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Flight testing of drone-delivered automated external defibrillators for simulated out-of-hospital cardiac arrest in suburban Thailand

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The use of automated external defibrillators (AEDs) in a timely manner is critical for improving survival rates in out-of-hospital cardiac arrest (OHCA) cases. However, in developing countries, logistical and infrastructural challenges often result in delays, particularly in suburban areas. This study evaluates the feasibility and safety of using drones to deliver AEDs in suburban OHCA scenarios. A series of ninety test flights were conducted using a DJI Matrice 600 drone (DJI, China) to deliver a Philips HeartStart AED (Philips, Netherlands) across varying payloads. Bystanders in simulated OHCA situations identified their location via mobile applications, enabling the drone operator to dispatch the drone beyond the pilot's line of sight. The results showed a 97.7% success rate in AED delivery, with a median flight distance of 4042 m and a median response time of 7 min and 39 s. Despite payload variations, the drone maintained adequate speed and landing accuracy, with a mean speed of 9.17 m per second and a median landing error of 122 centimeters. The findings suggest that drones have significant potential for improving emergency medical responses in suburban areas of developing countries. Integration into emergency services could address current delays, though further research is necessary to optimize performance under varying conditions.

Keywords Out-of-hospital cardiac arrest (OHCA), Automated external defibrillators (AED), Drone delivery, Response time, Suburban areas

Abbreviations

AED	Automated external defibrillator
OHCA	Out-of-hospital cardiac arrest
EMS	Emergency medical service
GPS	Global positioning system

Out-of-hospital cardiac arrests (OHCAs) are a leading cause of death worldwide, demanding immediate intervention to improve survival outcomes[1,2]. Survival rates depend heavily on timely intervention, with immediate CPR and rapid automated external defibrillator (AED) use being crucial[3–7]. However, in many developing countries, including Thailand, infrastructural and logistical challenges, especially in suburban areas, often delay these interventions[8]. Suburban areas face unique emergency medical service (EMS) challenges due to dispersed populations, traffic congestion, limited road networks, and distances from healthcare facilities, all contributing to longer response times and decreased survival chances[9]. A previous study in suburban areas of Thailand found that the response time to EMS arrival has a median time of about 11–13 min[10]. Therefore, new methods of reaching OHCA victims earlier could be beneficial to patients.

Unmanned Aerial Vehicle or Drone technology offers a promising solution for timely emergency medical care in suburban areas. Drones can bypass obstacles and traffic, delivering AEDs directly to emergencies, thus reducing defibrillation time, which is critical for OHCA survival. Integrating drones into EMS protocols could revolutionise cardiac emergency management in hard-to-reach areas[8,9,11,12].

However, implementing drone-delivered AEDs requires thorough investigation into feasibility and safety. Key aspects include evaluating drone capabilities like flight range, payload capacity, and reliability, and testing performance under various weather conditions[13]. Establishing safety protocols to prevent malfunctions,

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collisions, and ensuring proper AED handling and use by laypersons is also crucial, alongside regulatory compliance and integration into existing airspace systems[14]. Moreover, Identifying the location of a cardiac arrest in extensive suburban areas can sometimes be challenging due to the larger size of suburban areas and their lower population density[12,15–17]. The rapid uptake in smartphone ownership in recent years has significantly impacted communication in healthcare[18] and could play a significant role in pinpointing locations and delivering essential medical equipment to the scene quickly.

Conducting a feasibility and safety study on drone-delivered AEDs is crucial for reducing defibrillation time and improving OHCA survival rates, particularly in suburban areas. In developing countries like Thailand, drone operations face significant limitations, especially in transporting items. This study represents the initial phase of a larger research project aimed at advancing the use of drones for medical equipment transportation in Thailand. The researchers sought to demonstrate the feasibility and safety of this approach, establishing the necessity of this study. It specifically evaluates drone performance and safety in Thailand's suburban areas, offering a model for other developing countries and valuable insights for shaping policy and best practices.

Methods
Study design
This study was designed as a detailed flight-testing evaluation simulating OHCA in suburban areas to investigate the feasibility and safety of using drones to deliver AEDs. The primary focus was on assessing drone flight performance metrics, including speed, accuracy, operational reliability, and the impact of different payload weights.

