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EFFICIENCY EVALUATION OF INTELLIGENT HEALTHCARE SYSTEMS BASED ON INNOVATIVE DEA MODEL - TAKING THE APPLICATION OF UNMANNED AIRCRAFT SYSTEM (UAS) AS AN EXAMPLE

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Abstract

This paper investigates the efficiency evaluation and strategic application of Unmanned Aerial Systems (UAS) within the smart healthcare ecosystem. Driven by the profound integration of Artificial Intelligence (AI), the nascent 6G communications, and the low-altitude economy, smart healthcare has transitioned toward the construction of highly resilient, automated logistics networks. As a critical mobile medical infrastructure, UAS has demonstrated a decisive impact on mitigating healthcare disparities in remote areas and shortening emergency response times within the critical "Golden Hour."

This paper adopts an innovative Data Envelopment Analysis (DEA) model -- the Three-stage Entropic Weight Method with Assurance Region (tEWM-AR) approach -- to measure operational efficiency across scenarios such as emergency medical supply delivery, remote deployment of Automated External Defibrillators (AEDs), and dynamic patient monitoring in aging communities. Empirical results indicate that the tEWM-AR model effectively addresses high-uncertainty variables within medical environments, confirming that the integration of UAS significantly enhances the service resilience and carbon-neutral operational efficiency of healthcare institutions.

According to the latest report from IDTechEx, the global drone market (encompassing both commercial and consumer sectors) is projected to grow from $69 billion in 2026

to $147.8 billion by 2036, with a compound annual growth rate (CAGR) of 7.9%. Notably, the deployment of commercial drones is accelerating, with annual shipments expected to exceed 9 million units by 2036 (MakerPRO, 2026/01). This trend underscores the robust global demand for high-frequency, low-latency medical logistics solutions. The evaluation framework proposed herein not only provides a scientific metric for mobile healthcare technologies but also offers critical empirical support for policymakers in designing low-altitude medical rescue corridors and establishing technical standards.

Keywords: Unmanned Aerial Systems (UAS), Smart Healthcare, Low-Altitude Economy, Data Envelopment Analysis (DEA), tEWM-AR Model, Healthcare Resilience, Service Efficiency, Accessibility.

1. Introduction

In recent years, Intelligent Healthcare has emerged as a pivotal development trend within the modern medical landscape. Driven by the profound integration of technologies such as the Internet of Things (IoT), Big Data Analytics, and Generative Artificial Intelligence (Gen AI), smart medical services have transitioned from traditional digitalized models toward "predictive" and "proactive" service paradigms. Such rapid advancements in digital technology have not only maximized the analytical depth of medical data but have also catalyzed the emergence of disruptive innovation tools, most notably Unmanned Aerial Systems (UAS). The implementation of UAS is swiftly reshaping the logic of traditional medical supply distribution. It demonstrates significant service resilience and accessibility, particularly in addressing "last-mile" logistics challenges and remote medical monitoring.

1.1 Background and Research Motivation

At present, Taiwan is undergoing one of the most profound demographic structural transformations globally. According to the latest statistics from the Ministry of the Interior (MOI) and the National Development Council (NDC): "Taiwan transitioned into an 'Aged Society' at the end of March 2018. As of late October 2025, the total population stood at 23,310,853, of which 4,637,897 were aged 65 and above. This elderly cohort accounts for 19.9% of the total population, placing Taiwan on the verge of becoming a 'Super-Aged Society'" (MOI Statistical Bulletin, 2025).

The speed of this process has truly set a world record: the progression from an "Aged Society" to a "Super-Aged Society" has taken less than 10 years, significantly faster than Japan (11 years), the United States (15 years), and France (126 years). Furthermore, as the working-age population shrinks, Taiwan's dependency ratio is projected to climb to 53.2% by 2030, meaning that every 1.8 productive individuals will support one dependent.

Faced with such an abrupt aging wave, the demand for adjustments in long-term care, medical services, and the associated support burden has become increasingly urgent. In particular, the requirements for emergency medical rescue (e.g., AED delivery) and long-term care supplies in remote and aging communities will eventually manifest as severe challenges characterized by resource scarcity and rising exigency. Against this backdrop, governments worldwide have incorporated the "Low-Altitude Economy" into their national strategies. In Taiwan, for instance, the Civil Aeronautics Administration (CAA) of the Ministry of Transportation and Communications revised the "Regulations Governing Remote-control Unmanned Aircraft" in 2025. This revision eased restrictions on Beyond Visual Line of Sight (BVLOS) operations for medical purposes, providing a regulatory "green light" for UAS to integrate into the smart healthcare ecosystem. UAS not only effectively alleviates the pressure of medical manpower shortages but also reduces the delivery time of emergency medications or biological samples by 40%–60% under extreme terrain or traffic congestion. Consequently, scientifically evaluating the operational efficiency of UAS within smart healthcare systems has become a pressing task for policymakers and medical institutions to optimize resource allocation.

