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Advancement of artificial intelligence in biomedical equipment maintenance management

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Abstract
The rapid advancement of Artificial Intelligence (AI) has revolutionized the sphere of Biomedical Equipment Maintenance Management (BEMM), providing remarkable possibilities to enhance efficiency, accuracy, and ordinary overall performance. This abstract presents a top-level view of the massive strides in incorporating AI into BEMM practices. AI applications in BEMM consist of predictive protection fashions leveraging device-to-know algorithms to research historic gadget statistics, become aware of patterns, and expect capacity disasters, thereby enabling proactive upkeep interventions. Furthermore, AI-driven robotic systems have emerged to automate ordinary renovation responsibilities, minimizing human intervention and decreasing downtime. Integration of natural language processing enables green communication between technicians and AI structures, streamlining troubleshooting and selection-making tactics. AI-based picture recognition technology contributes to diagnostic competencies, allowing fast and correct identification of faulty components. The amalgamation of AI and the Internet of Things (IoT) in BEMM facilitates actual-time tracking of the system's overall performance, making an allowance for facts-pushed choice-making and optimizing protection schedules. Despite these improvements, demanding situations including records protection, moral issues, and the need for professional personnel to manage AI systems persist. This abstract highlights the transformative potential of AI in BEMM, emphasizing its position in predictive preservation, automation, conversation enhancement, and diagnostic accuracy, at the same time as acknowledging the want for addressing associated demanding situations to fully harness its blessings inside the biomedical system protection area.

Keywords: Artificial intelligence, biomedical equipment, maintenance management, predictive maintenance, machine learning, robotic systems, image recognition

Introduction
The introduction of Artificial Intelligence (AI) into Biomedical Equipment Maintenance Management (BEMM) marks a paradigm shift within the manner healthcare facilities manipulate and optimize their crucial equipment. As the healthcare zone increasingly relies on sophisticated biomedical devices for diagnostics and treatment, the call for efficient renovation strategies will become paramount. AI, with its predictive analytics and machine mastering competencies, has emerged as a powerful tool to decorate the reliability and performance of biomedical devices (Ahmed *et al*., 2020) [1]. The integration of AI permits healthcare establishments to transport from traditional reactive preservation methods to proactive strategies, wherein potential troubles are identified and addressed before they strengthen into vital failures. This transformative shift now not simplest reduces downtime but also contributes to fee financial savings and improved patient care (Al-Turjman *et al*., 2020) [2].

The usage of AI in BEMM extends beyond predictive upkeep, encompassing robot systems that automate routine maintenance duties. These structures, prepared with AI algorithms, can navigate through complicated biomedical systems, identify anomalies, and perform essential upkeep without human intervention. This automation not only effectively complements efficiency but also minimizes the danger of human blunders, ensuring the optimal functioning of important scientific devices (Arinez *et al*., 2020) [3]. Moreover, AI enables seamless communication inside the maintenance surroundings, incorporating herbal language processing to enable green collaboration between technicians and AI structures. This collaborative approach streamlines troubleshooting strategies, hurries up selection-making,

and empowers maintenance groups to cope with troubles with agility (Banerjee *et al*., 2020) [4].

While the mixing of AI in BEMM brings about several benefits, it isn't always without demanding situations. Ethical concerns, information safety, and the want for skilled personnel to manipulate AI systems pose hurdles that require cautious navigation (Cioffi *et al*., 2020) [5].

Nevertheless, the introduction of AI in Biomedical Equipment Maintenance Management represents a groundbreaking development that holds substantial promise for healthcare facilities aiming to optimize device performance, ensure affected person safety, and navigate the complexities of contemporary medical generation (Foresti *et al*., 2020) [6]. This study aims to analyze the effect of Artificial Intelligence on Biomedical Equipment Maintenance Management (BEMM), exploring how AI technologies can enhance predictive renovation, automate habitual obligations, and enhance verbal exchange within the renovation atmosphere. By assessing the transformative potential of AI in BEMM, the examined objectives are to provide insights into optimizing device reliability, minimizing downtime, and ultimately advancing the efficiency of healthcare facilities in coping with vital biomedical devices. The studies, Kaushik, P. (2022) [21] seek to address both the possibilities and challenges related to the integration of AI in BEMM to contribute precious information to the healthcare industry.

Literature Review

The literature on the integration of Artificial Intelligence (AI) in Biomedical Equipment Maintenance Management (BEMM) underscores its transformative potential in optimizing maintenance practices within healthcare facilities. Previous studies have consistently highlighted the pivotal role of AI in predictive maintenance, emphasizing its capacity to analyze historical equipment data and forecast potential failures. For instance, Haleem *et al*. (2019) [7] demonstrated the effectiveness of machine learning algorithms in predicting equipment failures by identifying patterns and trends in maintenance data. This predictive capability enables healthcare institutions to shift from reactive to proactive maintenance strategies, reducing downtime and improving overall equipment reliability (Hamamoto *et al*., 2020) [8].

In addition to predictive maintenance, robotic systems powered by AI have emerged as a focal point in the literature. Javaid *et al*. (2021) [9] conducted a comprehensive review showcasing the evolution of robotic systems in BEMM, outlining their capacity to automate routine maintenance tasks. These robotic systems, equipped with AI algorithms, navigate through complex biomedical equipment, identify anomalies, and execute necessary repairs without human intervention. This automation not only streamlines maintenance processes but also enhances the precision and efficiency of routine tasks, contributing to the overall reliability of biomedical equipment (Long *et al*., 2017) [10].

The literature also emphasizes the communication-enhancing capabilities of AI in BEMM. Integration of natural language processing (NLP) facilitates seamless interaction between technicians and AI systems. Mamoshina *et al*. (2017) [11] explored the application of NLP in BEMM, illustrating how it enhances communication and collaboration by allowing technicians to interact with AI systems using natural language. This improved communication accelerates troubleshooting processes, expedites decision-making, and empowers maintenance teams to address issues with agility, ultimately contributing to the efficiency of maintenance operations (Naugler & Church, 2019) [14].

Despite the evident advantages, challenges associated with the integration of AI in BEMM have been acknowledged in the literature. Ethical considerations, data security, and the need for skilled personnel to manage AI systems are recurring themes in studies by Manickam *et al*. (2022) [12] and Mehta *et al*. (2019) [13]. These studies highlight the importance of addressing these challenges to fully harness the benefits of AI in BEMM while ensuring the ethical and secure implementation of these technologies in healthcare settings.

Methodology

Questionnaire Development

The study's questionnaire was meticulously developed with the primary goal of evaluating the effectiveness of biomedical equipment in the GCC region's medical sector, specifically comparing findings across various GCC nations. The intended audience comprises medical professionals, including physicians, nurses, and biomedical technicians, in the GCC region. The questionnaire focuses on current usage, perceived effectiveness, and experiences with biomedical equipment. It was designed in simple, understandable English, incorporating both open-ended and closed-ended questions to facilitate quantitative data collection. A small group pilot-tested the questionnaire to ensure clarity, comprehendibility, and alignment with study goals.

Qualitative Research Approach

The qualitative research approach is employed, aligning with the social sciences domain and management literature's common usage. This method, while subjective, provides in-depth information and comprehension regarding the study's subject matter. Researchers analyze and interpret data, influenced by their prior research experiences. Qualitative research is deemed optimal for exploratory investigations and analyzing social issues within an organizational context. The potential for bias exists due to the subjective nature of interpretation, but it facilitates a nuanced understanding of the study's context.

