Journal of Healthcare Simulation

Journal of Healthcare Simulation

KEY CONCEPTS

Healthcare simulation of drone delivery of EpiPen® for anaphylaxis treatment

Hemendra Worlikar[1], Kevin Johnson[2], Patrick Johnson[3], Spyridoula Maraka[4], Ian McCabe[1], Derek O'Keeffe[1,5]

[1]*Health Innovation via Engineering Laboratory, Cúram Science Foundation Ireland Research Centre for Medical Devices, University of Galway, Galway, Ireland*
[2]*Department of Nursing and Midwifery, Faculty of Education and Health Sciences, University of Limerick, Limerick, Ireland*
[3]*Faculty of Education and Health Sciences, School of Education, University of Limerick, Limerick, Ireland*
[4]*Division of Endocrinology and Metabolism, Department of Medicine, University of Arkansas for Medical Sciences, Little Rock, Arkansas, USA*
[5]*School of Medicine, College of Medicine, Nursing and Health Sciences, University of Galway, Galway, Ireland*

Corresponding author: Hemendra Worlikar, hemendra.worlikar@universityofgalway.ie

https://johs.org.uk/article/doi/10.54531/ASNI9805

Declarations

Authors' contributions

None declared.

Funding

The authors gratefully acknowledge funding through Science Foundation Ireland (SFI) via Cúram—Ireland's Centre for Research in Medical Devices (Research Centre Award Reference: 13/RC/2073) and through Industry Partnership with CISCO Systems Ireland Ltd. through its Community Digital Accelerator (CDA) Programme. Additional funding through the Department of Public Expenditure and Reform (DPER) was gratefully received as part of the Future Tech Challenge award 2022.

Availability of data and materials

None declared.

Ethics approval and consent to participate

None declared.

Competing interests

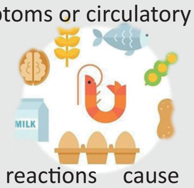
None declared.

Submission Date: 12 April 2024
Accepted Date: 07 January 2025
Published Date: 25 July 2025

Healthcare Simulation of Drone Delivery of an EpiPen® for Anaphylaxis Treatment

Overview

The World Allergy Organization (WAO) terms anaphylaxis as a rapid, potentially deadly allergic reaction involving severe compromise in airway, breathing, or circulation, sometimes without typical skin symptoms or circulatory shock. [1,2]



Food-induced reactions cause a significant portion of anaphylaxis cases globally, particularly affecting children, with common triggers including peanuts, tree nuts, milk, egg, sesame seeds, fish, and shellfish in both adults and children. [1,3]

All-cause anaphylaxis in Europe	20-30 deaths per year	Food induced anaphylaxis
1.5 to **7.9** per 100 000 person-years	**Reported death in UK due to anaphylaxis**	**~50%** of these deaths arising from food

Data from the European Academy of Allergy and Clinical Immunology Food Allergy & Anaphylaxis Group. [1]

Treatment: Assessment of reaction severity and vital signs guides initial treatment decisions. Priority is given to stabilizing the airway and circulation. Intramuscular epinephrine is the preferred medication for anaphylaxis treatment. [3,4]

Example: Adrenaline auto-injector such as EpiPen®

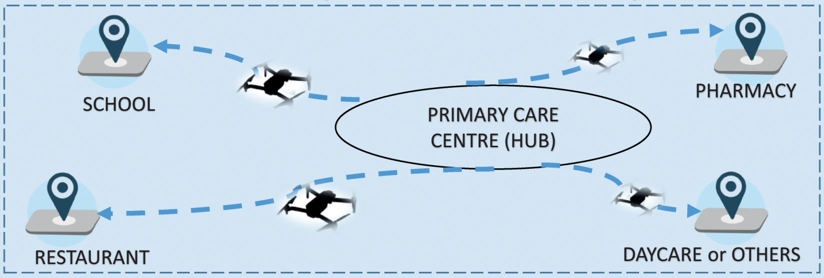
Problem Statement

Enhance the effective delivery of high-value, low-weight, short-shelf-life medications, such as epinephrine, to remote locations with limited inventory, thereby improving preparedness for medical emergencies, particularly those involving food-induced anaphylaxis.

