WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Perceived Cost-Effectiveness and Operational Benefits of Hiring an In-House Preventive Maintenance Services Biomedical Engineer in the Level 2 Private Hospital in Cabuyao, Laguna

Diana Miranda, Dr. Erwin M. Faller*

St. Bernadette of Lourdes College, Graduate School, Quezon City, Metro Manila 1111, Philippines

A B S T R A C T

Frequent downtime of medical devices disrupts patient care and increases hospital costs. This study examined the perceived cost-effectiveness and operational benefits of employing an in-house biomedical engineer dedicated to preventive maintenance in a Level 2 private hospital in Cabuyao, Laguna. Using a descriptive correlational design, a structured survey gathered responses from 123 hospital personnel including administrators, physicians, nurses, ancillary staff, and department heads. Descriptive statistics summarized perceptions, and Pearson's correlation tested the link between cost-effectiveness and operational benefits. Respondents strongly agreed that hiring an in-house biomedical engineer reduced maintenance expenses, lessened reliance on outsourced services, and improved budget forecasting. Operational benefits included faster repair turnaround times, reduced equipment downtime, and extended device lifespan. A statistically significant positive correlation showed that higher perceived cost-effectiveness was associated with greater operational benefits. This model can serve as a guide for similar hospitals aiming to enhance patient safety, equipment reliability, and financial sustainability.

Keywords: Biomedical Engineer, Preventive Maintenance, Cost-Effectiveness, Operational Efficiency, Hospital Administration, Healthcare Management

1. Introduction

Healthcare delivery relies heavily on advanced medical equipment for accurate diagnoses, effective treatment, and quality patient care (Zamzam et al., 2021). Malfunctions can cause operational delays, increased costs, and risks to patient safety (Tucker & Spear, 2006). Preventive maintenance, therefore, is critical to ensuring equipment reliability and accuracy (Li et al., 2022). Hospitals often choose between outsourcing maintenance and employing in-house biomedical engineers (Khan et al., 2023).

Globally, hospitals must balance financial constraints with increasing healthcare demands (Chopra et al., 2024). Outsourcing maintenance appears cost-effective but may lead to delayed repairs and lack of control over schedules (Fernandez, 2010). In the Philippines, resource limitations and rising healthcare demands pose additional challenges (Seposo, 2019). Private Level 2 hospitals, such as Holy Rosary of Cabuyao Hospital, face difficulties due to specialized equipment needs for surgery, intensive care, and imaging (Reiling et al., 2008).

This study evaluates whether employing an in-house biomedical engineer for preventive maintenance can address these challenges, focusing on cost-effectiveness and operational benefits.

2. Methodology

This study used a descriptive correlational quantitative design to evaluate perceptions of cost-effectiveness and operational benefits of hiring an in-house biomedical engineer. Data were gathered from 123 hospital staff, including administrators, physicians, nurses, ancillary personnel, and department heads, selected through purposive sampling. A validated structured questionnaire measured demographic profiles, perceptions of cost-effectiveness, and operational benefits using Likert-scale items.

Data analysis involved frequency and percentage distribution for demographics, weighted means for perception levels, and Pearson correlation to examine relationships between variables. Ethical considerations included informed consent, voluntary participation, and confidentiality of responses.

3. Results and Discussions

Table 1. Respondents' Profile

Profile		Frequency	Percentage
Age	20 - 29 years old	15	12.20%
	20 - 39 years old	36	29.30%
	40 - 49 years old	52	42.30%
	50 - 59 years old	19	15.40%
	60 years old and above	1	0.80%
Years of Experience	less than 1 year	2	1.60%
	1 - 5 years	24	19.50%
	6 - 10 years	33	26.80%
	11 - 15 years	35	28.50%
	more than 15 years	29	23.60%
Experience with Equipment Maintenance	Yes	4	3.30%
	No	77	62.60%
	Not directly, but I have knowledge about it	42	34.10%
Position	Administrative & Support Services	34	27.60%
	Medical Staff	51	41.50%
	Department Head	8	6.50%
	Ancillary Staff	27	22.00%
	Others	3	2.40%
Educational Background	High School	0	0.00%
	Associate Degree	1	0.80%
	Bachelor's Degree	101	82.10%
	Master's Degree	8	6.50%
	Doctorate	13	10.60%
Total		123	100.00%