Study site
The study was conducted at the Pattaya campus of Thammasat University in Chon Buri Province, Thailand. This site was chosen for its representative suburban environment, featuring a mix of open spaces, buildings, and varying topography, providing a realistic and practical setting for testing drone delivery systems. Suburban areas surrounding major cities in Thailand share similar characteristics, making this location well-suited to explore the potential of drone-delivered AED systems in suburban settings. These areas typically have higher populations than rural regions but face limited access to AEDs and longer EMS response times compared to urban centers. All test flights were conducted beyond the visual line of sight (BVLOS) of the pilot, meaning the drone operator could not directly see the drone's position or its landing location. The flights were carried out by experienced pilots from an external organization specializing in drone operations both in Thailand and internationally (FlingX Co., Ltd.; https://fling-ai.com). Prior to the test flights, the pilots underwent training that covered flight operations, navigation, and handling of the drone with the specific payload of an AED. The training also included operations conducted BVLOS.

Approval
The study received approval from Thammasat University and the Civil Aviation Authority of Thailand (CAAT). Both institutions ensured adherence to safety protocols and compliance with aviation regulations. Ethical approval was not required as the study was simulation-based and did not involve actual patients or patient data.

Drone and AED selection
The DJI Matrice 600 ("M600") (DJI, China) drone was selected for its advanced capabilities, including a robust multi-constellation satellite global positioning system (GPS) signal receiver unit, a maximum payload capacity of 7 kg, and a flight range of 5–20 km[19]. The drone's advanced flight control systems and safety features, such as obstacle avoidance and automated return-to-home functions, supported its use (Fig. 1). The researchers did not use a Real-Time Kinematic (RTK) unit to enhance the drone's positioning, as the controlled test environment allowed standard GPS navigation to provide adequate accuracy for the study's objectives. The primary aim was to evaluate the feasibility of drone-delivered AED systems under widely accessible conditions without relying on advanced positioning technologies like RTK. Additionally, excluding RTK simplified the operational setup and reduced costs, aligning with the study's goal of developing practical and scalable solutions.

An aftermarket cargo box was selected and installed to accommodate a standard-sized AED, with the empty box weighing approximately 1.7 kg. The Philips HeartStart AED (Philips, Netherlands), including its carrying case, was chosen for this study, weighing approximately 2 kg. To assess the impact of different AED weights on drone performance, an additional 2 kg was added to the 2 kg AED, simulating a total weight of 4 kg. The total payload weight, including the cargo box and the AED, was 3.7 kg and 5.7 kg, ensuring the findings would be applicable to a range of AED models used in real-world settings (Fig. 2).

Study protocol
Ninety test flights were performed, categorized into three groups based on payload: no load, 2 kg AED, and 4 kg AED. These flights aimed to evaluate the drone's performance across different operational conditions. Each flight's details were recorded. The test flights were planned using GPS coordinates from mobile phones to designate landing points. The latitude and longitude coordinates were provided to the drone pilot using mapping applications like Google Maps or Apple Maps. In the simulated OHCA scenarios, the bystander identified their location using these applications and sent the coordinates to the drone operator to dispatch the drone to the specified location. The designated points included various locations on the university campus to simulate real-world emergency scenarios, such as open fields, building areas, and locations with moderate obstacles. The takeoff point was fixed at the front of the control center, where the research team, pilot, and measurement equipment were located. The landing point, however, was randomized for each flight by the research assistants. These landing points were chosen to represent locations where cardiac arrest patients might realistically be

Fig. 1. The DJI Matrice 600 drone with a cargo box used in this study.

found. Each landing point was unique but could be in a nearby area. The pilot was not informed of the landing point in advance and directed the drone only to the location provided. After measuring the landing point error, the pilot instructed the drone to return to the original takeoff point, where the battery was replaced before proceeding to the next test (Fig. 3).

