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ORIGINAL

Return on investment of rapid ICU workforce upskilling: an economic and cost-effectiveness analysis

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Abstract

Purpose: Although healthcare crises are infrequent, they may place extraordinary stress on Intensive Care Units (ICUs), often exposing critical weaknesses in workforce planning and resulting in acute staffing shortages. This study presents a comprehensive economic evaluation of large-scale, rapid ICU workforce upskilling as a strategic response to such pressures. Specifically, we assess the cost-effectiveness, economic sustainability, and resilience-building potential of these interventions during crisis conditions.

Methods: C19_SPACE, a Europe-wide upskilling initiative led by the European Society of Intensive Care Medicine (ESICM), was implemented across 24 countries between 2020 and 2021. A societal economic evaluation and return on investment (ROI) was calculated through deterministic modeling and validated using probabilistic sensitivity analysis across a range of plausible scenarios, including variations in patient throughput, training efficacy, and healthcare system parameters.

Results: The total societal investment in the program was €20.1 million, translating to an average cost of €1146 per participant and €1720 per Quality-Adjusted Healthcare Worker (QAHW). Deterministic modeling estimated an ROI of 478%, with program costs fully recovered in just 5.1 days. Probabilistic sensitivity analysis confirmed the robustness of these findings, with a mean ROI of 455% (95% CI 130–1029%) and a median break-even point of 5.4 days (95% CI 2.66–13.04 days).

Conclusion: Rapid, structured ICU workforce upskilling initiatives deliver substantial economic returns and significantly expands healthcare capacity. Strategic investment in emergency workforce upskilling is economically sound and crucial for healthcare system resilience during future crises.

Keywords: Economic evaluation, Crisis management, Cost-effectiveness, Workforce training, Upskilling

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Introduction

Critical care systems are frequently tested by large-scale crises that generate a sudden and sustained increase in demand for intensive care services [1]. Whether driven by infectious disease outbreaks, environmental disasters, or other high-impact events, such scenarios expose structural vulnerabilities and stretch intensive care unit (ICU) capacity to its limits [2]. In these contexts, system resilience depends not only on material resources but also on the ability to rapidly mobilize and reconfigure the healthcare workforce to meet emerging needs [3]. Conventional strategies for crisis response have largely focused on logistical measures—such as increasing ICU bed numbers, repurposing wards, and reallocating equipment [4]. However, these efforts are often constrained by a more fundamental bottleneck: the availability of skilled personnel. Even in high-income countries, the number of physicians and nurses with critical care expertise is limited and cannot be easily expanded through traditional workforce pipelines, which rely on lengthy, resource-intensive training pathways [5].

To address this challenge, healthcare systems have explored flexible workforce models that support rapid deployment in times of crisis [5, 6]. One approach involves the targeted upskilling of non-ICU professionals—physicians and nurses from other specialties—who can be temporarily integrated into critical care teams [7]. This strategy aims to enhance surge capacity while trying to maintain continuity of care. Importantly, it represents a broader shift from reactive measures to proactive preparedness, embedding upskilling as a core element of health system resilience. A prominent example of this approach is the COVID-19 Skills Preparation Course for Europe (C19_SPACE), funded by the European Union (EU) Commission, and developed by the European Society of Intensive Care Medicine (ESICM). Designed for broad implementation across multiple countries, the program provided standardized, competency-based training to upskill non-ICU healthcare professionals, enabling them to effectively support critical care services during periods of heightened demand [8, 9]. While the clinical rationale for such programs is increasingly accepted, the economic impact of large-scale, rapid-response upskilling initiatives remains poorly characterized.

Implementing such programs requires significant investment—both direct costs (e.g., materials, coordination, and personnel) and indirect costs (e.g., time away from clinical duties). Previous estimates of critical care upskilling programs suggest wide variability in per-person expenditures, ranging from €3100 to €24,000 depending on intensity and delivery model [10, 11]. Given these significant expenditures, understanding the financial efficiency and return-on-investment (ROI) of such initiatives is essential. In contrast to standard healthcare investments, crisis-driven interventions demand heightened efficiency; resource misallocation or mismanagement not only results in financial losses but also risks compromising patient care and exacerbating pressures on an already overstretched healthcare system [6].