2. Current Status of UAS Applications in Smart Healthcare

As global healthcare systems grapple with structural challenges such as population aging, medical labor shortages, and the inequitable distribution of resources in remote areas, traditional service delivery models are increasingly struggling to meet modern demands for real-time responsiveness and precision. Within this context, the profound integration of Intelligent Healthcare and mobile technology has paved a new path for medical transformation. Specifically, Unmanned Aerial Systems (UAS/UAV) -- leveraging their superior spatial mobility and potential for autonomous integration -- are rapidly evolving beyond their early military and aerial photography origins. Today, they are infiltrating multi-dimensional domains, including medical logistics, emergency rescue, and remote monitoring.

2.1 Definition and Application of Intelligent Healthcare

According to the authoritative definition by the World Health Organization (WHO), Intelligent Healthcare (also referred to as Digital Health or eHealth in broader contexts) signifies the profound application of Information and Communication Technology (ICT) within the healthcare sector. Its scope has expanded from early-stage administrative automation to advanced clinical decision support systems (CDSS) and public health surveillance. Taiwan has played a pivotal role in this transformation. Building upon early initiatives such as Electronic Medical Records (EMR) and Picture Archiving and Communication Systems (PACS), and progressing to recent RFID-based hospital security programs and value-added applications of Health Big Data, Taiwan has established a robust digital foundation.

The core of intelligent healthcare lies in the vertical integration of cross-disciplinary technologies. As illustrated in Figure 1, this study categorizes its framework into six major technological pillars, collectively termed the ABCDEF architecture:

A (AI): Facilitates advanced medical imaging diagnostics and predictive medical analytics.

B (Blockchain): Ensures privacy protection and immutability during cross-institutional medical record exchanges.

C (Cloud): Provides vast storage and elastic computing capabilities for massive medical datasets.

D (Data): Employs Big Data mining to uncover latent disease correlations.

E (Edge Computing): Enables real-time localized computation at the point of care to minimize latency.

F (Fifth Generation/6G): Provides an ultra-high-speed, low-latency transmission environment to support telesurgery and UAS navigation.

According to the latest data published by Grand View Research (2025) and InvesTaiwan (2024), the global intelligent healthcare market is entering a period of explosive growth. Between 2023 and 2030, the market is projected to expand at a Compound Annual Growth Rate (CAGR) of 12.8% to 14.5%, with global output expected to

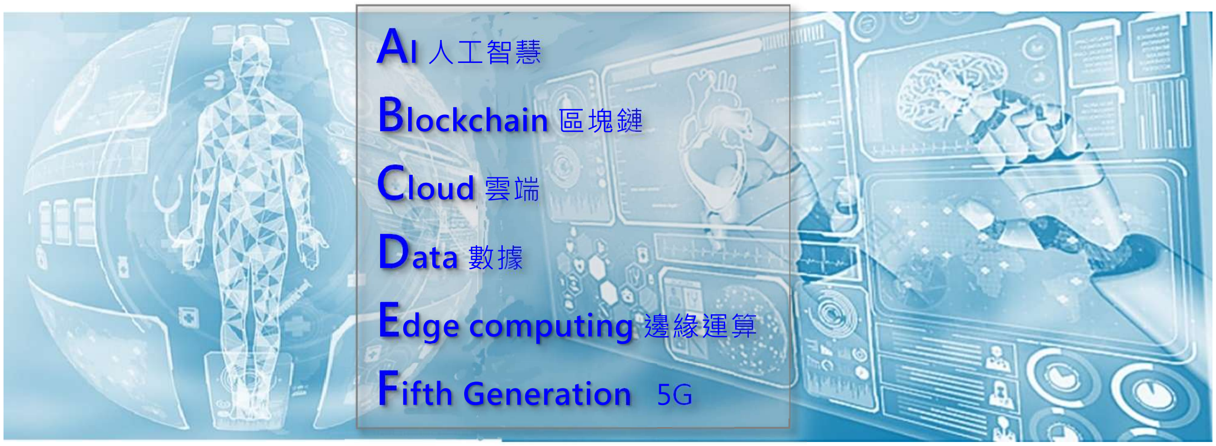

Figure 1. Six major technological applications of smart healthcare
(Source: Self-compilation of this article)

reach between $385.2 billion and $520 billion by 2030. Notably, three major markets -- the Asia-Pacific (including Japan, China, Southeast Asia, and India), the United States, and Europe -- currently command over 90% of the global market share.

2.2 Multi-scenario Applications and In-depth Case Studies of UAS Technology.

As the technological boundaries of smart healthcare systems continue to expand, Unmanned Aerial Vehicle (UAV/UAS) technology has evolved from simple aerial photography tools into highly autonomous mobile medical nodes. The following sections provide an in-depth exploration of three core application scenarios:

2.2.1 Emergency Medical Supply Delivery

Globally, approximately 3 to 5 million people lose their lives annually due to delays in the delivery of emergency medications, blood products, or antivenoms. UAS possesses a decisive advantage in overcoming topographical barriers and urban traffic congestion. In-depth Case Study: The success of Zipline in Rwanda and Ghana has become a global benchmark. By the end of 2025, Zipline had cumulatively delivered over 1.5 million doses of vaccines and blood samples. This initiative reduced the blood wastage rate in remote areas by 61% and improved emergency response efficiency by 45%.

Technical Data: Research confirms that in urban environments, UAS delivery of emergency supplies -- such as Automated External Defibrillators (AEDs) -- is, on average, 6 to 10 minutes faster than traditional ambulances. For patients with sudden myocardial infarction, this translates to an increased survival rate of approximately 35% to 40%.

