration between Member States, non-governmental organizations, and industry partners is critical to overcoming implementation costs and regulatory complexities. The WHO could be pivotal in facilitating this collaboration, fostering knowledge sharing and promoting best practices.
3. *Community Engagement:* Community engagement must be at the heart of any drone initiative to ensure ethically and culturally appropriate uses of the technology in diverse contexts. Creating opportunities for meaningful involvement, including leadership, among community partners communicates respect: for impacted populations, their priorities, and decision-making processes. New collaborations can further fuel innovation, adaptation, and sustainability, where opportunities are opened up for local knowledge-holders to troubleshoot context-specific challenges and improve systems.
4. *Research and Development:* Funding and resources dedicated to further advancing academic research within the medical delivery drones must be a priority. Specifically, more foundational research on the ethics, processes, barriers, and facilitators of implementing and scaling the impact of this technology will be necessary for its continued development.
5. *Capacity Building:* Capacity building, including the training of community health workers and community leaders, who might influence their adoption and uptake and investing in the infrastructure required for drone technology, is vital. The WHO and other stakeholders can facilitate this process by supporting workshops, capacity assessments, and program implementation.
6. *Funding Mechanisms:* Addressing the gaps needed to support scaled and sustainable medical drone systems will be costly. National governments, international donors, and the private sector alike must increase and improve investments toward digital health system transformation, research, and capacity building, particularly in low- and middle-income countries.

5. Conclusions

Recent global health emergencies, including pandemics, natural disasters, and humanitarian crises, have revealed weaknesses in existing health systems and highlighted the need for innovative solutions. Medical delivery drones offer a promising path toward strengthening emergency response and resilience, particularly in resource-constrained settings. By embracing this technology, investing in its development, ensuring expanded usage occurs

with the involvement of impacted populations, and building appropriate regulatory frameworks, health practitioners can work to deliver health for all.

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References

1. Wong BLH, Nordström A, Piot P, Clark H. From polycrisis to metacrisis: Harnessing windows of opportunity for renewed political leadership in Global Health Diplomacy. *BMJ Global Health* **2024**, *9*, doi:10.1136/bmjgh-2024-015340.
2. Kickbusch I, Piselli D, Agrawal A, Balicer R, Banner O, Adelhardt M, et al. The lancet and Financial Times Commission on governing health futures 2030: Growing up in a Digital World. *Lancet* **2021**, *398*, 1727–1776.
3. Holly L, Franz C, Smith R. From strategy to implementation—on the pathways of the youngest countries in Sub-Saharan Africa towards digital transformation of health systems. The Lancet and Financial Times Commission. Available online: https://www.governinghealthfutures2030.org/pdf/resources/FromStrategyToImplementation-GIZReport.pdf (accessed on 6 June 2024).
4. Holly L, Smith RD, Ndili N, Franz C, Stevens EA. A review of Digital Health Strategies in 10 countries with young populations: Do they serve the Health and wellbeing of children and youth in a digital age? *Front. Digital Health* **2022**, *4*, 817810.
5. Petrakaki D, Chamakiotis P, Curto-Millet D. From 'making up' professionals to epistemic colonialism: Digital Health platforms in the Global South. *Soc. Sci. Med*. **2023**, *321*, 115787.
6. 2023 emerging technologies and Scientific Innovations: A global public health perspective. World Health Organization. Available online: https://www.who.int/publications/i/item/9789240073876 (accessed on 31 May 2024).
7. Tan Y-R, Wong BLH, Kiwuwa-Muyingo S, Stinckwich S, Yap P. Editorial: A digitally-enabled, science-based Global Pandemic Preparedness and Response Scheme: How Ready are we for the next pandemic? *Front. Public Health* **2024**, *12*, doi:10.3389/fpubh.2024.1429615.
8. Wong BLH, Delgrange M, Nathan NL, Luévano CD, Martin-Moreno JM, Otok R; et al. The Association of Schools of Public Health in the European Region statement on the erosion of Public Health Systems. *Public Health Rev.* **2021**, *42*, doi:10.3389/phrs.2021.1604112.
9. The Lancet Digital Health. The sky's the limit. *Lancet Digit Health* **2022**, *4*, doi:10.1016/S2589-7500(22)00044-9.
10. UAV for Payload Delivery Working Group (UpDWG). Medical Delivery Drone Database. Seattle (WA): UAV for Payload Delivery Working Group (UpDWG). Available online: https://www.updwg.org/md3/?action=filter (accessed on 28 June 2023).
11. O'Sullivan B, Leaman M. Medical delivery drones as a tool to improve health equity in Sub-Saharan Africa. *Global Health Annu. Rev*. **2022**, *1*, 70–73.
12. McCall B. Sub-Saharan Africa leads the way in medical drones. *Lancet* **2019**, *393*, 17–18.
13. Bu D, Hernandez M, Haruna F, Abasi PM, Kremer P. Improving Health Access Through the Distribution of COVID-19 Vaccines Using Drones in Ghana. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4401693 (accessed on 25 June 2023).
14. Kremer P, Haruna F, Sarpong RT, Agamah D, Billy J, Osei-Kwakye K, et al. An impact assessment of the use of aerial logistics to improve access to vaccines in the Western-North Region of Ghana. Vaccine. 2023 Jun 19. Available online: https://doi-org.proxy1.lib.uwo.ca/10.1016/j.vaccine.2023.06.036 (accessed on 25 June 2023).