Consequently, systematic economic evaluation of crisis-driven upskilling initiatives is essential to optimize resource allocation, manage financial constraints effectively, and safeguard care quality [12]. By accurately assessing the cost-effectiveness and economic impacts such as the ROI of such programs, healthcare systems can minimize waste, maintain operational effectiveness, and prevent additional strain on limited healthcare personnel [13].

This study provides a comprehensive economic evaluation of the C19_SPACE program, examining its direct and indirect costs, resource utilization, and broader system impact. By integrating clinical and economic perspectives, this study provides data-driven insights into the cost-effectiveness of the crisis response strategy. The findings aim to guide policymakers in optimizing resource allocation for rapid large-scale workforce training, ensuring that such upskilling initiatives deliver maximum value with minimal risk of misallocation.

Take-home message

This study provides an economic evaluation of a large-scale ICU upskilling program implemented in a crisis context. While prior research has primarily examined clinical outcomes or training effectiveness, this analysis quantifies financial returns and system-level benefits, offering empirical evidence for rapid workforce training as a strategic investment. The findings equip policymakers with actionable insights on cost-effectiveness and resource prioritization in emergency preparedness and response.

Methodology

Economic analysis framework

This study aims to evaluate the economic impact of the C19_SPACE program using a comprehensive, three-step approach that balances in-depth analysis with the limitations imposed by data availability. Our methodology integrates cost analysis, cost-effectiveness analysis (CEA), and scenario-based simulations to assess financial efficiency and ROI. The analysis utilizes data from the C19_SPACE program, which provided training to 17,494 professionals; 12,086 of these participants were certified, with support from 2400 trainers. Competency test scores increased from a pre-training average of 63.1% to a post-training average of 83.6% ($p < 0.005$) [8].

Phase 1: cost analysis

The first phase of the evaluation focuses on determining the cost per trained healthcare professional, aimed to provide an understanding of the program's financial efficiency. The cost of the training program was calculated by incorporating both direct and indirect costs, as detailed in Tables 1 and 2.

Phase 2: cost-effectiveness analysis (CEA)

Cost analysis in isolation is insufficient to capture the full value of the program, as its intended impact lies in improving patient care. Given the ethical constraints inherent to crisis settings, direct measurement of patient outcomes was not recorded. To address this limitation, we developed the Quality-Adjusted Healthcare Worker (QAHW) index—defined as a healthcare professional attaining ≥ 80% proficiency in ICU-relevant skills, as determined by expert consensus—to serve as a proxy for training effectiveness. The cost per QAHW was subsequently calculated, providing a pragmatic estimate of cost-effectiveness in the absence of direct outcome data.

Table 1 Input parameters derived from the C19_SPACE study, including all course design, implementation, and opportunity costs* (defined as time spent away from clinical duties)

Category	Parameter	Value (range)
Training program budget	Training development cost *Management coordination* IT PLATFORM (SETUP & MAINTENANCE) Virtual reality environment (VRE) content development 3D glasses: purchase & transport Video lectures	€2,485,050
Training implementation	Faculty time per training event	10 h
	Number of faculty members	75 people
	Training time per participant	12 h
Trainees	Total trainees *Doctors trained* Nurses trained	17,494 people *8213 people* 9281 people

Phase 3: return-on-investment supported by scenario-based simulations

In Phase 3, we refine the analysis conducing an ROI with scenario-based simulations that estimate the program's impact based on intermediate outcome related to increased capacity. By combining empirical data from the study with published international estimates, we develop a model for the post-training clinical phase. Key metrics include the increase in patient treatment capacity—reflecting the ability to manage a higher patient volume through an expanded and upskilled workforce—and the corresponding rise in ICU capacity, measured by the number of additional beds that could be safely staffed and operated.

Although a significant number of physicians were trained, the primary limitation in scaling ICU capacity stemmed from nursing availability—particularly in light of shift scheduling and nurse-to-bed ratio requirements. Consequently, despite physicians comprising 50% of the participants, our core calculations focused on nursing resources.