The drone was flown to these points, simulating emergency AED delivery. The flight elevation was maintained at 80–90 m to avoid obstacles and ensure a clear path. The test flights were conducted under a range of weather conditions, including variations in temperature, wind speed, and cloud cover. Flights were performed only on sunny days to ensure visibility and compliance with safety regulations. However, other weather conditions, such as light rain, heavy rain, or high winds, were not tested due to safety concerns and the limitations of the drone's operating specifications. Each flight was monitored and controlled by a licensed drone operator with safety protocols in place. Emergency physicians were present during every flight to handle potential emergencies.

Data collection and outcomes measurement

For each flight, comprehensive data were collected to evaluate the drone's performance. The flight distance from takeoff to landing was measured using the drone's GPS system. Drone response time, the duration from flight initiation to arrival at the target, was recorded. Overall speed was calculated by dividing flight distance by response time. Wind speed was measured with an anemometer at the launch site. Battery usage was tracked by monitoring battery levels before and after each flight. The landing distance error, or deviation from designated GPS coordinates, was measured in meters using a tape measure.

Sample size estimation and statistical analyses

A "failed flight" was determined based on the drone's inability to reach the designated landing point within an acceptable distance, where it was expected that a bystander could retrieve the AED from the drone for use, or if technical or operational issues prevented the drone from completing its mission. The drone's accurate landing rate is set at 99% (hypothesized = 0.99), with an acceptable margin of error of no more than 5% of the total flight testing (postulated = 0.94). With a significance level of 95% and a predictive power of 80%, the sample size was calculated using a one-sample comparison of proportions method and a two-sided test. The calculation determined that at least 87 test flights are needed to have sufficient power to potentially reject the null hypothesis.

Continuous data were presented as mean with standard deviations or median with interquartile range, and categorical data were summarized as frequencies and percentages. A multivariable regression analysis was conducted to determine the association of various factors (e.g., payload weight, wind speed, battery usage) with the drone's overall speed and landing accuracy. A secondary analysis was conducted, with stratification based on battery usage percentage to evaluate the drone's performance under varying battery conditions. The analysis included a comparison of the flight distances and durations achieved with battery usage not exceeding 40%, across two different payload weights. This stratification highlights the operational efficiency and safety margins

AED model	Weight (kg)	Height (mm)	Width (mm)	Depth (mm)
Zoll AED3	2.5	127	237	247
Zoll AED Pro	2.95	239	234	77
Zoll AED Plus	3.05	293	242	134
Philips HeartStart FRx	1.6	227	181	61
Philips HeartStart FR3	1.6	221	135	69
Philips HeartStart Onsite AED	1.5	211	188	72
HeartSine Samaritan 500P	1.1	204	185	49
Defibtech Lifeline	2	300	216	69
Cardiolife AED 3100	2.3	97	206	252
Mediana Heart on A15	2.65	240	29	95

Fig. 2. The Philips HeartStart AED used in this study, including the carrying case, weighs 2 kg. Additional weight was added to simulate a total weight of 4 kg, making the findings applicable to various AED models in real-world settings.

of the drone as battery levels decrease, ensuring that the drone retains sufficient power to return to the control center. This analysis reflects real-world scenarios where drones must operate within specific battery limits to maintain safety. A p-value less than 0.05 was considered statistically significant. All analyses were performed using STATA software version 14.0 (StataCorp, College Station, TX).

Results

This study was conducted in October 2022. A total of ninety test flights covering a distance of 487 km and a total flight time of 14 h were conducted. Accurate delivery of the payload was achieved in 88 out of 90 test flights.

The baseline data from Table 1 shows the median flight distance across all flights was 4042 m, with variations among no load (6514.5 m), 2 kg AED (4009.5 m), and 4 kg AED (4026.5 m). The overall median drone response time was 459 s (7 min and 39 s). The mean overall drone speed was 9.17 m per second (m/s) (33 km per hour; km/hr), slightly higher for no load (9.87 m/s; 35.5 km/hr) compared to the 2 kg (8.89 m/s; 32 km/hr) and 4 kg AED (8.75 m/s; 31.5 km/hr) loads. Wind speed had a median of 0.4 m per second, and battery usage averaged 41%. Landing accuracy showed a median error of 122 centimeters from the expected point, with slight variations across payloads.