Quantitative Research Approach

The study employs a quantitative research approach, characterized by methodical and organized data collection and statistical analysis. This approach involves the collection of numerical data, suitable for measuring and quantifying aspects such as human behavior, attitudes, and performance. The analysis will include regression analysis and frequency analysis to examine the effectiveness of medical equipment, associated costs, and differences across GCC nations.

Data Collection

Data is collected from the Emirates Health Service, focusing on the Fujairah Medical Zone within the UAE. This zone, part of the broader healthcare system, comprises over 1500 healthcare professionals and serves as the research unit of analysis. A semi-structured interview questionnaire,

including both open-ended and closed-ended questions, was administered to technical and assistance specialists. Questions cover handling procedures, maintenance, and efficacy of medical equipment, ensuring standardization and reliable findings.

Data Analysis

Data analysis involves examining differences in equipment effectiveness and associated costs across the region. It includes a review of literature, regression analysis, frequency analysis, and comparison of equipment effectiveness and costs between different GCC countries. The impact of equipment on patient outcomes is also assessed. The coding and frequency of responses are calculated to provide a comprehensive understanding of the handling, operating procedures, maintenance, and efficacy of biomedical equipment.

Random Sampling

Random sampling, a probability sampling method, ensures an equal chance of selection for all members of the population, eliminating bias. The formula used guarantees representativeness, enhancing the generalizability of results to the entire population. This method is crucial for obtaining accurate and unbiased insights into the experiences and perceptions of healthcare professionals regarding biomedical equipment.

Regression Analysis

Regression analysis, specifically simple linear regression, is employed to estimate associations between dependent and independent variables. The model allows researchers to simulate long-term relationships and assess the strength of these relationships. In the context of the study, regression analysis aids in understanding the impact of various factors on the effectiveness and costs of biomedical equipment.

Frequency Analysis

Frequency analysis examines the distribution of variables in the dataset, helping identify patterns or trends. It involves calculating how often each value occurs, offering insights into the distribution of variables. In this study, frequency analysis is crucial for understanding the prevalence of different practices related to handling, operating, maintaining, and assessing the efficacy of biomedical equipment.

ANOVA Test

The Analysis of Variance (ANOVA) test is employed to assess the influence of independent variables on the dependent variable. It enables a comparison of multiple groups simultaneously to determine relationships. The F-ratio statistic from the ANOVA test allows for the analysis of variability between and within samples. This test aids in understanding differences in equipment effectiveness and costs across different GCC countries.

Results and Discussion

Table 1: Demographic variable wise frequency, percentage and mean

Demographic		Frequency	Percent	Mean	SD
Gender	Male	900	60	1.4	0.49006
	Women	600	40		
	Total	1500	100		
Designation	Nurses	365	24.3	2.0333	0.72058
	Nursing technicians	720	48		
	Doctors	415	27.7		
	Total	1500	100		
Experience	0 to 5	385	25.7	1.9933	0.71201
	6 to 10	740	49.3		
	11 to 15	375	25		
	Total	1500	100		

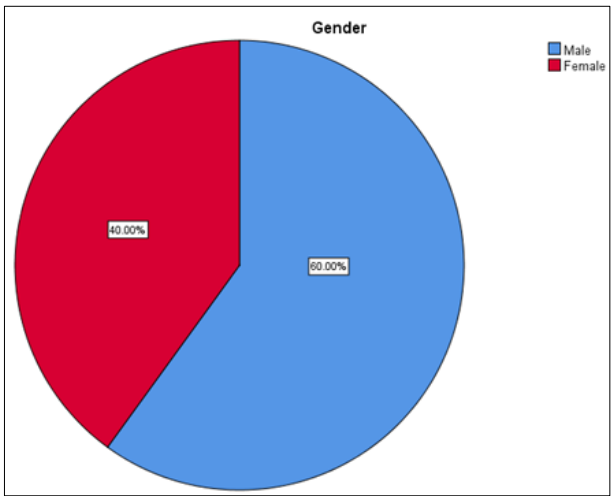

Fig 1: Gender

The above figure and the table show the respondent gender percentage. The 60% respondents participated in the study are male and 40% are female. Most of the respondents participated in the study are male respondents.

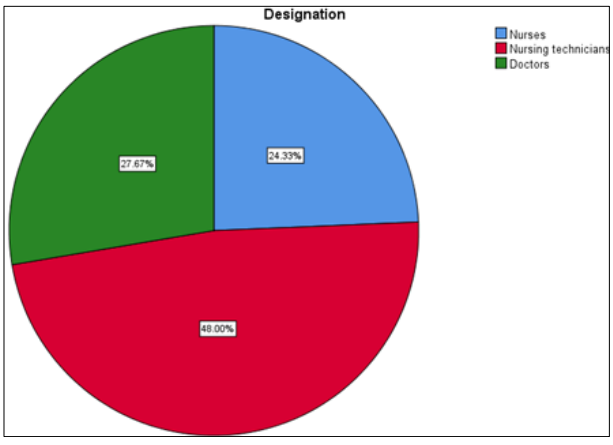

Fig 2: Designation

The above figure and the table show the respondents designation percentage. The respondents with designation of Nursing technicians are 48.0%, 27.67% doctors are participated and 24.33% of the respondents participated in the study are nurses

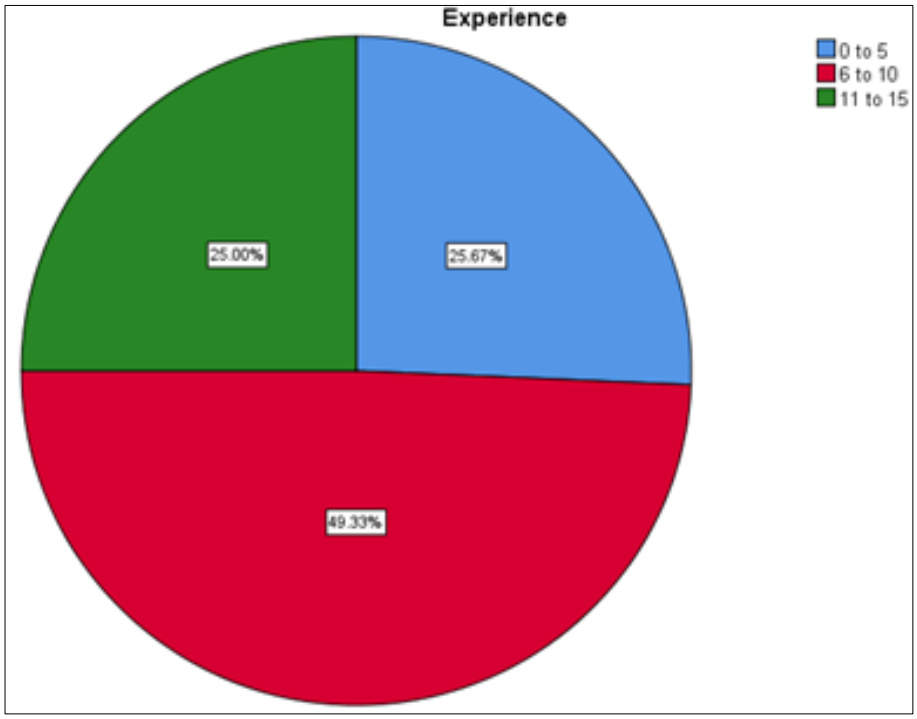

Fig 3: Experience

The above figure and the table show the respondents experiences, 49.33% of the respondents in study have 6 to 10 years of experience, 25.67% have experience of 0 to 5 years and 25.0% of the respondents have 11 to 15 years of experience.