Return on investment (ROI)

The ROI is calculated as the net profit from the investment divided by its initial cost

$$\text{ROI (\%)}* = \left[\left(\text{Monetary Benefit} - \text{Investment Costs}\right) / \text{Investment Costs}\right] \times 100.$$

Table 2 Input parameter taken from international literature; when data were not available expert opinion was obtained

	Value	Min	Max	References
Knowledge status	0.82	0.63	1.00	[8]
Working hours per week (hours)	40	36	48	[21]
FTE (full-time equivalent) shifts per month	22	20	24	[21]
Salary of a healthcare worker (HCW) per hour (€)	60	35	150	[22]
Patients per doctor ratio	8	6	10	[23]
Patients per nurse ratio	2	1	4	[24, 25]
ICU length of stay (LOS)	8	5	13	[26]
Cost of ICU stay ICU patient	12,500	5500	18,000	[27, 28]
Bed utilization rate	75%	60%	85%	[22] Expert opinion

*An ROI (%) greater than 1 indicates a positive return, while an ROI less than 1 indicates a negative return.

All costs were reported in Euro (EUR), and no currency conversion was necessary, as all financial data originated from institutions and sources within the European Union. The chosen time horizon for the analysis was 1-month post-training. This short timeframe was selected to capture immediate outcomes, including direct implementation costs, workforce availability, and operational adjustments within healthcare institutions. Although short term, the analysis also reflects early indicators of medium-term benefits—such as improved workforce capacity and enhanced system resilience—which are essential in evaluating the initial return-on-investment of the training program. Given the 1-month analysis period, discounting of costs and outcomes was not necessary.

Input data

Direct costs These include implementation costs, equipment costs, personnel costs, and operating costs. We used published international literature to estimate hourly wages, workforce capacity (full-time equivalent (FTE)), and staffing ratios. The economic value generated per patient was estimated by assuming that the average cost incurred to treat a patient reflects the economic value attributed to the patient's full stay. Tables 1 and 2 summarize the input parameter and assumptions used in the model.

Indirect costs and opportunity costs From a societal perspective, we account for indirect costs, including opportunity costs—the value of healthcare professionals' time spent in training rather than providing clinical care. Although opportunity costs do not involve direct financial outlays, they represent a significant societal investment, particularly in programs where time is the primary resource. Including these costs captures the full value of mobilized human capital, crucial during the pandemic when diverting physicians strained already limited resources. We calculated opportunity costs by multiplying trainees' hourly compensation by the time spent attending and preparing for the training.

Capacity calculation

Capacity and throughput were estimated based on key assumptions (and tested within their min–max range): each newly trained nurse works 48 h per week, totaling approximately 22 shifts per month, with a bed-to-nurse ratio of 2:1. We calculated monthly "nurse shifts", multiplied this by the patient-to-nurse ratio to determine total "patient shifts", and then divided by the required shifts per patient to estimate the number of patients managed per nurse per month.

Sensitivity and uncertainty analysis

Deterministic scenario analysis

To establish a clear and interpretable foundation for evaluating economic implications, we initiated the analysis using a deterministic framework. This approach allows for the direct comparison of predefined scenarios based on fixed input values, offering transparent "what-if" benchmarks for stakeholders and decision-makers.

Three scenarios were defined to reflect likely, optimistic, and pessimistic operational environments derived from explicit values, as highlighted in Table 2:

- Scenario I (probable): 75% bed utilization, 8-day length of stay, 2 patients per nurse, €12,500 cost per patient
- Scenario II (best case): 85% utilization, 5-day stay, 4 patients per nurse, €18,000 value per patient
- Scenario III (worst case): 60% utilization, 13-day stay, 1 patient per nurse, €5500 value per patient

Probabilistic sensitivity analysis

To complement the point estimates derived from the deterministic framework and better capture real-world variability, we conducted a probabilistic sensitivity analysis using Monte Carlo simulation with 10,000 iterations. This methodology facilitates robust estimation under uncertainty by incorporating variability in the key input parameters. Specifically, we modeled the length of stay (LOS) in ICU, patient-to-nurse ratios, training costs, and per-patient ICU costs using triangular probability distributions drawn from literature.

This probabilistic approach allows for continuous sampling across the plausible ranges of each input parameter, generating a distribution of potential economic outcomes.

Results

Participants and outcome

Cost analysis

Table 3 presents the cost breakdown of the total investment in the training program. From a societal perspective, the overall cost of the program amounted to € 20,055,235. When divided by the number of trainees, this results in a cost of € 1146 per trainee for the full program.