2.2.2 Delivery of Remote Medical Equipment and Precision Instruments

In regions with complex geographical environments, transporting expensive and heavy diagnostic equipment -- such as portable ultrasound machines and electrocardiogram (ECG) monitors -- has historically presented a significant logistical challenge.

Case Study: Between 2024 and 2025, the Canadian drone logistics company Drone Delivery Canada (DDC) implemented the "Medical Express Program" in remote indigenous communities. This initiative not only reduced delivery times by 100% (achieving near-instantaneous logistics relative to previous methods) but also demonstrated energy consumption levels 50 times lower than those of traditional diesel trucks.

Environmental Contribution: With the rise of "Green Healthcare," the low-carbon characteristics of UAS allow them to garner higher weights in Data Envelopment Analysis (DEA) efficiency evaluations. According to a 2026 report in Nature Sustainability (a Nature Portfolio journal), "replacing short-range fuel-based logistics with UAS can reduce the logistical carbon footprint of healthcare institutions by approximately 80%."

2.2.3 Remote Patient Monitoring and Physiological Data Transmission

Unmanned Aerial Vehicle (UAV/UAS) technology not only as couriers but also as aerial monitoring stations. Equipped with high-resolution infrared sensors and 6G transmission modules, UAS are capable of conducting real-time inspections for individuals in home quarantine or across aging communities.

Economic Benefit Data: An empirical report from the National Library of Medicine (NLM) in 2025 indicates that remote monitoring technology integrated with UAS can save each cardiac patient approximately $1,810 to $2,150 annually in outpatient and hospitalization costs. This paradigm effectively alleviates the crisis of healthcare workforce depletion within a "Super-Aged Society."

2.3 Market Prospects, Policy Incentives, and Technological Synergies

The penetration rate of the global drone market within the healthcare sector is accelerating. According to a cross-analysis of market research reports published by Global Information, Inc. (GII, 2024) and MarketsandMarkets (MnM, 2026): "The global medical drone market is projected to expand at a robust growth rate of 13.8% to 16.5%, reaching a valuation of $1.82 billion by 2032." Furthermore, the mobile health (mHealth) market surpassed $60 billion in 2025 and is expected to cross the $100 billion threshold in 2026.

Innovative policies from various governments have also provided significant momentum. For instance, the success of Australia's Swoop Aero and India's Swiggy in normalizing drone delivery models post-pandemic demonstrates the critical importance of synergy between technology and policy. The proliferation of UAS represents not only a revolution in logistical efficiency but also a major milestone in achieving healthcare equity -- the equalization of medical resource allocation.

3. Research Methodology

Given that Data Envelopment Analysis (DEA) can simultaneously process multiple inputs and outputs, it offers a broad scope of application and is particularly suitable for general performance evaluation problems. Furthermore, the analytical results derived from DEA tend to be more readily accepted by the evaluated units. To address the inherent irrationality of "zero weights" commonly found in traditional DEA models and to achieve a weight range evaluation that better reflects real-world conditions, this study adopts a contemporary DEA model: the tEWM-AR (Three-stage Expert Weighting Method with Assurance Region) model. Specifically, the efficiency evaluation process of the tEWM-AR model incorporates a comprehensive three-stage operational framework consisting of expert consultation, expert questionnaires, and iterative expert feedback.

Moreover, the expert interviews designed within the tEWM-AR model partially resemble the operational procedures of the Delphi Method (DM). The number of interviewees does not necessarily need to be large; the primary requirement is that they must be "experts" in the specific field under investigation to ensure their opinions possess sufficient consultative and reference value. The size of the expert panel is determined by the scope and complexity of the research topic, typically not exceeding 20 individuals.

Ultimately, the anticipated impacts of this approach include at least the following: (1) adhering to the Expert Weighting Method (EWM) theory to highlight the underlying importance and correlations between variables; (2) narrowing the 95% confidence intervals; and (3) maintaining stability in the mean values (Bao et al., 2020). The following four stages outline the sequential process of conducting an efficiency evaluation using the tEWM-AR model:

Stage 1: Expert Consultation
The primary focus of this stage is to conduct multiple rounds of iterative expert consultations. These consultations aim to define the specific "Research Topic" for the empirical verification in Chapter 4, as well as to identify the relevant key factors (variables) and their appropriate quantity required for designing the subsequent expert questionnaire.

Stage 2: Expert Interviews and Survey Administration
This stage involves two core tasks: first, defining the selection criteria for the experts; and second, inviting the identified experts to contribute their professional insights by completing the expert questionnaire.

Stage 3: Collection, Statistics, and Analysis of Expert Questionnaires
During this stage, four types of data related to efficiency evaluation are sequentially generated: (1) Actual Scores, (2) Importance Scores, (3) Evaluation Scores, and (4) Total Weights of Relative Importance. Specifically, the processes (or mathematical expressions) for generating the Evaluation Score Matrix and the Total Weights of Relative Importance Matrix are as follows:
Evaluation Score Matrix = [Actual Score Matrix] × [Importance Score Matrix].

