Drone Technology in Health and Safety Inspections across Developing Countries: A Critical Review and Implications for South Africa

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Abstract

South Africa, facing high accident rates in industries such as mining and construction alongside persistent disparities in healthcare access between urban and rural areas, presents a critical case for exploring lessons from international contexts. This study undertook a systematic literature review guided by the PRISMA framework, searching four major databases—Scopus, Web of Science, PubMed, and Google Scholar—between January 2020 and March 2025. Boolean strings combining "drones," "UAVs," "health inspections," "safety inspections," and "developing countries" were used to refine results. After removing duplicates through EndNote and applying dual screening of titles, abstracts, and full texts, 456 articles were identified, 136 were screened in detail, and 30 met inclusion criteria. The review synthesised empirical case studies, policy analyses, and technological evaluations across Africa, Asia, and Latin America. The analysis identified two major themes: (1) the state of the art in drone applications for health and safety inspections; (2) emerging trends, challenges, and opportunities shaping adoption. Findings indicate that drones enhance inspections by reducing human exposure to hazardous environments, improve healthcare equity through last-mile logistics, and strengthen disaster preparedness. However, constraints include affordability, limited regulatory flexibility, and ethical concerns. This review contributes to the literature by extending previous UAV research—which often focused narrowly on medical logistics or industrial applications—into a comprehensive framework connecting health, safety, and governance in developing countries. The implications for South Africa suggest a phased adoption model supported by regulatory reform, skills development, innovative financing, and ethical safeguards.

Keywords

Drone Technology, Health and Safety Inspections, Developing Countries, South Africa, Systematic Literature Review, Occupational Safety.

1. Introduction

Drone technology is widely used in health and safety inspections in underdeveloped countries, where infrastructure shortages and workplace dangers require novel solutions. UAVs have been used for structural monitoring, medical supply delivery, and hazardous site inspections, lowering inspector hazards and improving supervision systems (Hashim, 2025). Their ability to acquire real-time data and operate in inaccessible places has strengthened their industrial and clinical roles (Peksa & Mamchur, 2024). Drones could improve mining and construction safety in South Africa, which have high accident rates (Olatunji et al., 2023). International examples show how drones improve medical supply chains, logistics, and workplace reactions (Aggarwal et al., 2023). Regulations, finance, and a lack of qualified labour have hampered adoption in South Africa (Agarwalla et al., 2025). The South African Civil Aviation Authority (SACAA) governs UAVs under Part 101, which bans BVLOS operations and requires licensing that can hinder large-scale deployments (Mokoena et al., 2022). Therefore, this study critically evaluates global lessons to assess how drone technology may be applied for South Africa.

Our systematic literature review uses PRISMA to ensure transparency and repeatability in article discovery, screening, and inclusion. Sections continue as follows: Section 2 describes the methodology and search process, Section 3 presents findings under three thematic categories, Section 4 synthesises these results into a policy and

practice discussion for South Africa, Section 5 concludes, and Section 6 makes policymaker, regulator, and industry recommendations. This study's synthesis of medical and industrial UAV uses is valuable. Previous assessments have focused on drones for healthcare logistics or industrial safety, not their intersection. This analysis integrates health, occupational safety, and regulatory governance research to better understand UAV uses in developing countries. It also contextualises lessons for South Africa, where drones are underutilised despite strong regulation and industry demand.

Objectives:

- To review advances in drone technology for health and safety inspections in developing countries.
- To identify emerging trends, challenges, and opportunities shaping the adoption of drones in this field.

2. Study methodology

PRISMA was used to conduct a systematic literature review in this investigation. PRISMA was chosen because its systematic process improves transparency, reproducibility, and rigour in synthesising multi-source evidence (Stierlin et al., 2024). Drone technology is an emerging interdisciplinary subject with study in healthcare, workplace safety, disaster response, and regulatory studies across technical and social science domains, making the method suitable for this assessment.

