Cost-Effectiveness of an Automated Delivery Robot Program to Reduce Nursing Transport Burden in an Intensive Care Unit: A Hospital-Provider Perspective

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Background

- In addition to providing direct patient care, ICU nurses often need to transport medications, IV drips, and medical supplies within the unit.
- These tasks often require repeated walking between patient rooms and the storage area, reducing time available for patient care and increasing nurses' physical workload.
- Automated delivery robots are increasingly seen as tools to support hospital logistics and reduce manual handling. However, their economic value in Taiwanese hospitals remains unclear.

Objectives

- To evaluate the cost-effectiveness of a two-robot automated delivery system compared with manual transport by nurses in an ICU from the hospital provider's perspective.

Methods

- A cost-effectiveness analysis model was developed to compare a two-robot automated delivery system with manual transport by nurses in an ICU. Transport task data were collected from a 3-day observation period in an ICU with 15 patient rooms.
- Manual picking time was modeled as Unif(90,120) seconds in both strategies, with 105 seconds used in the base case.
- Manual transport included picking time and weighted round-trip walking time between patient rooms and the storage area.
- Robot-assisted delivery was modeled using discrete event simulation. The robot strategy consolidated transport tasks into scheduled delivery rounds, and all tasks were assumed to use the robotic arm.
- Costs were estimated from the hospital provider's perspective and included nurse labor cost, robot implementation cost, annual maintenance cost, and operating cost.
- One-way sensitivity analyses were conducted to assess the impact of key parameters on the ICER.

Table 1. Manual plan actual number of transport tasks per unit (data for three days)

Shift Type	Three-Day Task Count	Average Daily Task Count	Percentage
Day Shift	89	29.67	36.3%
Evening Shift	42	14.00	17.1%
Night shift	114	38.00	46.5%
Total	245	81.67	100.0%

Table 2. Robot plan delivery schedule

Transport time	Transport goods
02:00	IV fluids
04:00	Specimens
05:00	Medications
06:00	Medical supplies
15:00	Medications
18:00	Medical supplies

Table 2. Model Inputs

Parameters	Base-case input
Manual plan	
Hourly wage for nurses	Day-shift: NT$366/hour; Evening-shift: NT$441/hour; Night-shift: NT$471/hour
Time per manual operation	Picking time + manual walking time = 105s + 44s = 149s/time
Robot plan	
Annual cost of robots	By initial implementation cost= NT$10,000,528; Equipment lifespan= 7years; Discount rate= 3%; Annual maintenance cost= NT$233,472
Annual nurse labor cost in robot plan	NT$55,345 (by DES)
Time per manual operation	UNIF(90,120) (by DES)
Manual round-trip transport time	1237.8s (by DES)

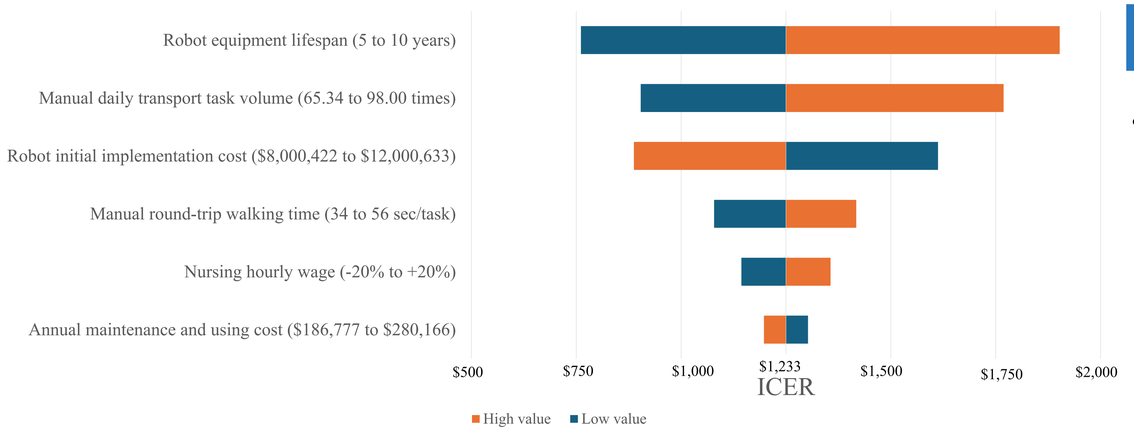
Results

- The robot-assisted strategy saved 1,108.28 nursing transport-related hours per year compared with manual transport.
- The incremental cost was NT$1,366,281, resulting in an ICER of NT$1,233 per nursing hour saved.

Table 3. Base Case Results

Option	Total cost (NTD)	Nursing Transport Time(hrs/year)	Incremental Costs	Incremental Nursing Hours Saved	ICER (△C/△E)
Robot	$1,893,965	125.50	$1,366,282	1108.28 hrs	NT$1,233
Manual	$527,684	1233.78			

Figure 1. Deterministic Sensitivity Results



Conclusions

- The two-robot delivery system reduced ICU nurses' transport-related workload, saving 1,108.28 nursing hours per year. The ICER was NT$1,233 per nursing hour saved, suggesting potential value for redirecting nursing time toward direct patient care.