By applying the Expert Weighting Method (EWM) theory to the Evaluation Score Matrix, we emphasize the underlying correlations and significance between variables to derive the Total Weights of Relative Importance Matrix.
Stage 4: Collection and Analysis of Iterative Expert Feedback

In the final stage, we calculate the consensus ratio (percentage of agreement) regarding whether the experts perceive the ranking results of the total relative importance weights for the six variables to be reasonable and consistent with professional judgment.

In conclusion, the adoption of the tEWM-AR model for efficiency evaluation not only offers the practical advantages of operational efficiency and direct expert engagement, but also provides a robust evaluative approach that approximates the true state of the population.

4. The Results and Discussion of Example Verification

As evidenced by various efficiency evaluation methods, the traditional Data Envelopment Analysis (DEA) frequently exhibits the irrational phenomenon of "zero variable weights." To circumvent this limitation, this study employs a newly developed methodology -- the tEWM-AR model. This model integrates a comprehensive suite of operational procedures, including expert consultation, expert interviews, expert questionnaires, and iterative expert feedback, into the efficiency evaluation framework.

In summary, the tEWM-AR model synthesizes the respective strengths of the Expert Weighting Method (EWM), the Assurance Region (AR) model, and a holistic expert interview approach. Such a methodology not only offers the practical benefits of operational efficiency and direct expert engagement but also serves as a robust evaluative paradigm that approximates the true state of the statistical population.

4.1 Stage 1 of the tEWM-AR Model: Expert Consultation

As discussed in Chapter 2, this study initially explored the development of Unmanned Aircraft Systems (UAS) within the smart healthcare sector. The global drone market is currently experiencing exponential growth. According to a report by Fortune Business Insights (2023), the global commercial drone market is projected to expand from USD 10.98 billion in 2023 to an estimated USD 548.1 billion by 2030, representing a Compound Annual Growth Rate (CAGR) of 25.8%.

4.1.1 Research Background and Technological Trends

Current technical demands have deeply permeated diverse sectors, including logistics delivery, defense, healthcare, environmental monitoring, and architectural surveying. This trend has catalyzed integrated solutions combining cloud databases, edge computing, and the Internet of Things (IoT), enabling drones to perform all-weather real-time image acquisition and 3D modeling. These advancements not only mitigate the operational risks for frontline personnel in hazardous environments (e.g., high-risk disaster zones or chemically contaminated areas) but also facilitate the intelligent transformation of Environment, Health, and Safety (EHS) protocols.

4.1.2 Considerations for Performance-Influencing Factors

Despite the myriad of applications, distinct technical pathways yield significant variances in the overall efficiency of medical delivery. Based on research by Hassanalian & Abdelkefi (2018) and other scholars, the core factors influencing UAS performance include:

Endurance: Commercial multi-rotor drones typically average 20–40 minutes of flight time, which limits the radius of long-distance medical distribution.
Energy Density: Battery energy density directly dictates the Maximum Takeoff Weight (MTOW).

Communication Bandwidth: 4G/5G latency is critical for remote manual intervention (5G latency can be reduced to below 1ms).
Sensing Precision: Concerns the reliability of LiDAR or ultrasonic obstacle avoidance technologies.

Maintenance Costs: Includes component lifespan and operator training expenditures.

4.1.3 Implementation of Expert Consultation and Variable Establishment

To ensure the methodological rigor of the research topic and to design a high-precision expert questionnaire, this study synthesized and screened the aforementioned performance-influencing factors to serve as the foundational framework for the "Expert Consultation" phase. This stage engaged a panel of 20 experts specializing in smart healthcare and aerospace engineering. Through a three-stage Iterative Consultation process, the following objectives were systematically achieved:

Initial Consultation: Evaluated the suitability of the pre-screened variables and excluded factors with weak relevance to healthcare scenarios.

Secondary Consultation: Refined variable nomenclature to ensure semantic consistency across both medical and engineering domains.

Tertiary Consultation: Finalized the research topic and confirmed the six key evaluation variables.

4.1.4 Final Output: Empirical Case Study Topic and Evaluation Variables

The expert panel reached a consensus on the following empirical verification framework:

Research Topic: "Efficiency Evaluation of Drones' Technology in Smart Healthcare Systems"

Six Key Evaluation Variables:

⑴ Delivery Speed: Evaluates UAS efficiency in medical supply delivery, particularly emergency response capabilities (studies indicate drones can reduce arrival times by 40–60% compared to ambulances).

⑵ Cost-effectiveness: Compares UAS logistics with traditional labor-intensive methods, measuring the Return on Investment (ROI) of per-kilometer delivery and maintenance costs.

⑶ Safety and Failure Rate: Assesses system reliability based on Mean Time Between Failures (MTBF), including risk management and fault-handling protocols during flight.

⑷ Medical Resource Accessibility: Measures the improvement in accessibility to remote areas (rural regions, isolated islands) or disaster zones.

⑸ Information Transfer Speed and Bandwidth: Evaluates the transmission performance of medical data to ensure synchronized, real-time information exchange.

⑹ Environmental Impact & Trends: Evaluates ecological factors such as low carbon emissions and noise pollution while considering future technological trends to ensure sustainability and innovation.