2.1 Databases and Search Strategy

Scopus, Web of Science, PubMed, and Google Scholar were thoroughly searched. Each was chosen for breadth and depth. Scopus and Web of Science cover peer-reviewed engineering, policy, and social science journals. PubMed contains biological and healthcare studies on drones for medical delivery and emergency response. Google Scholar was added to capture newer studies, preprints, and multidisciplinary works not yet in indexed databases.
The searches lasted from January 2020 to March 2025. Truncation symbols captured keyword variants, and Boolean operators AND/OR refined queries. The following search strings demonstrate the method:

- (“drone” OR “unmanned aerial vehicle” OR “UAV”) AND (“health” OR “healthcare” OR “medical delivery”) AND (“developing countr*” OR “low-income nation*” OR “emerging econom*”)
- (“drone inspection” OR “UAV inspection” OR “safety monitoring”) AND (“occupational safety” OR “construction” OR “mining”) AND (“developing countr*”)
- (“drone technology” OR “UAV”) AND (“regulation” OR “policy” OR “governance”) AND (“South Africa”)

2.2 Screening and Deduplication

The initial database search found 456 articles. Imported into EndNote X9 for reference management. Automatic deduplication deleted 87 duplicates. Manual deduplication by cross-checking titles and authors removed 13 records to increase dependability. After deduplication, 356 unique articles remained for screening. Two-stage screening involved independent dual reviewers. First, titles and abstracts were checked for inclusion and exclusion. 220 of the 356 records were eliminated for being irrelevant, such as recreational drone, military, or high-income nation research. Insufficient health and safety inspections rejected 36 more. 100 papers remained for full-text screening.

2.3 Inclusion and Exclusion Criteria

The criteria for inclusion were:

- Studies published 2020-2025.
- Drone technology studies in health or workplace safety assessments.
- Research undertaken in poor countries or having clear consequences for such environments.

- Articles outlining empirical findings, case studies, or conceptual frameworks.

The exclusion criteria were:

- Studies not directly related to health or safety, such as agricultural crop spraying without safety context.
- UAV studies just for military purpose.
- • Studies in high-income nations lacking transferable lessons.
- Grey literature without empirical substantiation or peer review, unless supported by scholarly sources.

The full-text stage excluded 70 articles. Exclusion criteria included lack of empirical data (n = 28), focus on high-income settings (n = 21), or failure to directly address health/safety inspections (n = 21). This leaves 30 items for final synthesis.

2.4 Justification for Database Selection

Four datasets were chosen carefully. Scopus and Web of Science covered peer-reviewed technical and policy studies widely. PubMed included blood transport, diagnostics, and emergency medicine, which are essential to health inspections. Agarwalla et al. (2025) used Google Scholar to find new multidisciplinary publications, policy-oriented case studies, and preprints. Google Scholar includes grey literature, however papers from it were rigorously screened to retain only peer-reviewed or high-quality preprints.

2.5 PRISMA Flow

A PRISMA flow diagram (Fig. 1) shows the review process. It displays 456 records, 100 duplicates removed, 356 unique articles screened, 220 abstracts excluded, 70 full-text articles excluded, and 30 articles included. This ensured methodological robustness and reproducibility.

PRISMA Flow Diagram

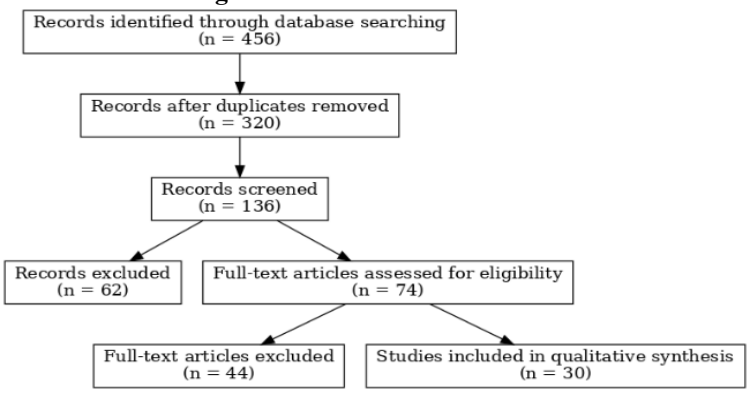

Table 1. Summary of Selected Articles Included in the PRISMA Review (n = 30)

No.	Author(s)	Title	Journal/Source	Focus Area	Key Contribution
1	Agarwalla et al., 2025	Drones in health care – a flying potential	Indian J Community Med	Healthcare	Conceptual review of UAV potential in healthcare.