Table 1 presents the demographic profile of the respondents. Most were aged 40 to 49 years (42.3%), followed by those aged 20 to 39 years (29.3%), while only 0.8% were 60 years and above. In terms of work experience, the largest group had 11 to 15 years of service (28.5%), followed by those with 6 to 10 years (26.8%), and the fewest had less than one year (1.6%). Regarding exposure to equipment maintenance, 42 respondents had knowledge but

no direct experience, 77 had no experience at all, and only 4 had direct maintenance experience. By job classification, most were medical staff (41.5%), followed by administrative or support services (27.6%) and ancillary staff (22%), with department heads (6.5%) and other classifications (2.4%) comprising the rest. In terms of educational attainment, a majority held bachelor's degrees (82.1%), while smaller portions had doctorates (10.6%) or master's degrees (6.5%), and only one respondent held an associate degree; none reported high school as their highest education level.

Table 2. Level of Perceived Cost-Effectiveness of Hiring an In-house Biomedical Engineer as Perceived by the Healthcare Workers

Indicator	Weighted Mean	Standard Deviation	Verbal Interpretation
1. Hiring an in-house biomedical engineer would reduce overall maintenance costs.	4.60	0.58	Very High
2. In-house maintenance services are more cost-effective than outsourced services.	4.23	0.60	Very High
3. Employing an in-house biomedical engineer could lead to long-term financial savings for the hospital.	4.37	0.67	Very High
4. Having an in-house biomedical engineer would optimize the hospital's budget allocation for biomedical maintenance.	4.40	0.59	Very High
5. Having an in-house biomedical engineer would increase transparency regarding maintenance costs.	4.30	0.72	Very High
Summative Mean	4.38	0.49	Very High

Table 2 presents the respondents' assessment of the perceived cost-effectiveness of hiring an in-house biomedical engineer. The weighted means of all indicators ranged from 4.23 to 4.60, with a summative mean of 4.38, interpreted as "very high." This indicates that respondents strongly believe having an in-house biomedical engineer would significantly reduce maintenance costs and improve financial management. The highest-rated indicator was the belief that hiring an in-house biomedical engineer would reduce overall maintenance costs, while the lowest was the comparison of in-house versus outsourced cost-effectiveness, though still rated very high.

Supporting literature reinforces these findings. Studies by Dzobo et al. (2020) and Amos and Gadzekpo (2016) reported that hospitals with internal maintenance teams save 20–35% compared to outsourced services due to reduced contract expenses and better control over resources. Choudhary (2023) also highlighted that in-house teams allow better fund distribution and budget forecasting, while Kabeta et al. (2023) and Hinrichs-Krapels et al. (2022) noted their ability to prevent major equipment failures and secure cost-effective spare parts. These advantages extend beyond direct costs, improving efficiency, reducing downtime, and enhancing long-term sustainability by prolonging equipment life.

Table 3. Level of Perceived Operational Benefits of Hiring an In-house Biomedical Engineer as Perceived by the Healthcare Workers

Indicator	Weighted Mean	Standard Deviation	Verbal Interpretation
1. Hiring an in-house biomedical engineer would improve the reliability of medical equipment.	4.59	0.58	Very High
2. An in-house biomedical engineer would lead to faster response times for equipment repairs.	4.52	0.56	Very High
3. Having an in-house biomedical engineer would enhance the overall quality of patient care.	4.21	0.75	Very High
4. An in-house biomedical engineer would provide valuable training and support to staff regarding equipment use and maintenance.	4.45	0.59	Very High
5. Effective communication and collaboration between departments would improve with an in-house biomedical engineer on-site.	4.07	0.85	High
Summative Mean	4.37	0.50	Very High

Table 3 summarizes the respondents' perceptions of the operational benefits of hiring an in-house biomedical engineer. Weighted means ranged from 4.21 to 4.59, with most indicators rated "very high" and only one indicator, related to communication and collaboration, rated "high." The overall

summative mean of 4.37 reflects a strong belief that in-house biomedical engineers significantly enhance hospital operations by ensuring equipment reliability, minimizing downtime, and improving workflow efficiency.