4.2 Stage 2 of the tEWM-AR Model: Expert Interviews

Following the completion of the "Expert Consultation" phase and the finalization of the research topic, this study subsequently invited 20 relevant experts to provide professional "Actual Scores" based on their specialized cognition. The implementation of the second stage of the tEWM-AR model is structured into two sequential steps, as detailed below:

Step 1: Selection Criteria and Profile of Interviewees
In alignment with the research topic, "Efficiency Evaluation of Drones' Technology in Smart Healthcare Systems," the criteria for selecting interviewees were strictly defined. The participants were required to be General Managers, Associate Vice Presidents, or Department Managers currently serving in the production departments of the high-tech manufacturing industry with more than three years of professional experience in their respective roles (see Table 4-1 for details).

Table 4-1: Profiles and Professional Backgrounds of the Interviewed Experts

Expert		Current Company Position	Interview Time
1	Expert A	Manager	October 15, 2025
2	Expert B	General manager	October 17, 2025
3	Expert C	Manager	October 21, 2025
4	Expert D	Manager	October 23, 2025
5	Expert E	Manager	October 27, 2025
6	Expert F	Manager	October 30, 2025
10	Expert G	Senior manager	October 31, 2025
8	Expert H	Manager	November 3, 2025
9	Expert I	General manager	November 5, 2025
10	Expert J	Manager	November 10, 2025
11	Expert K	Manager	November 10, 2025
12	Expert L	Manager	November 12, 2025
13	Expert M	Manager	November 14, 2025
14	Expert N	Manager	November 110, 2025
15	Expert O	Manager	November 19, 2025
16	Expert P	Manager	November 21, 2025
110	Expert Q	Manager	November 24, 2025
18	Expert R	Manager	November 26, 2025
19	Expert S	Manager	November 210, 2025
20	Expert T	Manager	November 28, 2025

(Source: Self-compilation of this article)

Step 2: Design of the Expert Questionnaire and Invitation of Participants Following multiple rounds of iterative

expert consultation, two primary outcomes were established during this stage, providing the foundation for the subsequent research:

(1) Finalization of the Research Topic:

The study was formally titled "Efficiency Evaluation of Drones' Technology in Smart Healthcare Systems."

(2) Definition of Evaluation Variables:

The six key reference factors (variables) for the performance evaluation were definitively identified.
Consequently, the primary task during this step involved synthesizing the finalized Research Topic and Variable Names

to design an "Expert Questionnaire" that aligns with the evaluative requirements of the tEWM-AR model (refer to Appendix A for the complete instrument).

4.3 Stage 3 of the tEWM-AR Model: Collection, Statistics, and Analysis of Expert Questionnaires

In this stage, the statistical processing of the "Expert Questionnaires" sequentially generates four key datasets:

Actual Score Matrix (Table 4-2);
Importance Score Matrix (Table 4-3);
Evaluation Score Matrix (Table 4-4);
Total Weights of Relative Importance Matrix for each variable (Table 4-5).

The generation process is detailed in the following four steps:

Step 1: Construction of the Actual Score Matrix

Focusing on the first key evaluation factor, "Wireless Charging Time," experts were invited to provide "Actual Scores" based on their professional judgment. These individual assessments were then synthesized to construct the Actual Score Matrix.

Table 4-2: Expert Assessments for the First Variable: The Actual Score Matrix

Expert	Delivery Speed
Expert A	98
Expert B	88
Expert C	98
Expert D	91
Expert E	91
Expert F	93
Expert G	91
Expert H	90
Expert I	91
Expert J	91
Expert K	91
Expert L	86
Expert M	99
Expert N	92
Expert O	91
Expert P	96
Expert Q	98

Expert R	95
Expert S	99
Expert T	90

(Source: Self-compilation of this article)

Step 2: Construction of the Importance Score Matrix

For all subsequent evaluation factors (starting from the second variable), experts were invited to provide importance ratings relative to the "first variable." These relative assessments were compiled to establish the Importance Score Matrix.

Table 4-3: Expert Ratings Relative to the First Variable: The Importance Score Matrix

Expert	The importance of the first variable	The relative importance of the second variable	The relative importance of the third variable	The relative importance of the fourth variable	The relative importance of the fifth variable	The relative importance of the sixth variable
A	1	1.9	1.9	1.8	1.9	2.0
B	1	1.6	2.0	1.7	2.0	1.9
C	1	2.0	1.7	1.7	1.9	1.6
D	1	1.6	1.5	1.6	1.8	2.0
E	1	1.9	1.7	2.0	1.7	2.0
F	1	2.0	1.4	2.0	1.7	1.9
G	1	1.6	1.8	1.8	1.9	1.9
H	1	1.9	1.6	1.9	1.7	1.8
I	1	1.7	2.0	1.8	1.6	2.0
J	1	1.7	1.8	2.0	1.8	1.7
K	1	2.0	1.9	1.6	1.6	1.7
L	1	2.0	1.5	2.0	2.0	1.7
M	1	1.8	1.4	1.5	1.9	1.9
N	1	1.8	1.8	2.0	1.8	1.6
O	1	1.6	1.6	1.8	1.7	1.9
P	1	2.0	1.5	1.7	1.7	1.5
Q	1	1.8	1.4	1.6	1.9	1.8
R	1	1.9	1.7	1.5	1.9	1.7
S	1	1.7	1.9	1.5	2.0	1.5

T	1	1.9	1.4	1.6	1.9	1.9

(Source: Self-compilation of this article)

Step 3: Calculation of the Evaluation Score Matrix

Following the procedural framework described in Step 1, Stage 3 of the Methodology (Chapter 3), the Evaluation Score Matrix is derived. Specifically, this matrix is the product of the Actual Score Matrix (Table 4-2) and the Importance Score Matrix (Table 4-3). The resulting data is tabulated in Table 4-4.