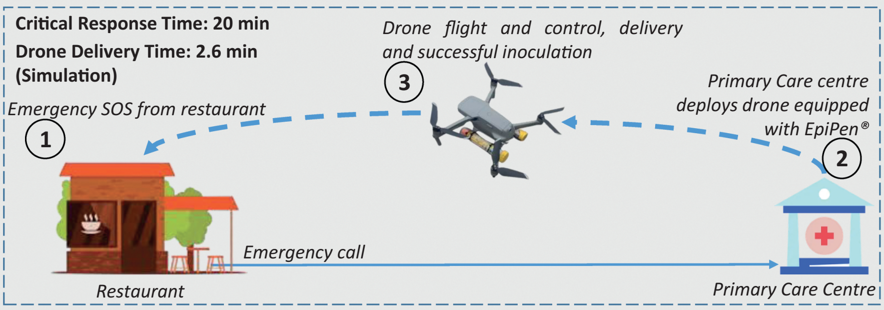
Innovation

Drones, originally military UAVs, now have civilian applications. Drones are unmanned aircraft vehicles typically controlled from the ground. Our strategy centralizes vital medication for swift deployment using the hub-and-spoke model, optimizing resource management. [5-7] This was achieved with equipping the drone with EpiPen®.

Conceptual Framework for drone delivery to remote locations



Simulated Use Case



Drone Model	DJI Mavic Air 3
Average Flight Speed	30-68 km/h
Payload Capacity (Modified)	~ 120g
Wind Resistance upto	43 km/h (max)
Flight Path (Line of sight limit)	300 m

Learning Reflections: To address emergency healthcare challenges, integrating drone delivery into a hub-and-spoke model ensures timely access to life-saving medications (eg. epinephrine and anti-venom), overcoming the impracticality of widespread storage. The tested simulation run with DJI Mavic Air 3 (modified) successfully delivered medication under 3 minute, including prep and loading, thereby stabilizing the emergency situation. Commercial drones can typically fly 100 km/h covering 15 km within 10-minute, well under the critical response window [8], ensuring timely delivery of epinephrine during anaphylaxis. This approach strengthens emergency response time in remote locations and communities, saving lives and improving healthcare outcomes during most emergency situations.

Strengths: Drones enable autonomous and rapid delivery of emergency medication.

Considerations: Waypoints identifications; payload capacity; government aviation and medication regulations; personnel training; and inclement weather

Summary

Drones are crucial in deploying high-value, low-shelf-life medications like EpiPen® or anti-venom, showcasing their essentiality in emergency response. The demonstrated feasibility of this achieved simulation underscores the significance of integrating drone technology in medical supply chain management.

References

1. Philbin D. IAEM clinical guideline emergency management of anaphylaxis in adult patients. Irish Association for Emergency Medicine; 2022.
2. Cardona V, Ansotegui IJ, Ebisawa M, El-Gamal Y, Fernandez Rivas M, Fineman S, et al. World allergy organization anaphylaxis guidance 2020. The World Allergy Organization Journal. 2020 Oct 30;13(10):100472. doi: 10.1016/j.waojou.2020.100472
3. Cianferoni A, Muraro A. Food-induced anaphylaxis. Immunology and Allergy Clinics of North America. 2012; 32(1):165–195.
4. Sampson HA. Anaphylaxis and emergency treatment. Pediatrics. 2003;111(Suppl_3):1601–1608.
5. Beck S, Bui T, Davies A, Courtney P, Brown A, Geudens J, et al. An evaluation of the drone delivery of adrenaline auto-injectors for anaphylaxis: pharmacists' perceptions, acceptance, and concerns. Drones. 2020;4(4):66.
6. O'Keeffe DT, Johnson K, Maraka S. Provision of bidirectional remote patient care with an unmanned aerial vehicle. Mayo Clinic Proceedings. 2020;95(4):830.
7. Arbabi H, Nasiri MM, Bozorgi-Amiri A. A hub-and-spoke architecture for a parcel delivery system using the cross-docking distribution strategy. Engineering Optimization. 2021;53:1593–1612.
8. Turner PJ, Soar J, Dodd A, Hampshire S, Hughes A, Sargant N, Whyte AF. Emergency treatment of anaphylaxis guidelines for healthcare providers. Resuscitation Council UK; 2021.