4.2 Handling of biomedical equipment

Table 2: Statement-wise frequency analysis (percentages and means) of the factor-Handling of biomedical equipment

Statements		SD	D	N	A	SA	Total	Mean
Design-out maintenance protocols should be followed for biomedical equipment	Frequency	230	265	245	460	300	1500	3.2233
	Percentage	15.3	17.7	16.3	30.7	20	100	
Safety measures should be taken when handling biomedical equipment	Frequency	240	240	245	405	370	1500	3.2833
	Percentage	16	16	16.3	27	24.7	100	
All biomedical equipment should be handled with care and stored in a secure location when not in use.	Frequency	170	395	230	460	245	1500	3.1433
	Percentage	11.3	26.3	15.3	30.7	16.3	100	
Make sure to always wear the proper safety equipment when handling biomedical equipment	Frequency	105	315	215	575	290	1500	3.42
	Percentage	7	21	14.3	38.3	19.3	100	
Preventive maintenance, which includes systematic (periodic) maintenance and condition-based maintenance protocols should be followed for biomedical equipment	Frequency	180	300	200	565	255	1500	3.2767
	Percentage	12	20	13.3	37.7	17	100	
Corrective maintenance protocols should be followed for biomedical equipment	Frequency	185	175	140	775	225	1500	3.4533
	Percentage	12.3	11.7	9.3	51.7	15	100	

The above table depicts the statement-wise percentages and frequencies of the factors of handling biomedical equipment. The statement “Corrective maintenance protocols should be followed for biomedical equipment” has the highest mean value of 3.4533 and it has the ‘agree’ percentage of 66.7%. The statement “Make sure to always wear the proper safety equipment when handling biomedical equipment” has the second highest mean value 3.42 and it has the ‘agree’ percentage of 57.6%. The statement “All biomedical equipment should be handled with care and stored in a secure location when not in use” has the lowest mean value 3.1433 and the ‘disagree’, neutral percentage is 52.9%. Most of the respondents are stated that corrective maintenance protocols should be followed for biomedical equipment.

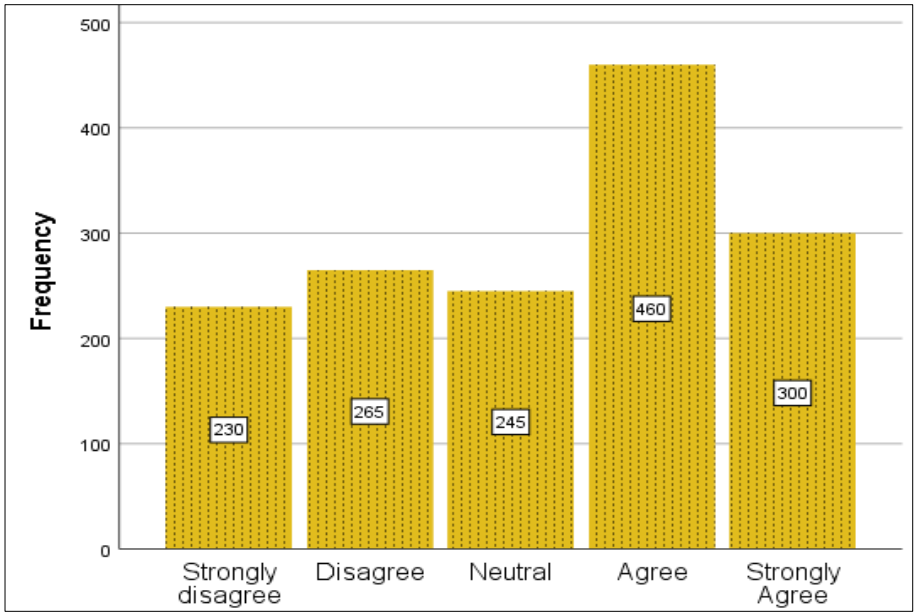

Fig 4: Design-out maintenance protocols should be followed for biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Design-out maintenance protocols should be followed for biomedical equipment". Out of 1500 respondents 230 are strongly disagreed this statement, 265 respondents disagreed, 245 respondents are not answered to this statement, 460 respondents agreed and 300 respondents strongly agreed this statement. Most of the respondents stated that design-out maintenance protocols should be followed for biomedical equipment.

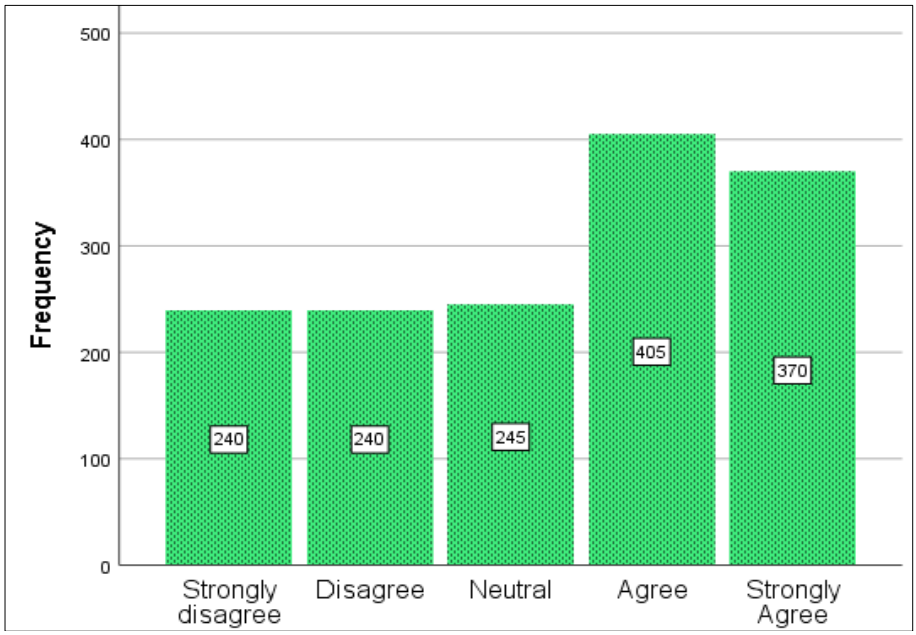

Fig 5: Safety measure should be taken when handling biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "safety measures should be taken when handling biomedical equipment". Out of 1500 respondents 240 are strongly disagreed this statement, 240 respondents Disagreed, 245 respondents are not answered to this statement, 405 respondents agreed and 370 respondents strongly agreed this statement. Most of the respondents stated that safety measures should be taken when handling biomedical equipment.