The mathematical relationship is expressed as follows:

$$Evaluation\ Score\ Matrix = Actual\ Score\ Matrix \times Importance\ Score\ Matrix$$

$$= Table\ 4-2 \times Table\ 4-3$$

$$= Table\ 4-4$$

Table 4-4: Evaluation Score Matrix (Product of Actual and Importance Score Matrices)

專家	Delivery Speed y1	Cost-effectiveness y2	Safety and Failure Rate y3	Medical Resource Accessibility y4	Information Transfer Speed and Bandwidth Limitations y5	Environmental Impact and Future Development Trends y6
A	98	186	186	176	186	196
B	88	141	176	150	176	167
C	98	196	167	167	186	157
D	97	155	146	155	175	194
E	97	184	165	194	165	194
F	93	186	130	186	158	177
G	91	146	164	164	173	173
H	90	171	144	171	153	162
I	91	155	182	164	146	182
J	91	155	164	182	164	155
K	97	194	184	155	155	165
L	86	172	129	172	172	146
M	99	178	139	149	188	188
N	92	166	166	184	166	147

O	97	155	155	175	165	184
P	96	192	144	163	163	144
Q	98	176	137	157	186	176
R	95	181	162	143	181	162
S	99	168	188	149	198	149
T	90	171	126	144	171	171

(Source: Self-compilation of this article)

Step 4: Derivation of the Total Weights of Relative Importance Matrix

In accordance with the procedures outlined in Step 2, Stage 3 of the Methodology (Chapter 3), the Total Weights of Relative Importance Matrix is derived. This stage emphasizes the underlying significance and inter-correlations among the various variables. The calculated weights are consolidated into Table 4-5.

4.4 Stage 4 of the tEWM-AR Model: Collection, Statistics, and Analysis of Iterative Expert Feedback

Following the statistical processing of the "Expert Questionnaires" (as shown in Table 4-5), this study conducted follow-up interviews with the 20 experts to solicit "Iterative Expert Feedback" (refer to Appendix B for the feedback form). This stage allowed experts to express their level of concurrence with the finalized statistical results.

The analysis of the aggregated feedback from the 20 experts confirms that the tEWM-AR methodology effectively highlights the experts' professional assessment of the "relative importance" among variables. Furthermore, these results demonstrate a high degree of correlation with future trends in the global UAV technology market (see Table 4-6).

4.4.1 Analysis of Expert Consensus and Rationality

Based on the data presented in Table 4-6, the following conclusions can be drawn:

Table 4-5: Total Weights of Relative Importance Matrix for the Six Variables

Delivery Speed	Cost-effectiveness	Safety and Failure Rate	Medical Resource	Information Transfer Speed and	Environmental Impact and	The sum of the 'weight of Relative importance	Ranking

				Acces-sibility	Band-width Limita-tions	Future De-velopment Trends	score'	
y1	20	11.0630	12.1175	11.5132	11.0421	11.2053	76.941	⑥
y2	36.4000	20	22.1204	20.9344	20.1147	20.4441	140.014	②
y3	33.5000	18.5894	20	19.2648	18.5064	18.7823	128.643	⑤
y4	35.1000	19.3951	21.2415	20	19.4182	19.6404	134.795	④
y5	36.4000	20.1521	22.0630	21.0000	20	20.4154	140.030	①
y6	36.0000	19.9631	21.8297	20.6969	19.8967	20	138.386	③

Table 4-6: Expert Consensus Ratio on the Rationality of Ranking Results for the Total Relative Importance Weights (Six Variables)

Rank-ing	The names of the six reference important factors	Reason-able	No com-ment	unrea-sonable
①	y5：Information Transfer Speed and Bandwidth Limitations	50%	40%	10%
②	y2：Cost-effectiveness	55%	35%	10%
③	y6：Environmental Impact and Future Development Trends	15%	80%	5%
④	y4：Medical Resource Accessibility	45%	45%	10%
⑤	y3：Safety and Failure Rate	45%	55%	-
⑥	y1：Delivery Speed	60%	40%	-

(1) Analysis of the "Reasonable" Ratio Expert Consensus) The ranking results indicate a pronounced consensus among experts regarding the top three evaluation criteria. Specifically, "y5: Information Transfer Speed and Bandwidth" and "y2: Cost-effectiveness" achieved rationality agreement ratios of 50% and 55%, respectively, reflecting a high level of expert alignment on the significance of these two factors. Furthermore, "y1: Delivery Speed" received a 60% "Reasonable" response rate, further substantiating its strategic priority in UAS (Unmanned Aircraft Systems) applications.

(2) Analysis of the "No Opinion" Ratio (Uncertainty or Divergence) Data in the

table reveal that "y6: Environmental Impact and Future Trends" garnered an 80% "No Opinion" ratio. This high percentage may suggest a degree of ambiguity or uncertainty regarding the role of environmental factors among experts. Alternatively, it may indicate that the correlation between environmental impact and current technical implementation remains to be clearly defined in the present stage.