Literature supports these findings, noting that resident biomedical engineers reduce repair delays and allow customized maintenance schedules aligned with hospital needs (Kelvin-Agwu et al., 2024; Demir et al., 2023). Their presence facilitates quicker response to equipment failures, strengthens coordination between technical and clinical staff, and contributes to regulatory compliance (Javaid et al., 2022; Badnjevic et al., 2023). Additionally, they improve spare parts management, prevent unplanned breakdowns through early diagnostics, and assist in decisions related to technology integration and adoption (Li & Carayon, 2021; Junaid et al., 2022). These advantages collectively enhance patient safety, operational flexibility, and readiness during high-demand situations or emergencies.

Table 4. Relationship Between Perceived Cost-Effectiveness and Operational Benefits When Grouped According to Age

Grouping	Results	Interpretation
20 - 29 years old	r=.627	Significant relationship exists / Moderate positive correlation
	p=.012*	
20 - 39 years old	r=.641	Significant relationship exists / Moderate positive correlation
	p=<.001	
40 - 49 years old	r=.746	Significant relationship exists / High positive correlation
	p=<.001*	
50 - 59 years old	r=.903	Significant relationship exists / Very high positive correlation
	p=<.001*	
*significant @.05		

Table 4 shows the relationship between perceived cost-effectiveness and operational benefits when grouped by age. Results indicate a positive correlation across all age groups, with correlation strength increasing as age rises. Younger respondents (20–29 and 30–39 years) showed moderate correlations ($r \approx 0.627–0.641$, $p < 0.05$), reflecting their awareness of the link between cost-effectiveness and operational benefits but limited exposure to decision-making. Mid-career respondents (40–49 years) demonstrated a high positive correlation ($r = 0.746$, $p < 0.001$), while the highest correlation was observed among those aged 50–59 years ($r = 0.903$, $p < 0.001$), suggesting that experience and seniority deepen understanding of how in-house biomedical engineering enhances hospital operations. Literature supports this trend, noting that senior healthcare professionals, through years of managing budgets and clinical teams, are more aware of preventive maintenance's role in reducing downtime and improving efficiency. Overall, findings imply that as professionals gain experience and greater operational responsibility, they increasingly recognize the value of cost-effective in-house biomedical engineering.

Table 5. Relationship Between Perceived Cost-Effectiveness and Operational Benefits When Grouped According to Years of Experience

Grouping	Results	Interpretation
1 - 5 years	r=.533	Significant relationship exists / Moderate positive correlation
	p=.007*	
6 - 10 years	r=.634	Significant relationship exists / Moderate positive correlation
	p=<.001*	
11 - 15 years	r=.770	Significant relationship exists / High positive correlation
	p=<.001*	
more than 15 years	r=.892	Significant relationship exists / High positive correlation
	p=<.001*	
*significant @.05		

Table 5 highlights the correlation between perceived cost-effectiveness and operational benefits when grouped by years of experience. Results show a consistent positive correlation across all experience levels, with correlation strength increasing with tenure. Staff with one to five years of experience displayed a moderate correlation ($r = 0.533$, $p = 0.007$), while those with six to ten years showed a higher correlation ($r = 0.634$, $p < 0.001$), reflecting a growing understanding of the link between cost-effective biomedical engineering and hospital operations as they take on more responsibilities. Respondents with 11 to 15 years of experience exhibited a strong positive correlation ($r = 0.770$, $p < 0.001$), and those with more than 15 years demonstrated the highest correlation ($r = 0.892$, $p < 0.001$), indicating that experienced staff strongly recognize the strategic value of in-house biomedical maintenance.

This trend aligns with literature emphasizing that professional experience deepens awareness of how preventive maintenance supports financial and operational outcomes (Li & Carayon, 2021; Fasbender & Gerpott, 2022). Senior healthcare workers, having faced budgetary and operational challenges, better understand the benefits of internal biomedical engineering in reducing downtime and ensuring efficient hospital functions (Zamzam et al., 2021; Corciova et al., 2024). The findings suggest that leveraging the insights of experienced staff can enhance organizational acceptance and support for in-house biomedical engineering strategies.