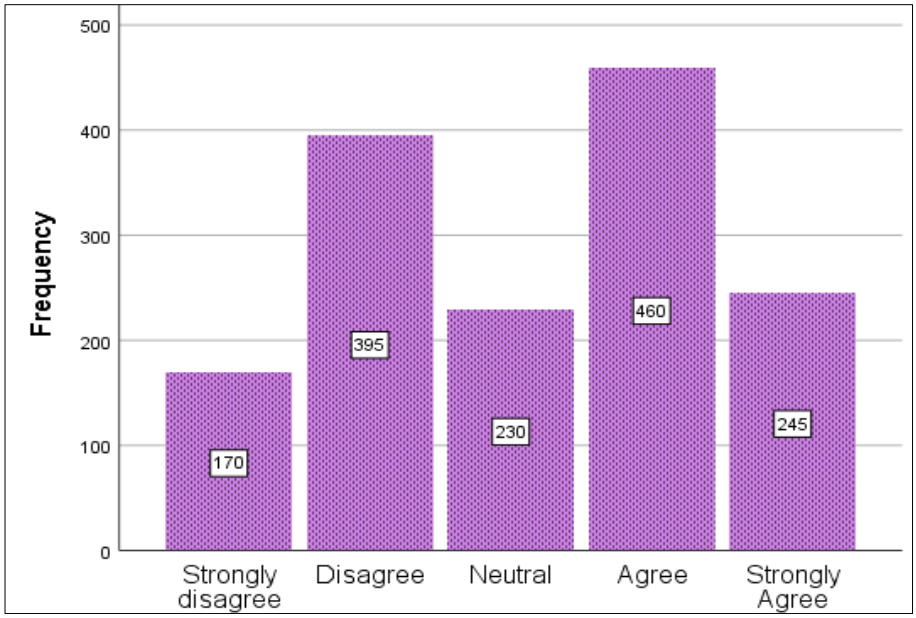

Fig 6: All biomedical equipment should be handled with care and stored in a secure location when not in use

The above bar chart shows the 'agree' and 'disagree' percentages of the statement, "All biomedical equipment should be handled with care and stored in a secure location when not in use." Out of 1500 respondents, 170 are strongly disagreed this statement, 395 respondents disagreed, 230 respondents are not answered to this statement, 460 respondents agreed and 245 respondents strongly agreed this statement. Most of the respondents stated that all biomedical equipment should be handled with care and stored in a secure location when not in use.

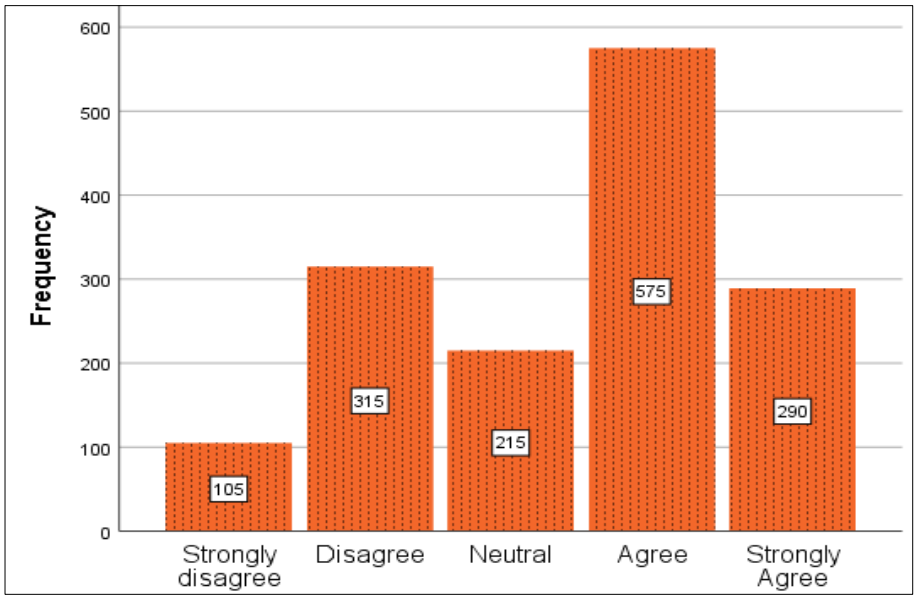

Fig 7: Make sure to always wear the proper safety equipment when handling biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Make sure to always wear the proper safety equipment when handling biomedical equipment". Out of 1500 respondents 105 are strongly disagreed this statement, 315 respondents Disagreed, 215 respondents are not answered to this statement, 575 respondents agreed and 290 respondents strongly agreed this statement. Most of the respondents stated that make sure to always wear the proper safety equipment when handling biomedical equipment.

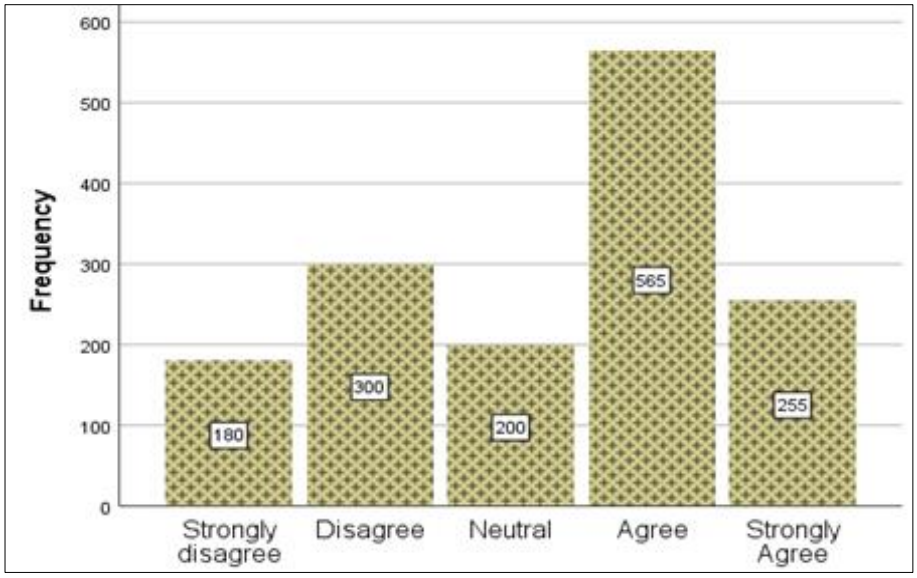

Fig 8: Preventive maintenance, which includes systematic (Periodic) maintenance and condition-based maintenance protocols should be followed for biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Preventive maintenance, which includes systematic (periodic) maintenance and condition-based maintenance protocols should be followed for biomedical equipment". Out of 1500 respondents 180 are strongly disagreed this statement, 300 respondents Disagreed, 200 respondents are not answered to this statement, 565 respondents agreed and 255 respondents strongly agreed this statement. Most of the respondents stated that preventive maintenance, which includes systematic (periodic) maintenance and condition-based maintenance protocols should be followed for biomedical equipment.

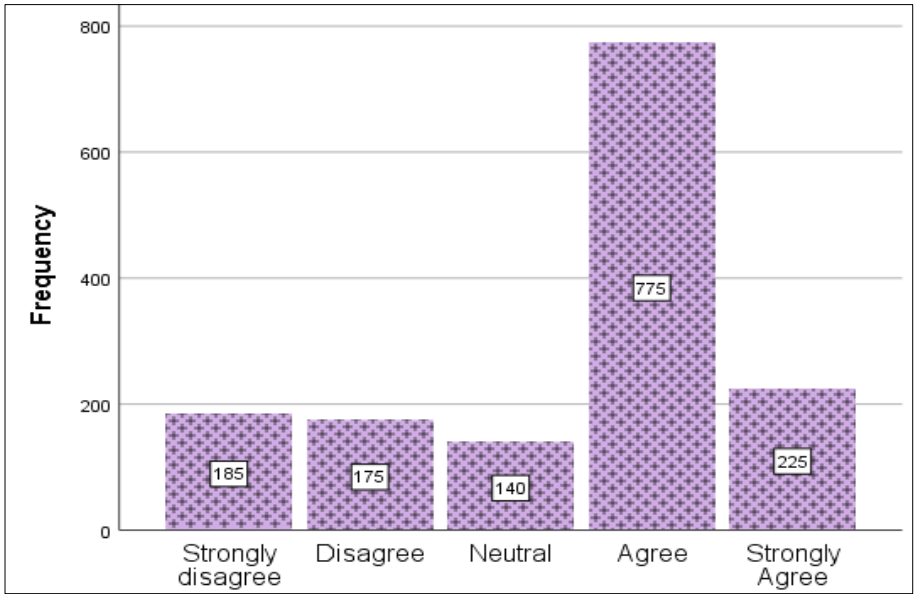

Fig 9: Corrective maintenance protocols should be followed for biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Corrective maintenance protocols should be followed for biomedical equipment". Out of 1500 respondents 185 are strongly disagreed this statement, 175 respondents disagreed, 140 respondents are not answered to this statement, 775 respondents agreed and 255 respondents strongly agreed this statement. Most of the respondents stated that corrective maintenance protocols should be followed for biomedical equipment.