Table 2 presents a multivariable regression analysis of drone speed based on payload type, adjusted for flight route, wind speed, and battery usage. Carrying a 2 kg AED reduced speed by 0.83 m/s (3 km/hr) (95% CI: 0.41

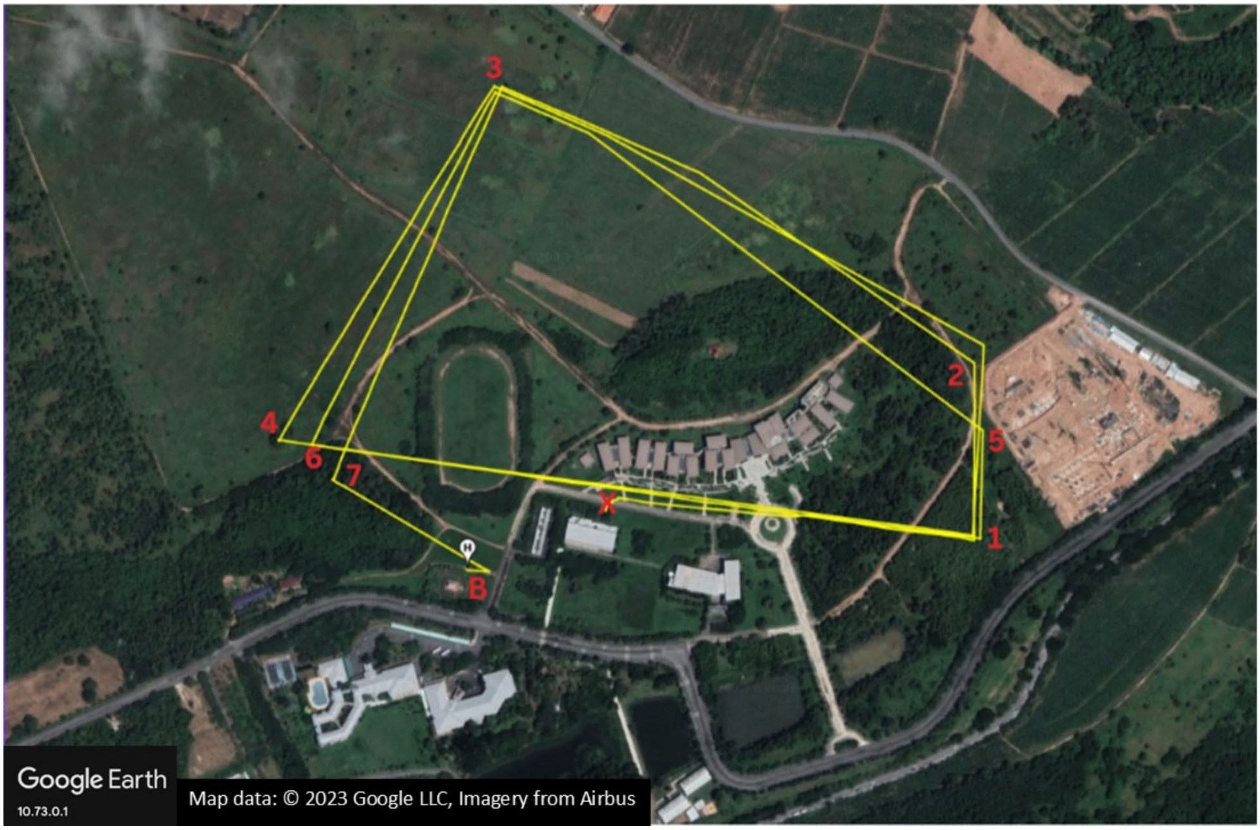

Fig. 3. Top view perspective for one of the ninety flights flown. Points of Latitude, Longitude: Takeoff point X: 12.919714, 100.996491; Point 1: 12.919312, 101.000732; Point 2: 12.921340, 101.000584; Point 3: 12.923320, 100.995093; Point 4: 12.920471, 100.993120; Point 5: 12.920358, 101.000757; Point 6: 12.920278, 100.993376; Point 7: 12.919859, 100.993995; Landing point B: 12.918966, 100.994931. Note that the takeoff and landing points are at different locations.