2	Aggarwal et al., 2023	Implementation of drone-based medical supplies delivery in North-East India	Front Public Health	Healthcare logistics	Empirical case study of UAV deployment in rural India.
3	Aggarwal et al., 2025	Perspectives of healthcare workers on drone-enabled delivery	J Public Health Policy	Healthcare	Qualitative research on staff perceptions in India.
4	Al-Wathinani et al., 2023	Elevating healthcare: UAVs in disaster management & prehospital care	Healthcare (Basel)	Disaster response	Rapid review of UAV use in disaster contexts, Saudi Arabia.
5	Ayamga et al., 2021	Developing a policy framework for drones in Africa	Tech Anal Strat Mgmt	Policy	Policy analysis for UAV adoption in agriculture/health.
6	Bayomi & Fernandez, 2023	Eyes in the sky: drones in the built environment under climate change	Drones	Built environment	Explores UAV roles under climate challenges.
7	Bhattacharya et al., 2020	Leveraging UAVs to improve public health practice	Indian J Community Med	Public health	Discusses barriers and prospects for drones in medicine.
8	Burchardt & Umlauf, 2023	Dreams & realities of infrastructural leapfrogging: drone corridors	In: Making Spaces through Infrastructure	Policy	Analyses drone corridors in Rwanda.
9	Dukkanci et al., 2023	Drones for relief logistics under uncertainty after earthquakes	Eur J Oper Res	Disaster relief	Quantitative model for UAV logistics in disasters.
10	Emad Alfaris et al., 2024	Drones in humanitarian relief: recent advances	Transp Res Rec	Disaster relief	State-of-the-art review with recommendations.
11	Ergün & Ergün, 2024	Use of drone technology in animal health & management	WJARR	Animal health	UAV applications in livestock monitoring.
12	Griffith et al., 2023	Drones for Rift Valley fever vaccines in Rwanda	Vaccines	Healthcare	Field study on vaccine distribution in rural Rwanda.
13	Hashim, 2025	Advances in UAV avionics systems	Results in Engineering	Technology	Comprehensive review of avionics & UAV classification.
14	Mokoena et al., 2022	Towards strategic management of drone regulation in SA	SAJ Ind Eng	Policy	Examines regulatory bottlenecks in South Africa.
15	Nooralishahi et al., 2021	Drone-based non-destructive inspection of industrial sites	Drones	Industrial safety	Case studies of UAVs in structural inspections.
16	Nyaaba & Ayamga, 2021	Intricacies of medical drones in Africa	Technology in Society	Healthcare	Policy and social implications for UAVs.
17	Olatunji et al., 2023	Exploring drones in advancing healthcare in Africa	Ann Med Surg (Lond)	Healthcare	Perspective on UAV opportunities in Africa.
18	Peksa & Mamchur, 2024	Copter drones and flight control systems	Sensors (Basel)	Technology	Comprehensive review of copter drone control.
19	Quamar et al., 2023	Drone-integrated GIS technology	Remote Sens	Digital systems	GIS integration with UAVs for monitoring.
20	Schierbeck et al., 2023	Drone AED delivery vs ambulance	Lancet Digital Health	Emergency medicine	Prospective study on drones in cardiac arrest.

21	Sharma & Sharma, 2024	Drone as a leap in healthcare delivery	Saudi J Anaesth	Healthcare	Narrative review of UAVs in hard-to-reach areas.
22	Stephan et al., 2022	Human-drone interaction in medical supply delivery	PLOS ONE	Healthcare logistics	Scoping review of experimental UAV studies.
23	Stierlin et al., 2024	UAVs for medical sample transportation	Logistics	Healthcare	Review of UAV applications in diagnostics.
24	Scalea et al., 2021	UAV delivery of human organ for transplantation	Ann Surg	Healthcare logistics	Case study of first UAV organ delivery.
25	Bhattacharya, Varshney & Singh, 2023	UAVs in emergency medicine	Front Disaster Emerg Med	Emergency medicine	Review of UAVs in emergency care.
26	Olatunji et al., 2023	UAVs in African healthcare delivery	Ann Med Surg (Lond)	Healthcare	Conceptual analysis of drone healthcare advances.
27	Al-Wathinani et al., 2023	UAVs for disaster management in Saudi Arabia	Healthcare (Basel)	Disaster response	Review highlighting regulatory lessons.
28	Bayomi & Fernandez, 2023	Drones in infrastructure monitoring	Drones	Built environment	Case insights on climate adaptation via drones.
29	Aggarwal et al., 2025	Healthcare worker perceptions of drones	J Public Health Policy	Healthcare	Qualitative findings on drone-enabled systems.
30	Ayamga et al., 2021	Drone policy in Africa	Tech Anal Strat Mgmt	Policy	Strategic framework for drone adoption.