The introduction of the Quality-Adjusted Healthcare Worker (QAHW) metric allowed for intermediate measurement of training effectiveness, showing that 12,086 trainees met predefined competency standards (≥ 80%

Table 3 Cost-effectiveness analysis of the C19_SPACE training program

Cost category	Cost per person (€)	People (Ppl)	Hours (h) per person	Total Cost (€)
Training program budget	–	–	–	€ 2,485,050
Subject matter experts	250	75	10	€ 187,500
Trainer costs	55	2400	14	€ 1,848,000
Opportunity costs for trainees				
Doctors	60	8213	19	€ 9,362,820
Nurses	35	9281	19	€ 6,171,865
Cost of the training program	–	2400	–	€ 20,055,235
Number of trainees	–	17,494	–	
Cost per trainee	–	–	–	**€ 1146**
Cost-effectiveness ANALYSIS				
Trainees meeting predefined performance standards[a]		12,086		
Cost per quality-adjusted trainee				**€ 1659**

QAHW Quality-Adjusted Healthcare Worker, *ROI* return on investment

[a] The predefined standards are to achieve a test score of > 80% of all desired tasks and knowledge

test score). The resulting average cost per QAHW was calculated at € 1659.

The direct budget allocated to the training development amounted to €2,485,050 (12%), covering core program expenses. Additionally, €187,500 (1%) was dedicated to engaging subject matter experts, while €1,848,000 (9%) covered local trainer compensation. In addition to direct costs, the analysis accounts for the opportunity costs of trainees, estimated at €15,534,685 (77%), representing the economic value of the time trainees spent away from clinical duties during the program.

Healthcare capacity and ROI analysis-Base Case analysis

Based on previously described capacity calculations, coupled with further assumptions on system efficacy, which are detailed in Table 2, the program enabled the activation of approximately 2537 additional ICU beds across participating hospitals. With an average ICU length of stay of 8 days, this translated into capacity for 9281 additional patients per month. Applying a standard cost value of €12,500 per ICU admission, the workforce trained by the program generated an estimated societal value of €116 million monthly. With an overall program cost of €20.1 million, these figures correspond to a return-on-investment (ROI) of 478%, with financial break-even achieved just 5.1 days after deployment.

Deterministic "What-if" scenario analysis

The "probable" scenario showed outcomes closely aligned with the point estimates described in the above mentioned "base case", with only slight variations resulting from adjustments to staffing variables—which emerged as the most influential factors affecting the final results. In the best-case scenario, the return-on-investment (ROI) was particularly strong, with a break-even point achieved in just over a day, underscoring the high value of the upskilling program. Scenario analysis further demonstrated that even in the worst-case scenario, the initial investment was recouped within just over a month—highlighting that upskilling initiatives can deliver rapid and resilient returns (Table 4).

Probabilistic Monte Carlo simulation

A probabilistic Monte Carlo simulation was conducted to account for uncertainty in key input parameters. The analysis yielded a mean return-on-investment (ROI) of 455%, with the central 90% of simulated outcomes

Table 4 Deterministic simulation scenario outcomes

Scenario	Total patients/month	Total economic value	Monthly ROI	Break-even time
I. Probable	9,866	123,332,920 €	514%	4.95 days
II. Best	23,598	424,764,000 €	2020%	1.4 days
III. Worst case	3,310	18,205,000 €	−9.2%	33 days