	Overall (*N* = 90)	**No load (*N* = 30)**	**2 Kg AED (*N* = 30)**	**4 Kg AED (*N* = 30)**
Flight distance median (IQR) (meter)	4042 (2279, 7976)	6514.5 (2270, 11204)	4009.5 (2271, 7976)	4026.5 (2409, 7189)
Drone overall response time median (IQR) (second)	459 (310, 768)	624.5 (303, 1022)	443.5 (303, 735)	451.5 (312, 759)
Take-off time median (IQR) (second)	31.5 (29, 33)	32 (29, 33)	30 (20, 32)	32 (30, 34)
Travel time median (IQR) (second)	379 (217, 619)	537.5 (212, 926)	358.5 (215, 656)	359.5 (219, 668)
Landing time median (IQR) (second)	60 (57, 66)	59 (55, 63)	60.5 (57, 66)	61 (59, 66)
Drone overall speed mean (SD) (meter per second)	9.17 (1.36)	9.87 (1.60)	8.89 (1.12)	8.75 (1.07)
Wind speed median (IQR) (meter per second)	0.4 (0.3, 0.7)	0.4 (0.3, 0.7)	0.5 (0.1, 0.6)	0.35 (0.3, 0.6)
Battery usage median (IQR) (percentage)	41 (28, 71)	41.5 (24, 71)	39.5 (26, 67)	42.5 (37, 78)
Landing point error from expected median (IQR) (centimeter)	122 (75.5, 174.5)	124 (95, 183)	125 (66, 165)	117 (73, 155)

Table 1. Baseline data of drone delivery of automated external defibrillator (AED) test flights.

Payload (*N* = 90)	**Mean difference of drone overall speed (meter per second)**	**95% confidence interval**	***P* value**
No load	Ref	Ref	
2 kg AED	− 0.83	− 0.41, − 1.25	< 0.001
4 kg AED	− 1.29	− 0.86, − 1.72	< 0.001

Table 2. Results from multivariable regression analysis of drone overall speed according to type of payloads. *Adjusted with flight route, wind speed, and battery usage.

	2 kg AED		4 kg AED	
	Battery usage within 40% ($N = 16$)	Battery usage over 40% ($N = 14$)	Battery usage within 40% ($N = 11$)	Battery usage over 40% ($N = 19$)
Maximum distance (meter)	4039	8200	4063	8400
Maximum drone overall response time (second)	465	839	473	877
Estimate maximum time to target within 4 km distance	7 min and 41 s	N/A	7 min and 46 s	N/A

Table 3. Battery usage, distance coverage, and drone operation time.

	No load ($N = 30$)		2 Kg AED ($N = 30$)		4 Kg AED ($N = 30$)	
	N	%	*N*	%	*N*	%
Landing distance error						
Within one meter	8	26.7	14	43.4	11	36.7
> 1–5 m	22	73.3	1	46.7	15	50.0
> 5–10 m	0	0	1	3.3	2	6.7
Over 10 m	0	0	1	3.3	1	3.3
Failed mission	0	0	1	3.3	1	3.3
Maximum landing distance error (meters)	3.35		28.0		195.0	
Expected successful delivery	30	100	29	96.7	29	96.7

Table 4. Landing distance error from expected landing points.

to 1.25, $p < 0.001$) compared to no load. Carrying a 4 kg AED further decreased speed by 1.29 m/s (4.6 km/hr) (95% CI: 0.86 to 1.72, $p < 0.001$).

Table 3 summarizes battery usage, distance coverage, and operation time for different payloads. Drones with 2 kg AED and battery usage within 40% covered up to 4039 m with a response time of 465 s (7 min and 45 s). Those over 40% battery usage covered up to 8200 m with a response time of 839 s (13 min and 59 s). Drones with 4 kg AED within 40% battery usage covered 4063 m in 473 s (7 min and 53 s), while those over 40% reached 8400 m in 877 s (14 min and 37 s). The estimated maximum time to reach a 4 km target was about 7 min and 41 s for the 2 kg AED and 7 min and 46 s for the 4 kg AED.