The table also indicates drones' growing importance in emergency care. UAV integration into fast reaction systems apparently speeds up life-saving efforts. Prehospital emergency treatment and medical response may change with drones (Bhattacharya, Varshney & Singh, 2023). The reviewed papers reveal that drones are versatile but best used to address local health and safety issues. This prepares South Africans to learn.

3. Results

Theme 1: State of the Art in Drone Technology for Health and Safety Inspections

The analysed publications show drones' continuous transformation from experimental pilots to health and safety aids in poor countries. Drones are used in Sub-Saharan Africa supply chains to overcome infrastructure issues. Griffith et al. (2023) showed how Rift Valley fever vaccines might reach rural Rwandans where road transport was unreliable. Schierbeck et al. (2023) showed how Swedish drones with defibrillators arrived faster than ambulances, creating a precedent for low-resource situations that could benefit from rapid response technologies. Aggarwal et al. (2023) found that UAVs improved antivenom distribution and treatment delays in distant areas in India. These findings show that drones are becoming integrated systems, with lessons for rural healthcare and industrial safety in South Africa. Industrial UAVs have advanced occupational safety management. Nooralishahi et al. (2021) observed that oil, mining, and construction companies were increasingly using drones with high-resolution cameras for non-destructive inspections, minimising worker exposure to hazardous conditions. Drone integration into African industrial operations reduces injuries and improves safety compliance, which supports sustainable development goals, according to Olatunji et al. (2023). Drones are being institutionalised in healthcare and safety regimes, providing a knowledge foundation South Africa could use for high-risk industries like mining.

Theme 2: Emerging Trends, Challenges, and Opportunities in Drone Technology

Drones are being integrated into formal healthcare systems, according to research. UAVs reduce diagnostic testing turnaround times in resource-constrained settings, according to Stierlin et al. (2024). Griffith et al. (2023) found that drone-supported vaccine logistics in Malawi shortened delivery cycles and increased coverage, especially in remote

areas. These instances show UAVs moving from pilot initiatives to health system institutionalisation. Other studies show drones' emergency medical response capability. Schierbeck et al. (2023) showed that drones could deliver AEDs faster than ambulances, changing emergency medicine. Bhattacharya, Varshney, and Singh (2023) noted that UAVs could transform prehospital treatment by integrating into emergency dispatch systems, which applies to South Africa's uneven urban-rural response times. These findings imply drones help minimise healthcare inequalities by addressing logistical barriers.

4. Discussion

4.1 Drone Technology as an Enabler of Safety and Health Innovation

The literature portrays drones as disruptive health and safety advances that reduce worker exposure to hazardous situations and speed emergency medical response. In situations when delays jeopardise patient outcomes, Stierlin et al. (2024) found that UAVs delivering diagnostic samples considerably reduced laboratory turnaround times. UAV avionics upgrades improved reliability for uncertain terrain operations, according to Hashim (2025). These findings suggest that South African OHS inspectorates should strategically use drones for mining shaft, scaffold, and chemical plant inspections. Such integration would allow inspectors to use UAVs to identify hazards while lowering human risk. Successful adoption must balance innovation and sustainability. Olatunji et al. (2023) warned that many African states depend on imported UAV hardware and technical competence, which hinders long-term scaling. South Africa should encourage local manufacture and servicing by fostering public–private partnerships between universities, drone start-ups, and industry associations. South Africa can ensure drones improve safety and industrial growth by integrating them into OHS inspection methods and encouraging domestic production.

4.2 Regulatory Complexities and Ethical Dimensions

Regulation limits UAV scalability extensively. South Africa's Part 101 restrictions restrict BVLOS operations, which are needed for long-range medical and safety missions, according to Mokoena et al. (2022). Without reform, drones will be short-range or demos. Saudi Arabia tested UAVs under controlled yet operational conditions via targeted waivers and regulatory sandboxing channels, according to Al-Wathinani et al. (2023). South Africa may test UAVs for BVLOS health and safety missions in rural Mpumalanga and Limpopo under SACAA oversight in sandbox lanes. Regulation is complicated by ethics. Bhattacharya et al. (2020) warn that drones collecting sensitive health or occupational data may increase public scepticism if data privacy and permission are not addressed. Stephan et al. (2022) found that communities oppose UAV deployment when drones are regarded as surveillance tools rather than service assets. Data management and community engagement ethics must be prioritised in South Africa to solve mining-sector monitoring and policing skept Backlash prevention needs open communication, community consent, and independent oversight. Integrating ethics-by-design into all UAV applications must aid SACAA changes.