Table 6. Relationship Between Perceived Cost-Effectiveness and Operational Benefits When Grouped According to Experience with Equipment Maintenance

Grouping	Results	Interpretation
Yes	r=.838	No significant relationship exists / High positive correlation
	p=.162	
No	r=.776	Significant relationship exists / High positive correlation
	p=<.001*	
Not directly, but I have knowledge about it	r=.725	Significant relationship exists / High positive correlation
	p=<.001*	
*significant @.05		

Table 6 examines the correlation between perceived cost-effectiveness and operational benefits based on respondents' experience with equipment maintenance. Results showed high positive correlations across all groups, though significance varied. Individuals with direct maintenance experience recorded the highest correlation ($r = 0.838$) but without statistical significance ($p = 0.162$) due to the small sample size. Conversely, respondents with indirect maintenance knowledge ($r = 0.725$, $p < 0.001$) and those with no maintenance experience ($r = 0.776$, $p < 0.001$) exhibited strong and statistically significant correlations. This indicates that both technical and non-technical staff, regardless of their level of involvement, strongly perceive that cost-effective in-house biomedical engineering enhances hospital operations.

The trend suggests that even staff without hands-on roles recognize benefits through observation of improved workflows and reduced downtime, while experienced staff derive their perceptions from direct technical knowledge. Literature supports these findings, noting that familiarity with maintenance processes—whether direct or indirect—fosters appreciation of in-house biomedical engineering's role in operational efficiency and patient safety (Dzobo et al., 2020; Usin et al., 2024). These results highlight the importance of leveraging broad organizational support, including both clinical and administrative staff, to strengthen investment in internal biomedical engineering strategies.

Table 7. Relationship Between Perceived Cost-Effectiveness and Operational Benefits When Grouped According to Role or Group Classification

Grouping	Results	Interpretation
Administrative & Support Services	r=.686	Significant relationship exists / Moderate positive correlation
	p=<.001*	
Medical Staff	r=.700	Significant relationship exists / High positive correlation
	p=<.001*	
Department Head	r=.942	Significant relationship exists / Very high positive correlation
	p=<.001*	
Ancillary Staff	r=.739	Significant relationship exists / High positive correlation
	p=<.001*	
*significant @.05		

Table 7 presents the correlation between perceived cost-effectiveness and operational benefits when grouped by professional role or classification. All groups—Administrative and Support Services, Medical Staff, Department Heads, and Ancillary Staff—showed significant positive correlations ($p < 0.001$), ranging from moderate ($r = 0.686$) to very high ($r = 0.942$). The strongest correlation was observed among department heads, reflecting their unique position in balancing operational performance and financial decisions.

Administrative and support staff demonstrated moderate-to-high correlations, likely due to their role in budget oversight and awareness of cost savings achieved through in-house maintenance (Usin et al., 2024). Medical staff, including nurses and physicians, reported strong correlations, recognizing improvements in patient safety and clinical efficiency from reliable equipment support (Dzobo et al., 2020; Kelvin-Agwu et al., 2024). Ancillary staff, such as laboratory and radiology personnel, also displayed high correlations, influenced by their daily reliance on specialized medical equipment for accurate diagnostics and timely services (Aruna & Gunasilan, 2018).

Overall, results indicate a broad institutional consensus across different roles that in-house biomedical engineering provides significant cost and operational advantages. This alignment underscores the value of such services and supports their adoption as a strategic component of hospital operations (Li & Carayon, 2021).

Table 8. Relationship Between Perceived Cost-Effectiveness and Operational Benefits When Grouped According to Educational Background

Grouping	Results	Interpretation
Bachelor's Degree	r=.699	Significant relationship exists / Moderate positive correlation
	p=<.001*	
Master's Degree	r=.877	Significant relationship exists / High positive correlation
	p=.004*	
Doctorate	r=.969	Significant relationship exists / Very high positive correlation
	p=<.001*	
*significant @.05		

Table 8 explores the correlation between perceived cost-effectiveness and operational benefits across different educational backgrounds. Results show statistically significant positive correlations for all groups ($p < 0.001$), with correlation strength increasing alongside education level. Respondents with bachelor's degrees recorded a moderate-to-high correlation ($r = 0.699$), those with master's degrees exhibited a stronger correlation ($r = 0.877$), and doctorate holders demonstrated the strongest relationship ($r = 0.969$). This trend indicates that more advanced education is associated with greater recognition of how cost-effective in-house biomedical engineering translates to operational improvements.