15. Nisingizwe MP, Ndishimye P, Swaibu K, Nshimiyimana L, Karame P, Dushimiyimana V, et al. Effect of unmanned aerial vehicle (drone) delivery on blood product delivery time and wastage in Rwanda: A retrospective, cross-sectional study and time series analysis. *Lancet Glob Health* **2022**, *10*, doi:10.1016/S2214-109X(22)00048-1.
16. Haidari LA, Brown ST, Ferguson M, Bancroft E, Spiker M, Wilcox A, et al. The economic and operational value of using drones to transport vaccines. *Vaccine* **2016**, *34*, 4062–4067.
17. Raguveer V, Kumar N, Riviello R, Ali-Awadh A, Arora H, Asamoah-Akuoko L, et al. Innovative blood transfusion strategies to address global blood deserts: A consensus statement from the Blood Delivery via Emerging Strategies for Emergency Remote Transfusion (Blood DESERT) Coalition. *Lancet Glob Health* **2024**, *12*, doi:10.1016/S2214-109X(23)00564-8.
18. USAID/Global Health Evaluation and Learning Support Activity (GHEvaLS). USAID; 2021 Oct. Available online: https://pdf.usaid.gov/pdf_docs/PA00ZB61.pdf (accessed on 6 June 2024).
19. Claesson A, Bäckman A, Ringh M, Svensson L, Nordberg P, Djärv T, et al. Time to Delivery of an Automated External Defibrillator Using a Drone for Simulated Out-of-Hospital Cardiac Arrests vs Emergency Medical Services. *JAMA* **2017**, *317*, 2332–2334.
20. Nimilan V, Manohar G, Sudha R, Stanley P. Drone-aid: An aerial medical assistance. *Int. J. Innovat. Technol. Explor. Eng.* **2019**, *8*, 1288–1292.
21. Mateen FJ, Leung KHB, Vogel AC, Cissé AFC, Chan TCY. A drone delivery network for antiepileptic drugs: A framework and modelling case study in a low-income country. *Trans. Royal Soc. Trop. Med. Hyg*. **2020**, *114*, 308–314.
22. Scalea JR, Pucciarella T, Talaie T, Restaino S, Drachenberg CB, Alexander C, et al. Successful implementation of unmanned aircraft use for delivery of a human organ for transplantation. *Annals Surg.* **2019**, *274*, doi:10.1097/sla.0000000000003630.
23. Toronto Lung Transplant Program and Quebec company transport lungs by drone. 2021. Available online: https://www.uhn.ca/corporate/News/Pages/Toronto_Lung_Transplant_Program_and_Quebec_company_transport_lungs_by_drone.aspx (accessed on 6 June 2024).
24. Africa CDC. Digital Transformation Strategy. 2023. Available online: https://africacdc.org/download/digital-transformation-strategy/ (accessed on 6 June 2024).
25. United States Agency for International Development (USAID) Center for Accelerating Innovation and Impact (CII). UAVs in Global Health: Defining a Collective Path Forward. Washington (DC): USAID CII; 2022. Available online: https://www.usaid.gov/cii/uavs-global-health (accessed on 7 June 2023).
26. United Nations International Children's Emergency Fund (UNICEF) Supply Division. How Drones Can Be Used to Combat COVID-19. Copenhagen: UNICEF Supply Division; 2023. Available online https://www.unicef.org/supply/media/5286/file/%20Rapid-guidance-how-can-drones-help-in-COVID-19-response.pdf.pdf (accessed on 7 June 2023).
27. Ghana launches the world's Largest Vaccine Drone Delivery Network [Internet]. 2019. Available online: https://www.gavi.org/news/media-room/ghana-launches-worlds-largest-vaccine-drone-delivery-network (accessed on 6 June 2024).
28. Drug delivery by drone to drop zones. 2023. Available online: https://www.updwg.org/implementation/drug-delivery-by-drone-to-drop-zones/ (accessed on 6 June 2024).
29. United Nations (UN) World Food Programme (WFP). Using drones to deliver critical humanitarian aid. Rome: United Nations (UN) World Food Programme (WFP); 2023. Available online: https://drones.wfp.org/updates/using-drones-deliver-critical-humanitarian-aid (accessed on 7 June 2023).
30. Introduction to the Drones for SDGs toolkit. 2021. Available online: https://www.unicef.org/innovation/documents/introduction-drones-sdgs-toolkit (accessed on 6 June 2024).
31. World Health Organization. (2021). (rep.). *Global strategy on digital health 2020–2025*. Available online: https://cdn.who.int/media/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf?sfvrsn=f112ede5_75 (accessed on 14 June 2024).
32. Global initiative on Digital Health. World Health Organization; 2024. Available online: https://www.who.int/publications/m/item/global-initiative-on-digital-health (accessed on 4 July 2024).