Maintenance of biomedical equipment

Table 3: Statement wise frequency analysis (Percentages and means) of the factor-Maintenance of Biomedical equipment

Statements		SD	D	N	A	SA	Total	Mean
"Equipment maintenance involves all activities related to providing an adequate level of service and limiting downtime of medical devices	Frequency	241	270	180	540	269	1500	3.2173
	Percentage	16.1	18.0	12.0	36.0	17.9	100.0	
Maintenance or service activity is required in order to ensure the devices are kept functioning	Frequency	180	280	215	550	275	1500	3.3067

within the limits imposed by the test criteria and to return devices to the required level of functioning after breakage or other failure	Percentage	12.0	18.7	14.3	36.7	18.3	100.0	
The primary goal of maintenance activity is to reduce, or, if possible, to eliminate the need of repairs	Frequency	235	340	250	425	250	1500	3.0767
	Percentage	15.7	22.7	16.7	28.3	16.7	100.0	
Proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment.	Frequency	190	165	215	665	265	1500	3.4333
	Percentage	12.7	11.0	14.3	44.3	17.7	100.0	
Medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy of the results".	Frequency	250	250	215	655	130	1500	3.11
	Percentage	16.7	16.7	14.3	43.7	8.7	100.0	

The above table depicts the statement-wise percentages and frequencies of the factors of maintenance of biomedical equipment. The statement "Proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment" has the highest mean value of 3.4333 and it has the 'agree' percentage of 62%. The statement "Maintenance or service activity is required in order to ensure the devices are kept functioning within the limits imposed by the test criteria and to return devices to the required level of functioning after breakage or other failure" has the second highest mean value 3.3067 and it has the agree percentage of 55%. The statement "The primary goal of maintenance activity is to reduce, or, if possible, to eliminate the need of repairs" has the lowest mean value 3.0767 and the 'disagree', neutral percentage is 45%. Most of the respondents are stated that proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment.

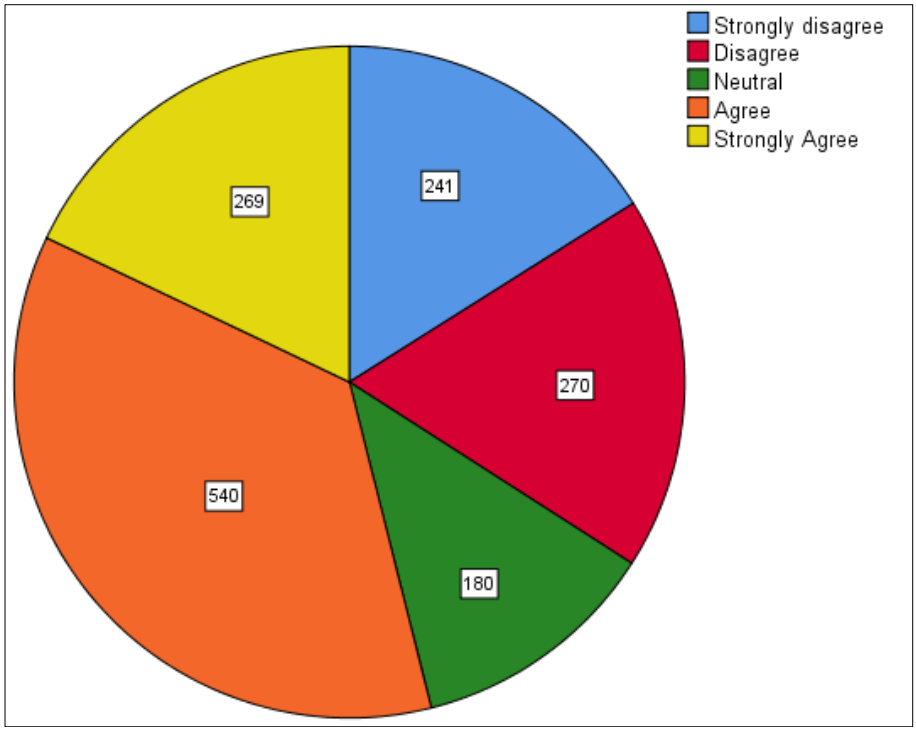

Fig 10: Equipment maintenance involves all activities related to providing and adequate level of service and limiting downtime of medical devices

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Equipment maintenance involves all activities related to providing an adequate level of service and limiting downtime of medical devices". Out of 1500 respondents 241 are strongly disagreed this statement, 270 respondents disagreed, 180 respondents are not answered to this statement, 540 respondents agreed and 269 respondents strongly agreed this statement. Most of the respondents stated that equipment maintenance involves all activities related to providing an adequate level of service and limiting downtime of medical devices.

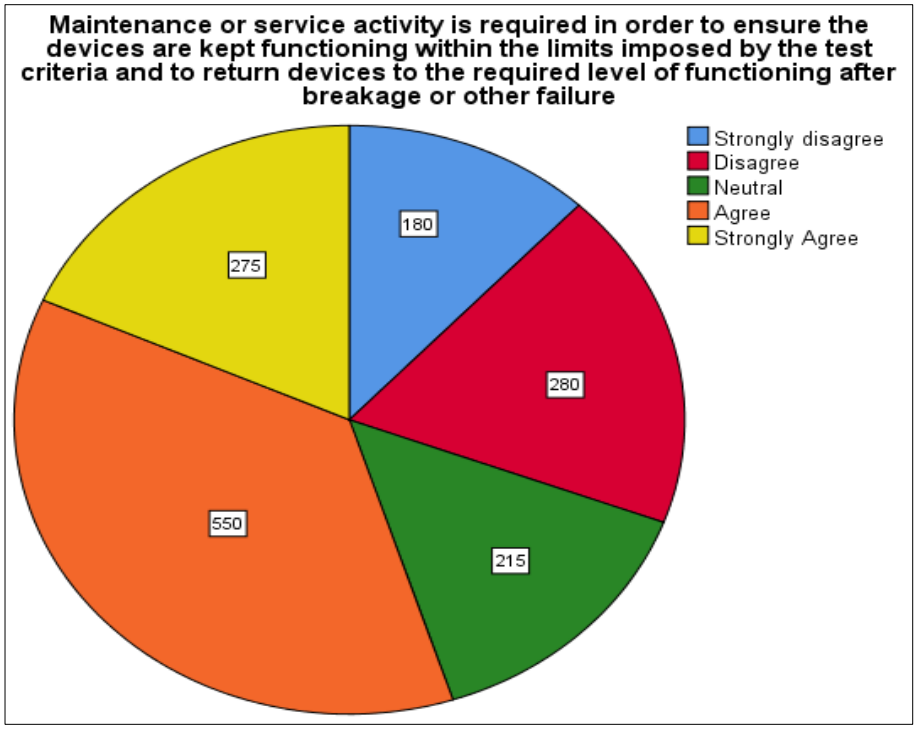

Fig 11: Maintenance or service activity is required in order to endure the devices are kept functioning within the limits imposed by the test criteria and ti return devices to the required level of functioning after breakage or other failure

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Maintenance or service activity is required in order to ensure the devices are kept functioning within the limits imposed by the test criteria and to return devices to the required level of functioning after breakage or other failure". Out of 1500 respondents 180 are strongly disagreed this statement, 280 respondents disagreed, 215 respondents are not answered to this statement, 550 respondents agreed and 275 respondents strongly agreed this statement. Most of the respondents stated that maintenance or service activity is required in order to ensure the devices are kept functioning within the limits imposed by the test criteria and to return devices to the required level of functioning after breakage or other failure.