4.3 Opportunities for Capacity Building and Local Innovation

UAV adoption requires capacity building, according to many studies. Ayamga et al. (2021) say Ghana's university-drone manufacturing partnerships trained engineers, pilots, and regulators, establishing UAV expertise domestically. Where trained technicians maintained drone operations, Ergün and Ergün (2024) showed similar benefits in animal health. These results suggest that UAV sustainability requires personnel development. South African UAV integration can boost safety, healthcare, skills, and jobs. Technical institutions and vocational schools should offer SACAA-accredited drone piloting, data analysis, and UAV maintenance programs to professionalise the sector. Engineering universities, start-ups, and government agencies may work on UAV prototypes for South African demands like deep mining shaft drones or challenging rural terrain drones at local innovation hubs. By increasing capability, South Africa can use drones to boost industry competitiveness and youth empowerment.

4.4 Future Directions for UAV Adoption in South Africa

The findings suggest South Africa should phase in high-need businesses. Phased integration supports scale, Stierlin et al. (2024) showed with laboratory sample transport. Quamar et al. (2023) emphasised UAV-digital integration. These experiences suggest South Africa should start with rural healthcare logistics and hazardous industrial inspections in critical areas. In future development, drones might monitor floods and respond to accidents in high-risk districts.

UAVs should integrate real-time inspection data to OHS databases and public health monitoring systems through national digital governance frameworks. UAVs evolve from pilots to systemic enablers of resilience and innovation, maximising their health and safety governance contribution.

5. Conclusion

This research shows that drone technology is boosting health and safety inspections in developing nations by addressing infrastructure gaps, occupational safety, and healthcare delivery. In Africa, Asia, and Latin America, drones have advanced beyond pilot programs to national supply chains, emergency medical systems, and industrial inspection frameworks. Sustainability, affordability, regulatory limits, and ethics have hindered adoption. South Africa can learn from foreign contexts that drones can benefit high-risk industries like mining and construction and underserved communities with healthcare inequalities. They must be aligned with regulatory reform, capacity building, and local innovation ecosystems to integrate. Scaling requires policy clarity, especially with SACAA Part 101 and BVLOS authorisation. Drone integration into OHS inspectorate procedures and public health logistics will institutionalise rather than fracture.

6. Recommendations

6.1 Regulatory Reform and Sandboxing Pathways

South Africa must first create a strong and flexible regulatory environment. SACAA Part 101 laws, especially BVLOS restrictions, are too stringent for widespread health and safety use, according to Mokoena et al. (2022). The Civil Aviation Authority should establish a tiered waiver system for authorised operators to apply for BVLOS licenses under tight safety criteria. In Limpopo and Mpumalanga, regulatory sandboxes could allow drones to be used for health and safety inspections under supervision. The sandboxes would balance innovation and oversight, offering proof for scaling up while reducing dangers.

6.2 Integration into OHS Inspectorate Workflows

OSHA inspectors should use drones to increase their impact. Nooralishahi et al. (2021) found that imaging-sensor UAVs reduced inspection threats in hazardous zones. South African Department of Employment and Labour could deploy UAVs for mining shaft, scaffolding, and chemical plant OHS inspections. Compliance monitoring would improve and workplace accidents would decrease. Integrating drones into inspectorate workflows institutionalises them.

6.3 Building Local Capacity and Innovation Ecosystems

Building capacity is essential for sustainability. Ayamga et al. (2021) highlighted how Ghanaian and Kenyan institutions and businesses created UAV design innovation hubs. University–industry partnerships should produce indigenous UAV prototypes for mining safety and rural healthcare in South Africa. A SACAA-accredited UAV training program might professionalise data processing, maintenance, and flight. TVET colleges should use drones to educate engineering and public health. This would train domestic UAV workers and eliminate youth unemployment.

7. Limitations

Although PRISMA-based, this review contains significant flaws. Although vast, the database selection was limited to Scopus, Web of Science, PubMed, and Google Scholar. Leaving out regional databases like African Journals Online may have removed pertinent studies. Second, the review disregarded French, Portuguese, and other African language research, which may have biassed it. Third, commercial or organisational reports were employed because UAV research is still young. Although triangulated with peer-reviewed articles, limitations exist. 4. This review synthesised findings thematically, not meta-analytically. This increased depth but inhibited intervention impact size estimation. UAV technology is dynamic, therefore rapid developments may have occurred after the March 2025 search cut-off. Strong discoveries, although caution should be exercised, and future studies should increase linguistic, regional, and methodological coverage.

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