(3) Perspectives on "Unreasonable" Ratings Regarding "y3: Safety and Failure Rate," while it obtained a 45% rationality rating, the remaining 55% of experts expressed "No Opinion." Notably, none of the experts categorized this factor as "Unreasonable." This distribution suggests that while perspectives on this variable are somewhat dispersed, there is no active dissent regarding its inclusion in the evaluative framework.

4.4.2 Further Focus Worth Discussing

The aforementioned findings suggest that while a solid consensus exists among experts regarding the relative importance of the evaluation criteria, certain areas of divergence and uncertainty remain. These results facilitate a deeper understanding of the relationship between expert judgment and empirical data, providing a robust framework for guiding future research and strategic decision-making. Furthermore, the statistical distribution in Table 4-6 highlights two significant focal points for discussion:

(1) Alignment Between Statistical Results and Global UAV Market Trends The statistical analysis demonstrates that the experts' assessment of variable importance is highly congruent with the application prospects of UAS in smart healthcare. For instance, the high level of agreement on "y5: Information Transfer Speed and Bandwidth" reflects the critical need for real-time responsiveness and high-efficiency connectivity in smart medical services—a requirement that directly aligns with global market demands.

(2) Positive Synergy Between UAS Technology and Smart Healthcare Systems The expert feedback and statistical results further validate the intimate correlation between UAS technology and the evolution of smart healthcare systems. UAS technology demonstrates significant value, particularly in enhancing medical resource accessibility, improving logistical efficiency, and supporting telehealth services. These findings exhibit a strong positive correlation with the global trajectory of smart healthcare development.

5. Conclusions and Recommendations

5.1 Conclusions

Through an in-depth exploration of the "total weight rankings of the six key evaluation factors" and the corresponding "iterative expert feedback" regarding UAS technology and smart healthcare systems, this study elucidates the critical relationship between statistical rankings and expert insights, while aligning these findings with global demand trends. Based on the statistical distribution presented in Table 4-6, two pivotal focal points for discussion are identified:

5.1.1 High Alignment Between Statistical Results and Market Demands: Focus on Speed and Cost

The statistical results indicate that "Information Transfer Speed and Bandwidth (50%)" and "Cost-effectiveness (55%)" are perceived by experts as the primary critical success factors. This reflects a strategic shift in the application of UAS technology within the healthcare market—moving beyond fundamental "flight capabilities" toward "data processing efficiency" and "operational cost management." Market Evidence: According to a Global Information, Inc. (GII) 2025 report, the global drone market is projected to grow from USD 31.23 billion in 2024 to USD 52.96 billion by 2030, representing a Compound Annual Growth Rate CAGR) of 9.20%. This growth momentum is primarily driven by the expansion of commercial applications, which substantiates the forward-looking perspectives of the experts in this study regarding technological optimization and economic viability.

5.1.2 Positive Correlation Between Industrial Transformation and Global Trends: Towards AI Intelligence and Software-Hardware Integration

The empirical data presented in the previous chapter indicates that "Environmental Impact and Future Development Trends" achieved an 80% consensus ratio among experts. This underscores that enhancing the accessibility of medical resources remains the core vision for the application of UAS technology.

Transformation Trends: Facilitated by the integration of advanced AI technologies, the drone industry is transitioning from a hardware-centric model toward a "Software-Hardware Integration and Ecological Collaboration" paradigm. Nations worldwide have identified "AI-enabled Drones" as a strategic priority for both national defense and economic positioning.

Positioning of Taiwan: While Taiwan possesses significant hardware advantages, it faces challenges from geopolitics and intense global competition. It is imperative for Taiwan to accelerate its technological transformation and refine regulatory frameworks. By establishing an "Autonomous and Trustworthy" supply chain, Taiwan can ensure data sovereignty while deepening the synergistic relationship between UAS and smart healthcare systems (Taiwan Economic Research Monthly, 2025/08).

5.2 Policy and Practical Recommendations

Based on the aforementioned research conclusions, this study proposes four strategic directions for the application of UAS in the smart healthcare sector.

5.2.1 Strengthening Technical Foundations and Economic Viability. Optimizing Transmission Performance: Continuous investment in R&D is essential to enhance data transmission speeds and bandwidth stability, particularly for high-stakes applications such as remote surgery and real-time tele-sensing.

Lowering Adoption Barriers: Improve cost-effectiveness through the application of advanced materials and economies of scale. Additionally, developing diversified leasing or "as-a-service" models can alleviate the initial financial burden of equipment acquisition for healthcare institutions.

5.2.2 Promoting Sustainable Development and Forward-looking Planning
Implementing Green Technology: Research should prioritize eco-friendly energy sources, such as hydrogen fuel cells or high-energy-density solid-state batteries, alongside the promotion of recyclable materials to align with the sustainability goals of smart healthcare.

Maintaining Architectural Flexibility: Establish highly adaptable technical frameworks to ensure that UAS systems can undergo rolling upgrades in response to evolving medical demands and advancements in AI technology.