Table 4 provides landing accuracy data. For drones with no load, 26.7% landed within one meter of the expected point, and 73.3% landed within one to five meters, with no failed missions. Drones carrying a 2 kg AED had 43.4% landing within one meter, 46.7% within one to five meters, and 3.3% each within five to ten meters and over ten meters, with one failed mission. Drones with a 4 kg AED had 36.7% landing within one meter, 50% within one to five meters, 6.7% within five to ten meters, and 3.3% over ten meters, with one failed mission. Maximum landing errors were 3.35 m for no load, 28 m for 2 kg AED, and 195 m for 4 kg AED, with an overall expected successful delivery rate of 96.7% for both AED payloads. There were two failed flights where landing had to be aborted due to unsafe conditions, such as the drone attempting to land in areas obstructed by obstacles like trees.

Discussion

This study highlights the potential of drones for delivering AEDs in suburban areas of developing countries. The median flight distance of 4042 m and median response time of 459 s show drones can quickly cover large areas and deliver AEDs promptly, crucial for improving OHCA survival rates. These findings suggest that drones could be a valuable addition to EMS, particularly where traditional response times are hindered by geographical and infrastructural barriers[20].

Battery usage and operational efficiency are also critical. Drones with lighter payloads (2 kg AED) covered up to 8200 m efficiently, while heavier payloads (4 kg AED) extended the range to 8400 m but used more battery power. These findings are crucial for planning and optimizing drone missions. The study found that within a 4-kilometer radius, transporting an AED with a drone takes under 8 min and uses less than 40% of the battery, ensuring enough power for the return trip. For one-way trips, drones can cover about 8 km.

Landing accuracy is crucial for drone deliveries. Results show drones have high precision, with a median landing error within 122 centimeters of the target and most flights landing within one to five meters. However, precision decreases with heavier payloads, with the 4 kg AED having a maximum landing error of 195 m. This indicates a need for improved navigation and landing technologies, especially for heavier payloads[13].

This study's protocol aims to replicate the key technologies that would be employed in a practical implementation of drones assisting patients experiencing OHCA. The concept of operations used in this study closely aligns with potential future applications, utilizing existing software, hardware, telecommunications infrastructure, and emergency communication protocols that match what would be required in an actual deployment.

The study simulated a scenario where a bystander witnessing a cardiac arrest could use Google Maps or Apple Maps on their mobile phone to pinpoint their location and transmit the latitude and longitude coordinates to a drone control center. This process mirrors a potential real-world application. Upon receiving these coordinates, the control center would dispatch a drone to the specified location. Results showed that the drone successfully landed within a usable range for AED deployment in 96.7% of cases. This high accuracy in drone-delivered AEDs is comparable to findings from studies conducted in Sweden demonstrating the potential efficacy of this approach in emergency response scenarios[11,21].

Drone delivery of an AED to patients with OHCA has the potential to improve patient outcomes. A study in Germany demonstrated that integrating drones into the chain of survival for OHCA significantly reduced the time to AED delivery, particularly in rural areas with limited EMS access[22]. Additionally, another study in Germany examined the use of drones for AED transport during nighttime and found it to be safe and effective, with reduced delivery times compared to traditional EMS[23]. Similarly, a recent study in Sweden highlighted a real-world case where drones successfully delivered an AED faster than traditional EMS. In one instance, a drone delivered an AED before EMS arrival, enabling successful defibrillation of the patient, who survived to hospital discharge with a good neurological outcome[24]. These and other studies confirm the safety and efficacy of using drones to deliver AEDs. They emphasize the potential of drones as promising and innovative tools that could serve as a new strategy to improve the survival rate of OHCA patients[25–27].

In Thailand, several factors have been found to influence the survival of OHCA patients, particularly bystander chest compressions and reduced EMS response times, which have been shown to improve 30-day survival outcomes[5]. It is widely recognized that bystander chest compressions and the use of AEDs play a critical role in the survival of OHCA patients. Efforts have been made to educate the public on performing basic life support and using AEDs[28,29], as well as to reduce the time it takes to access an AED[30,31]. This study, which explores the use of drones to deliver AEDs, shows promising potential to reduce AED access time, which could positively impact OHCA outcomes.