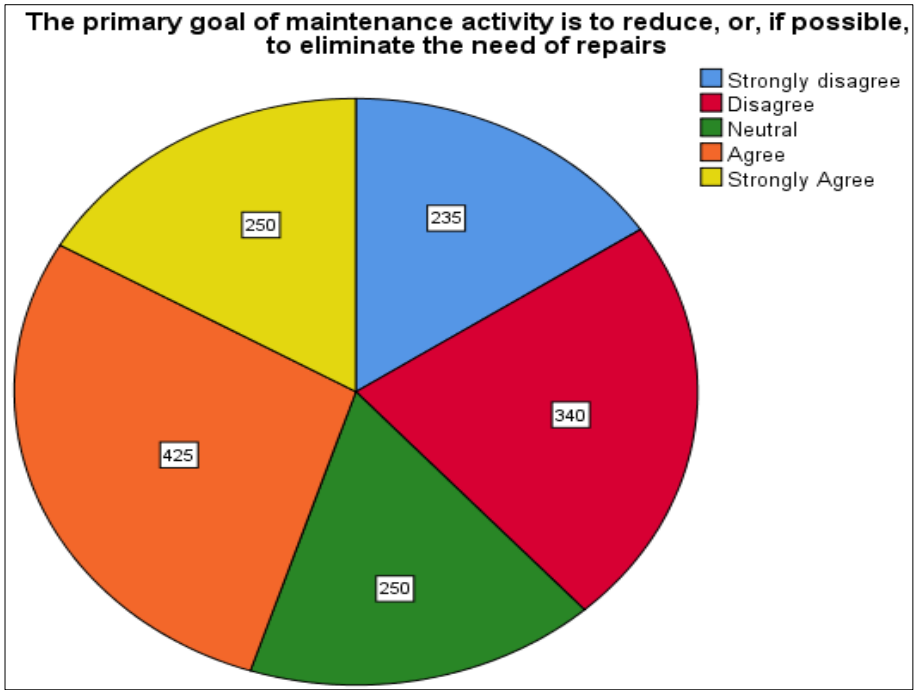

Fig 12: The primary goal of maintenance activity is to reduce, or, if possible, to eliminate the need or repairs

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "The primary goal of maintenance activity is to reduce, or, if possible, to eliminate the need of repairs". Out of 1500 respondents 235 are strongly disagreed this statement, 340 respondents Disagreed, 250 respondents are not answered to this statement, 425 respondents agreed and 250 respondents strongly agreed this statement. Most of the respondents

stated that the primary goal of maintenance activity is to reduce, or, if possible, to eliminate the need of repairs

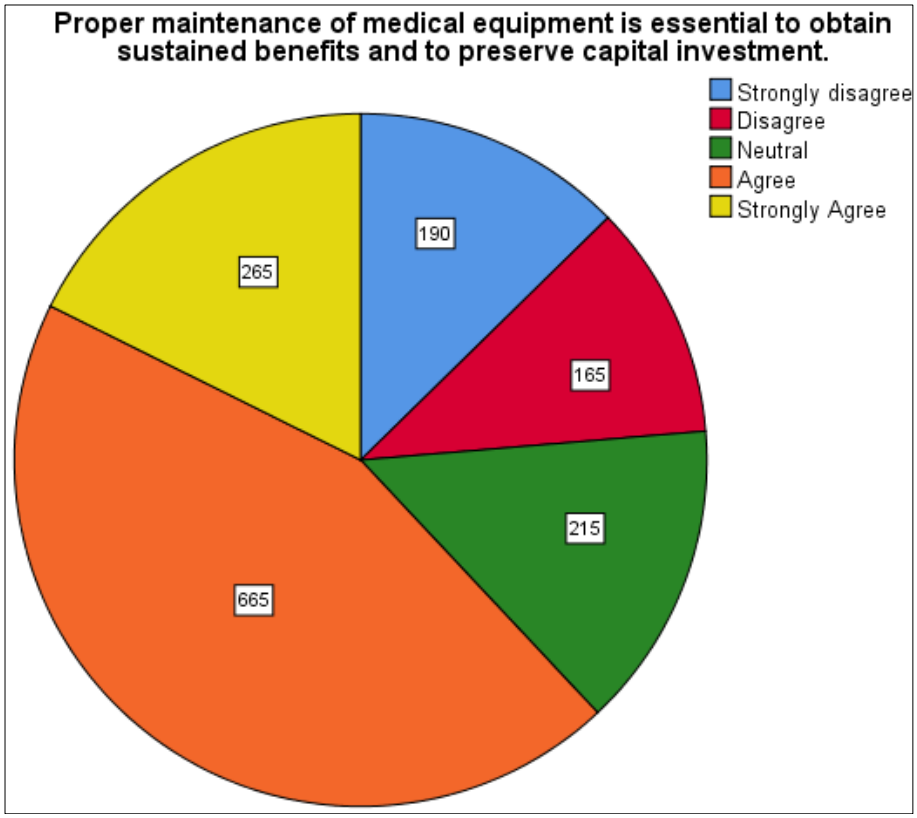

Fig 13: Proper maintenance of medical equipments is essential obtain sustained benefits and to preserve capital investment

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment." Out of 1500 respondents 190 are strongly disagreed this statement, 165 respondents disagreed, 215 respondents are not answered to this statement, 665 respondents agreed and 265 respondents strongly agreed this statement. Most of the respondents stated that proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment.

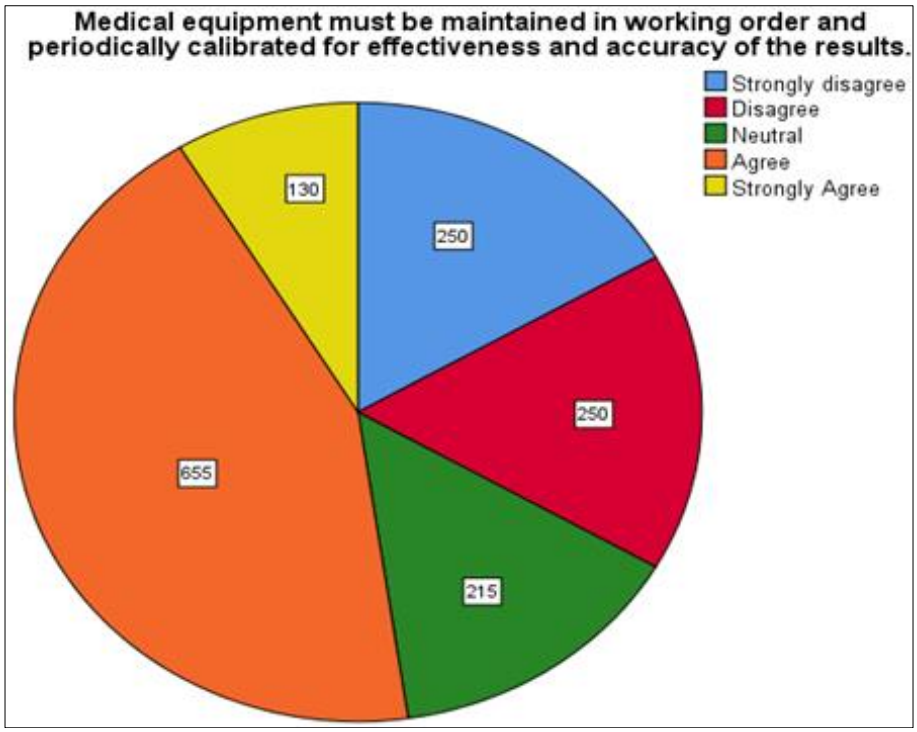

Fig 14: Medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy of the results

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy of the results". Out of 1500 respondents 250 are strongly disagreed this statement, 250 respondents disagreed, 215 respondents are not answered to this statement, 665 respondents agreed and 130 respondents strongly agreed this statement. Most of the respondents stated that medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy of the results.