The findings align with literature emphasizing that higher education equips healthcare professionals with advanced analytical and systems-thinking skills (Corciova et al., 2024; Aruna & Gunasilan, 2018). Bachelor-level staff, typically in clinical or support roles, develop practical awareness through direct experience, while master's and doctorate holders, often in managerial or leadership roles, possess deeper insight into strategic and operational interdependencies. Their training and responsibilities enhance their understanding of the financial and operational benefits of preventive biomedical maintenance. These results highlight the value of continuous education and professional development to strengthen organizational alignment and decision-making in hospital operations (Zamzam et al., 2021; Fasbender & Gerpott, 2022).

4. Summary of Findings, Conclusion, and Recommendations

Findings reveal that respondents perceive very high cost-effectiveness and operational benefits in hiring an in-house biomedical engineer. Significant positive correlations were found across all demographic and professional groups, with stronger relationships observed among older, more experienced, and more highly educated personnel. The study concludes that employing an in-house biomedical engineer enhances hospital efficiency, reduces reliance on outsourcing, minimizes downtime, and supports financial sustainability. It recommends adopting in-house preventive maintenance models, considering hybrid approaches for specialized equipment, and promoting continuous professional education to maximize understanding and support for biomedical engineering strategies.

Acknowledgements

The researcher expresses gratitude to family, adviser, classmates, and colleagues for their support throughout the completion of this study. Special thanks are extended to the hospital administration and staff who participated in the research, and to the Lord Jesus Christ for guidance and strength.

References

Alsaab R, Alsaab H (2023) Cost benefits of in-house biomedical engineering in hospital maintenance. Journal of Healthcare Management 45(3) 120–128.

Altayyar SS (2020) The essential principles of safety and effectiveness for medical devices and the role of standards. Medical Devices Evidence and Research 13 49–55.

Amos D, Gadzekpo A (2016) Comparative cost analysis of in-house versus outsourced biomedical equipment maintenance. International Journal of Healthcare Management 9(2) 108–113.

Aruna M, Gunasilan U (2018) Efficient equipment management for biomedical engineering department in the hospital. International Journal of Health Systems Research 12(2) 55–67.

Badnjevic A, Pokvic LG, Dzemic Z (2023) Ensuring compliance through effective medical device management: A review. Biomedical Engineering Online 22(1) 1–12.

Choudhary B (2023) Cost benefits analysis of in-house vs outsourced maintenance. FieldCircle 1(1) 1–8.

Corciova C, et al. (2024) Strategic biomedical engineering in hospital operations: A systems perspective. Healthcare Engineering Review 39(1) 18–29.

Demir F, Sahin B, Demir B (2023) Impact of preventive maintenance on equipment lifespan in Turkish hospitals. Journal of Healthcare Engineering 2023 1–9.

Dzobo D, Adotey J, Thomford NE, Dzobo KC (2020) Enhancing healthcare delivery through efficient device management: The role of biomedical engineers. Journal of Clinical Engineering 45(3) 112–119.

Javaid M, Haleem A, Singh RP, Suman R (2022) Biomedical engineering roles in modern healthcare. International Journal of Medical Engineering 39(2) 80–95.

Junaid M, et al. (2022) Diagnostic predictions in biomedical engineering for preventive maintenance. Healthcare Technology Letters 9(3) 45–53.

Kelvin-Agwu J, et al. (2024) Integration of biomedical engineering in healthcare operations. Journal of Clinical Technology 28(1) 33–45.

Li Y, Carayon P (2021) Cost-effectiveness analysis of biomedical maintenance strategies in hospitals. Healthcare Management Science 24(3) 211–223.

Nova R, et al. (2022) Emergency response and biomedical engineers during pandemics: Lessons learned. Global Health Operations 6(1) 44–53.

Seposo X (2019) Developmental changes in the Philippine health system: Accomplishments, successes and challenges. Healthcare 7(4) 116.

Usin T, et al. (2024) Correlation between hospital staff experience and biomedical equipment efficiency. International Journal of Hospital Administration 18(2) 100–112.

Zamzam M, Khan H, Wankar V (2021) Preventive maintenance practices in hospitals: A global review. Healthcare Technology Letters 8(4) 145–154.