5.2.3 Deepening International Collaboration and Market Penetration
Transnational Collaboration Mechanisms: Governments and academia are encouraged to participate in international standard-setting. Overcoming technical bottlenecks can be achieved through cross-border technology sharing and the exchange of best practices.
Stimulating Innovation Momentum: Leverage government subsidies or venture capital to channel funding into medical UAS applications, addressing global demands for emergency rescue and rural

medical distribution.

5.2.4 Refining Regulatory Frameworks and Technical Standards

Establishing Legal Frameworks: Develop specialized regulatory statutes for medical drones that clearly define flight safety protocols, patient privacy protection, and ethical compliance.

Standardizing Technical Specifications: Create a unified standardization system covering equipment quality, system interoperability, and operational procedures to mitigate application risks and ensure the quality of medical services.

5.3 Concluding Remarks

Unmanned Aircraft System (UAS) technology possesses immense transformative potential within the innovation of smart healthcare systems. Although technical bottlenecks and market challenges persist, the feasibility of its application can be effectively enhanced through the strategic recommendations proposed in this study -- namely, technological optimization, green transformation, international collaboration, and the refinement of regulatory frameworks. Future research should continue to monitor the integration of AI and fluctuations in the global supply chain to provide robust support for constructing a more efficient, secure, and resilient smart medical logistics ecosystem.

VI. References

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Appendix A

Expert Questionnaire

Research Topic: "Efficiency Evaluation of Drone Technology (DT) in Smart Healthcare Systems"

6 important factors related to the research topic of this paper:

1) Delivery Speed
2) Cost-effectiveness
3) Safety and Failure Rate
4) Medical Resource Accessibility
5) Information Transfer Speed and Bandwidth Limitations
6) Environmental Impact and Future Development Trends

The 6 questions in this Expert Questionnaire are as follows:

Q 1. Entrepreneur Xiaohu is currently planning to build a smart healthcare system. To improve the strategic benefits of "rapid delivery and response capabilities, reduced labor costs, avoidance of human risks, and real-time monitoring and data acquisition," please provide a rating of the strength of your professional understanding of the first important reference factor, "delivery speed," relative to the reference importance of "building a smart healthcare system"： points.

□ Very weak	□ Weak	□ Normal	□ Strong	□ Very strong
1 ~ 20	21 ~ 40	41 ~ 60	61 ~ 80	81 ~ 100 分

Q 2. Additionally, please also rate the importance of the second important reference factor, "Cost-effectiveness," relative to the first reference factor, " Delivery Speed," with a score of： points.

relative importance Low		relative importance Medium (same importance.)		relative importance High
1	5	10	15	20

Q 3. Please rate the importance of the third key reference factor, "Safety and Failure Rate," relative to the first key reference factor, "Delivery Speed," with a score of： points.

relative importance Low		relative importance Medium (same importance.)		relative importance High
1	5	10	15	20

Q 4. Please rate the importance of the fourth key factor, "Medical Resource Accessibility," relative to the first key factor, "Delivery Speed," and assign it a score of： points.

relative importance Low		relative importance Medium (same importance.)		relative importance High
1	5	10	15	20

Q5. Please rate the importance of the 5th key reference factor, "Information Transfer Speed and Bandwidth Limitations," relative to the first key reference factor, "Delivery Speed," with a score of： points.

relative importance Low		relative importance Medium (same importance.)		relative importance High
1	5	10	15	20

Q 6. Please rate the importance of the 6th key reference factor, "Environmental Impact and Future Development Trends," relative to the first key reference factor, "Delivery Speed," with a score of： points.

relative importance Low		relative importance Medium (same importance.)		relative importance High
1	5	10	15	20

Appendix B

This article revisited the 20 experts and invited them to provide professional "Feedback Opinions From Expert."

《Right Table》: Original data of the "relative importance" rating scores provided by experts.
《Left Table》: Statistical results for the "Table 4-5 'Weighted Summation of Relative Importance' Matrix".

(Reprinted from Table 4-5, "Statistical Results of 20 Experts")			(Original data provided by expert)	
The names of the six reference important factors	The sum of the 'weight of Relative importance score'	Ranking	Evaluation scores (Provided by experts)	Relative ranking of Evaluation scores
y5：Information Transfer Speed and Bandwidth Limitations	140.030	①		
y2：Cost-effectiveness	140.014	②		
y6：Environmental Impact and Future Development Trends	138.386	③		
y4：Medical Resource Accessibility	134.795	④		
y3：Safety and Failure Rate	128.643	⑤		
y1：Delivery Speed	76.941	⑥		

「Expert Feedback」:
This feedback was provided by experts regarding the content of the table above.

Statistical results in Table 4-5			It reasonable?
Ranking	The names of the	The sum of the 'weight	

	six reference important factors	of Relative importance score'	
①	y5：Information Transfer Speed and Bandwidth Limitations	140.030	○Reasonable ○No comment ○unreasonable
②	y2：Cost-effectiveness	140.014	○Reasonable ○No comment ○unreasonable
③	y6：Environmental Impact and Future Development Trends	138.386	○Reasonable ○No comment ○unreasonable
④	y4：Medical Resource	134.795	○Reasonable ○No comment

	Accessibility		○unreasonable
⑤	y3：Safety and Failure Rate	128.643	○Reasonable ○No comment ○unreasonable

⑥	y1：Delivery Speed	76.941	○Reasonable ○No comment ○unreasonable