Operation of biomedical equipment

Table 4: Statement wise frequency analysis (percentages and means) of the factor-Operation of biomedical equipment

Statements		SD	D	N	A	SA	Total	Mean
Parts and components are replaced as needed to maintain the safe and effective operation of biomedical equipment	Frequency	255	230	255	435	325	1500	3.23
	Percentage	17.0	15.3	17.0	29.0	21.7	100.0	
While operating biomedical equipment one should wear appropriate personal protective equipment (PPE)	Frequency	275	265	250	425	285	1500	3.12
	Percentage	18.3	17.7	16.7	28.3	19.0	100.0	
Ensure that all safety measures have been taken before starting to operate biomedical equipment	Frequency	215	345	210	500	230	1500	3.1233
	Percentage	14.3	23.0	14.0	33.3	15.3	100.0	
Ensure that all connections are secure before operating the biomedical equipment.	Frequency	175	140	195	480	510	1500	3.6733
	Percentage	11.7	9.3	13.0	32.0	34.0	100.0	
Do you agree the proper authorization to operate the biomedical equipment?	Frequency	180	340	260	360	360	1500	3.2533
	Percentage	12.0	22.7	17.3	24.0	24.0	100.0	

The above table depicts the statement-wise percentages and frequencies of the factors of operation of biomedical equipment. The statement "Ensure that all connections are secure before operating the biomedical equipment." has the highest mean value of 3.6733 and it has the agree percentage of 66%. The statement "Do you agree the proper authorization to operate the biomedical equipment?" has the second highest mean value 3.2533 and it has the agree percentage of 48%. The statement "While operating biomedical equipment one should wear appropriate personal protective equipment (PPE)" has the lowest mean value 3.12 and the 'disagree', 'neutral' percentage is having significant value. Most of the respondents are stated that ensure that all connections are secure before operating the biomedical equipment.

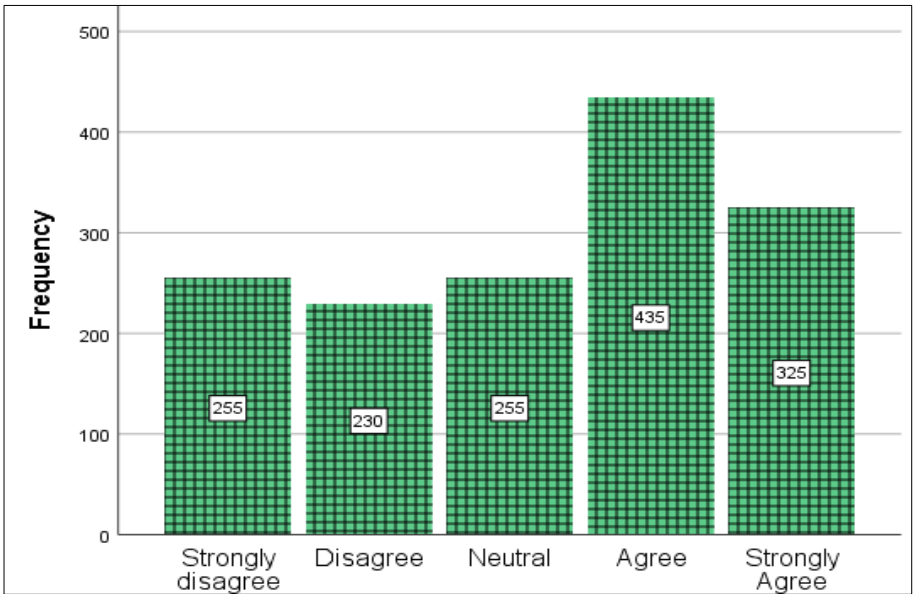

Fig 15: Parts and Components are replaced as needed to maintain the safe and effective operation of biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Parts and components are replaced as needed to maintain the safe and effective operation of biomedical equipment". Out of 1500 respondents 255 are strongly disagreed this statement, 230 respondents disagreed, 255 respondents are not answered to this statement, 435 respondents agreed and 325 respondents strongly agreed this statement. Most of the respondents stated that parts and components are replaced as needed to maintain the safe and effective operation of biomedical equipment.

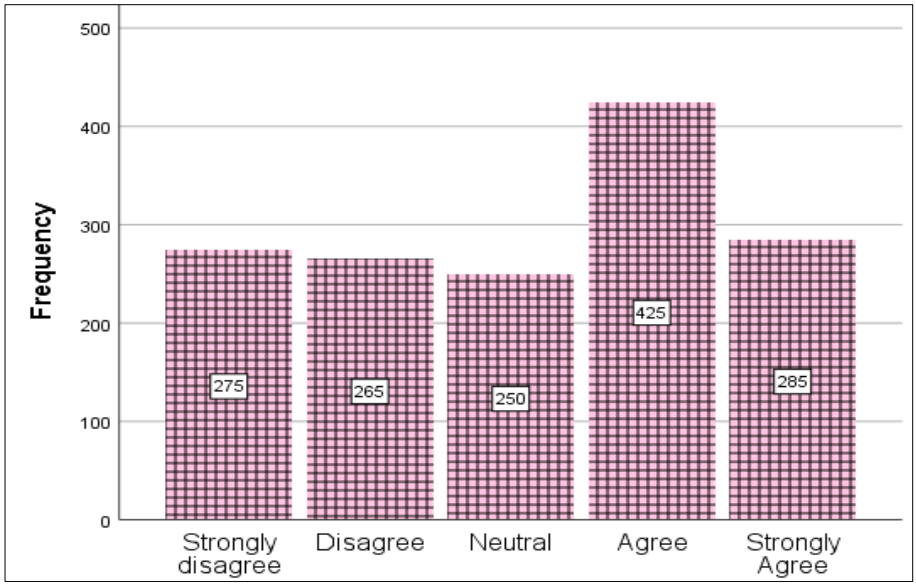

Fig 16: While operating biomedical equipment one should wear appropriate personal protective equipment (PPE)

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "While operating biomedical equipment one should wear appropriate personal protective equipment (PPE)". Out of 1500 respondents 275 are strongly disagreed this statement, 265 respondents disagreed, 250 respondents are not answered to this statement, 425 respondents agreed, and 285 respondents strongly agreed this statement. Most of the respondents stated that while operating biomedical equipment one should wear appropriate personal protective equipment (PPE).