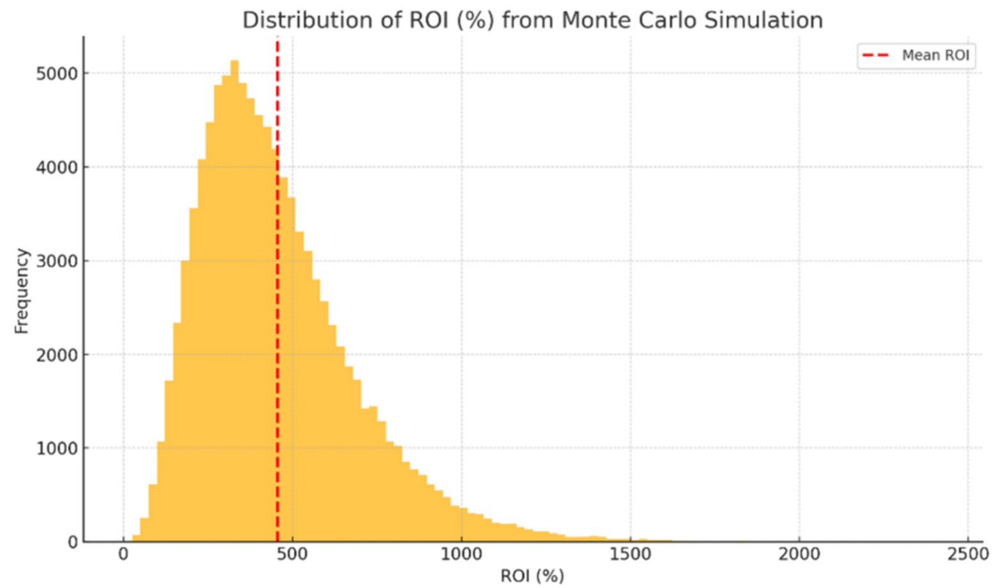

Fig. 1 Distribution of the ROI in the probabilistic Monte Carlo Simulation analysis

ranging from 130 (5th percentile) to 1029% (95th percentile). The mean time to break-even was 5.4 days, with 90% of simulations achieving cost recovery between 2.7 and 13.0 days. These results, as seen in Fig. 1, indicate a consistently favorable economic profile across a wide range of plausible scenarios.

Discussion

This study provides robust evidence that large-scale, time-limited upskilling interventions can serve as effective and economically sound responses to healthcare system strain during crises. The C19_SPACE program, implemented at unprecedented speed and scale across 24 European countries, achieved an ROI of 478%, with full program cost recovery in just 5.1 days. Probabilistic modeling further validated these results, showing a mean ROI of 455% (95% CI 130–1029%) and cost neutrality in 90% of simulations within 2 weeks of deployment.

In crisis settings, where time and resources are scarce, such outcomes are highly relevant. Policymakers must make swift, evidence-informed decisions about resource allocation. Embedding ROI modeling into program evaluation offers a critical, yet underutilized, tool for identifying high-yield strategies. While prior ICU-related economic studies have largely focused on capital infrastructure—such as ventilators or beds—this analysis brings the healthcare workforce to the forefront, quantifying its economic impact through operational metrics such as patient throughput and system-wide value generation [4].

The scale of the C19_SPACE program was central to its economic efficiency. Involving thousands of healthcare professionals, the program's reach enabled fixed costs (e.g., coordination and digital infrastructure) to be distributed across a large base. This reflects both the intense demand for ICU support during crisis periods and the opportunity to mobilize workforce capacity at scale. In contrast to smaller continuing medical education initiatives—where ROI is often modest or even negative [14] the high-leverage nature of crisis-responsive upskilling directly translated into expanded care delivery and accelerated system performance. Although not directly measured, the strategic choice to centralize virtual content and deliver practical training near clinical sites likely reduced logistical costs and enhanced staff availability.

A critical strength of our analysis is the explicit inclusion of opportunity costs, which accounted for 77% of the total program costs. These reflect the substantial value of healthcare professionals' time diverted from clinical duties—a particularly relevant factor given the program's rapid scale-up and the need to double training slots to meet unprecedented demand. While often excluded from hospital-based economic evaluations, opportunity costs are essential for capturing the full societal investment required by large-scale public health interventions [15, 16]. Excluding opportunity costs would underestimate the true societal investment and fail to reflect the full economic value of large-scale, crisis-responsive upskilling initiatives. Accounting for human capital mobilization provides a more comprehensive, policy-relevant understanding of return-on-investment in healthcare resilience [17].

The analysis was intentionally designed from a conservative, system-level perspective, focusing exclusively on the contribution of nurses—widely recognized as the principal constraint in ICU capacity expansion across European healthcare systems. This modeling choice aimed to provide a lower-bound estimate of program benefits, reflecting realistic implementation constraints and avoiding overestimation of impact. Under worst-case assumptions, wherein newly trained nurses were assigned a productivity level equivalent to only 10% of a fully trained ICU nurse, the model still demonstrated full cost recovery within 1 month. These results underscore the critical importance of tailoring workforce upskilling strategies to specific system bottlenecks to maximize efficiency and resilience.

Beyond the economic metrics, his study underscores the need for integrated evaluation frameworks that capture both financial and systemic dimensions of large-scale health interventions. Sound policy decisions in crisis settings must consider not only feasibility, but also economic viability, scalability, and logistical implementation [18]. By incorporating all these elements, this analysis offers a practical, data-driven foundation for guiding emergency resource allocation. As future crises—be they pandemics, climate-related events, or geopolitical conflicts—continue to challenge ICU capacity, rapid and strategic workforce development should be viewed not as an ancillary activity, but as a core pillar of preparedness. Investments in human capital, when executed at scale and guided by data, yield not only financial returns but also safeguard the continuity and quality of patient care when it is needed most.