In developing countries, logistical challenges for AED deployment include dispersed suburban populations, traffic congestion, and the limited availability of AEDs in critical areas. AEDs are often heavily concentrated in urban areas, leaving suburban and rural communities underserved[32–34]. This disparity is driven by a combination of socioeconomic and logistical factors. In suburban and rural areas, poor road conditions and a lack of public facilities further hinder the placement of AEDs in remote locations[34]. This uneven distribution of AEDs contributes to disparities in survival outcomes for OHCA. Studies have shown that survival rates are significantly higher in urban areas, where AEDs are readily available, compared to suburban and rural regions[32].

Seamless integration with EMS protocols, involving coordination between dispatch centers, drone operators, and ground responders, is necessary for timely and accurate AED delivery[11]. Analyzing the cost-effectiveness of drone delivery compared to traditional EMS methods is crucial, considering costs related to drone procurement, maintenance, and operation against potential savings from reduced response times and improved patient outcomes[35]. Finally, public acceptance and willingness to use drone-delivered AEDs are critical, requiring community engagement and education to build trust and ensure bystanders are prepared to use the technology effectively[14,36].

Conducting a feasibility and safety study on drone-delivered AEDs is crucial for several reasons. First, drone technology has the potential to significantly reduce defibrillation time, potentially improving survival rates and outcomes for OHCA patients, especially in underserved suburban areas[8,9,11,12]. This study may contribute to the development of innovative solutions to persistent challenges in emergency medical response, potentially expanding the scope for broader healthcare applications[8]. Additionally, the findings could serve as a reference for other developing countries facing similar challenges, potentially informing the consideration of drone technology in EMS systems globally.

Limitation

Despite these results, several limitations must be acknowledged. The study was conducted in a controlled environment at Thammasat University, which may not fully replicate real-world suburban conditions. The impact of varying weather conditions was not extensively explored, and adverse weather could significantly affect drone performance. Future studies should include a broader range of conditions to better assess reliability and safety.

Another limitation is the payload capacity. While the DJI Matrice 600 can carry up to 7 kg, the study focused on a maximum payload of 4 kg. Evaluating drones' performance with heavier and more complex payloads is essential to ensure applicability to a wider range of emergency equipment. The study did not involve actual OHCA scenarios or patient data, limiting the ability to assess the practical impact on patient outcomes. While simulation studies are valuable for initial assessments, real-world trials are necessary to understand the full benefits of this technology.

A notable limitation of this study is that it does not account for the time required for bystanders to locate and retrieve the AED from the drone upon its arrival, which could introduce delays to defibrillation and impact patient outcomes. Starks et al. highlighted the additional time required for bystanders to retrieve and use a drone-delivered AED and its potential impact on the chain of survival for OHCA cases[37]. Similarly, Sanfridsson et al. emphasized the challenges bystanders may face in interacting with drone systems, including confusion or hesitation, which could further delay CPR and defibrillation[14]. Addressing these potential delays in future studies would enhance the understanding of real-world feasibility and the design of more efficient drone-delivered AED systems.

Conclusion

The study demonstrates the potential of drones in delivering AEDs in suburban areas of developing countries, where logistical challenges often delay emergency responses. Despite reduced speed with heavier loads, drones maintained adequate speed for timely AED delivery. High landing accuracy indicates that drones can reliably deliver AEDs to specified locations. Future studies should address environmental limitations, weather conditions, and the impact of heavier payloads. Public acceptance and regulatory compliance are crucial for successful integration into EMS. Overall, drones for AED delivery could significantly enhance emergency care capabilities, especially in hard-to-reach areas.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions
W.S., N.K., and M.C. were responsible for conceptualization and methodology. W.S. and N.K. were responsible for data curation and investigation. W.S. and N.K. conducted the formal analysis, as well as data interpretation, discussion, supervision, validation, review, editing, and original draft preparation. All authors approved the final version of the manuscript for publication.

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Declarations

Competing interests
The authors declare that there are no financial or personal conflicts of interest that could have influenced the work reported in this manuscript. The last author, Michael Currie, is affiliated with FlingX, a company specializing in drone services. FlingX provided technical expertise in drone operations, including piloting the drones and ensuring compliance with aviation regulations. However, FlingX had no role in the study design, data collection, analysis, or interpretation of results. The authors affirm that the findings and conclusions of this study are independent and free from any external influence.

Additional information

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