Strengths and limitations

This study has several methodological strengths. First, it integrates multiple levels of economic evaluation—including cost analysis, cost-effectiveness analysis (CEA), and ROI—offering a comprehensive perspective that extends beyond cost-per-trainee metrics. Second, by adopting a societal perspective, it captures broader economic implications, such as increased hospital throughput and system responsiveness. This aligns with best practices in health economic evaluation and enhances the transferability of findings across settings [19]. Finally, the use of scenario-based simulation allows for the accommodation of uncertainty inherent in emergency program implementation. Probabilistic Monte Carlo and deterministic scenario analyses confirmed the program's economic viability even under cautious assumptions such as reduced bed utilization or lower economic value per patient.

Several limitations should be acknowledged. Most notably, the analysis lacks direct clinical outcome data—such as patient-level improvements, quality of care indicators, or mortality rates—primarily due to logistical and operational constraints during the emergency implementation phase. As a result, it is not possible to establish direct causal links between the training program and clinical outcomes. While the purpose of this analysis was to evaluate the knowledge gain, future research could aim to link upskilling initiatives with clinical performance metrics using integrated health system data. Furthermore, data on workforce-level effects, particularly in areas such as staff well-being and mental health, were not collected. These dimensions are particularly relevant, as intensive training interventions may influence stress levels, job satisfaction, and burnout—factors that are critical to long-term healthcare system resilience but were beyond the scope of this initial evaluation. Furthermore, the analysis adopts a short-term perspective, likely underestimating the broader and longer-term benefits of the program. These include sustained skill retention, changes in clinical practice, and the diffusion of knowledge among peers, which were not captured in the current model. While our ROI estimates are conservative, evidence from prior studies suggests that the impact of crisis training can persist for up to a year, with measurable improvements in clinical performance [20]. Future longitudinal studies should evaluate the durability of acquired competencies and their effect on workforce development and patient care.

Despite these limitations, our findings offer significant implications for policymakers and healthcare administrators. The demonstrated economic efficiency strongly advocates for strategic investments in emergency healthcare workforce training. Policymakers should incorporate systematic economic evaluations into crisis preparedness frameworks, thereby optimizing resource allocation and fostering greater healthcare system resilience.

Conclusion

This study provides strong economic evidence supporting the value of crisis-driven upskilling programs. The C19_SPACE initiative demonstrated that a well-structured, large-scale training effort can generate immediate financial and operational benefits, with a rapid ROI and a significant increase in ICU capacity. While emergency training requires a substantial initial investment, the results clearly show that such programs are not only cost-effective but also essential for strengthening healthcare system resilience. Future research should build upon these findings by incorporating longitudinal assessments of skill retention, direct patient outcome data, and comparative analyses across different healthcare settings.

Abbreviation

ICU: Intensive care unit; ROI: Return on investment; CEA: Cost-effectiveness analysis; QAHW: Quality-adjusted healthcare worker; FTE: Full-time equivalent; ESICM: European Society of Intensive Care Medicine; EUR: Euro; LOS: Length of stay; HCW: Healthcare worker.

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Author contributions

CE, MI, FV, JA and MC made substantial contributions to the conception and design of the study, as well as to the analysis and interpretation of the data. CE and GJS led the statistical analysis, CE took primary responsibility for drafting the manuscript. MC guided the evaluation process. MC, EA, and JK played a central role in conceptualizing the initial study and overseeing its implementation. Their input was instrumental in defining the scientific relevance and informing the design of the economic model. MC, JK, EA, and CE reviewed all revisions and provided in-depth scientific analysis, significantly enhancing the manuscript's quality. All authors contributed their expertise, critically revised the content, and approved the final version of the manuscript.

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Availability of data and materials

We used anonymized data, currently stored at the ESICM Data Management system. The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Conflicts of interest

No conflicts or competing interests regarding this study have been declared. The authors certify no conflicts of interest with any financial organization regarding the material discussed in the manuscript. Maurizio Cecconi is a Section Editor for Intensive Care Medicine journal. He has not taken part in the review or selection process of this article.

Consent for publication

Not applicable.

Ethical standards

This study involved only secondary economic data analysis and did not include human subjects; therefore, ethical review and approval were not required.

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