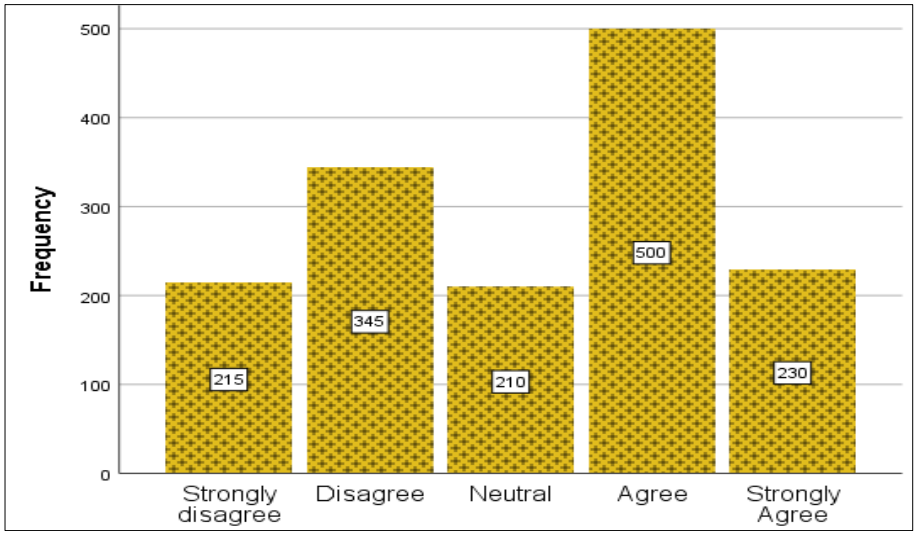

Fig 17: Ensure that all safety measures have been taken before starting to operate biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Ensure that all safety measures have been taken before starting to operate biomedical equipment". Out of 1500 respondents 215 are strongly disagreed this statement, 345 respondents disagreed, 210 respondents are not answered to this statement, 500 respondents agreed and 230 respondents strongly agreed this statement. Most of the respondents stated that ensure that all safety measures have been taken before starting to operate biomedical equipment.

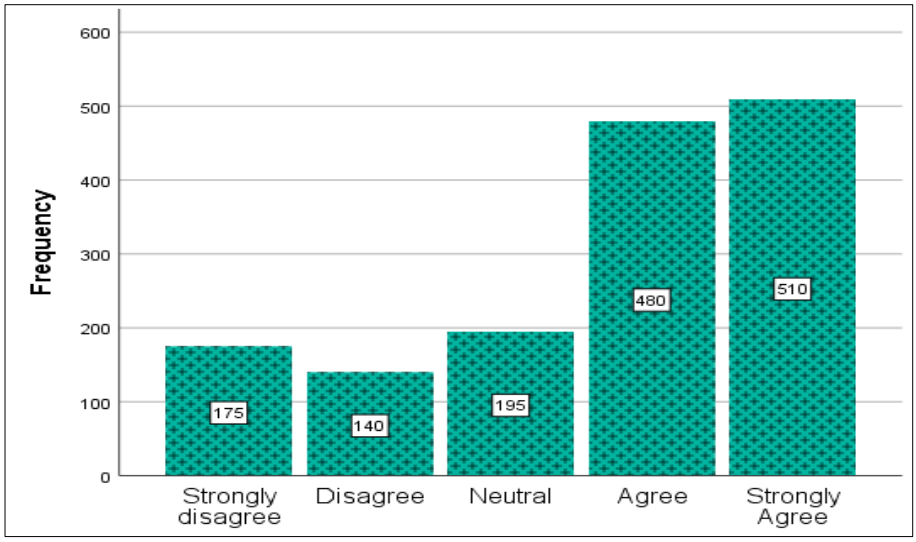

Fig 18: Ensure that all connections are secure before operating the biomedical equipment

The above bar chart shows the 'agree' and 'disagree' percentages of the statement "Ensure that all connections are secure before operating the biomedical equipment". Out of 1500 respondents 175 are strongly disagreed this statement, 140 respondents disagreed, 195 respondents are not answered to this statement, 480 respondents agreed and 510 respondents strongly agreed this statement. Most of the respondents stated that ensure that all connections are secure before operating the biomedical equipment.

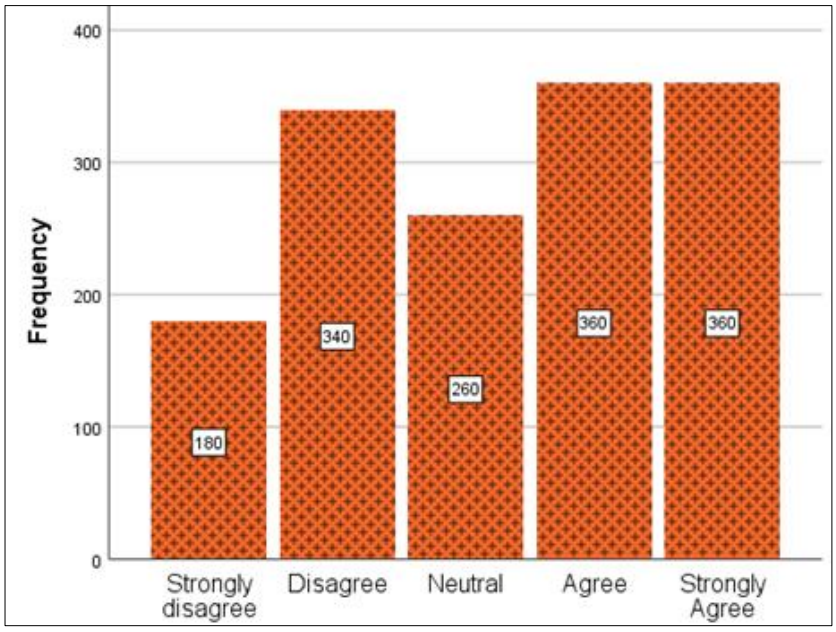

Fig 19: Do you agree the proper authorization to operate the biomedical equipment?

The above bar chart shows the 'agree' and 'disagree' percentages of the statement,"Do you agree the proper authorization to operate the biomedical equipment?" Out of 1500 respondents 180 are strongly disagreed this statement, 340 respondents disagreed, 260 respondents are not answered to this statement, 360 respondents agreed and 360 respondents strongly agreed this statement. Majority of the respondents stated that the proper authorization should be there to operate the biomedical equipment.

Table 5: Statement wise frequency analysis (percentages and means) of the factor-Efficacy of biomedical equipment

Statements		SD	D	N	A	SA	Total	Mean
It is easy to interpret the measurements	Frequency	195	325	320	380	280	1500	3.15
	Percentage	13.0	21.7	21.3	25.3	18.7	100.0	
Equipment produce same results multiple times	Frequency	220	270	240	475	295	1500	3.2367
	Percentage	14.7	18.0	16.0	31.7	19.7	100.0	
Biomedical equipment is easy to move and flexible	Frequency	280	265	215	430	310	1500	3.15
	Percentage	18.7	17.7	14.3	28.7	20.7	100.0	
Instrument is accurate for application	Frequency	390	385	210	350	165	1500	2.6767
	Percentage	26.0	25.7	14.0	23.3	11.0	100.0	

The above table depicts the statement-wise percentages and frequencies of the factors of efficacy of biomedical equipment. The statement "Equipment produce same results multiple times." has the highest mean value of 3.2367 and it has the 'agree' percentage of 51.4%. The statement "It is easy to interpret the measurements" and "Biomedical equipment is easy to move and flexible" has the second highest mean value 3.15 and it has the 'agree' percentage of 44% & 49.4% respectively. The statement "Instrument is accurate for application" has the lowest mean value 2.6767 and the 'disagree', 'neutral' percentage is significant. Most of the respondents are stated that equipment produce same results multiple times.

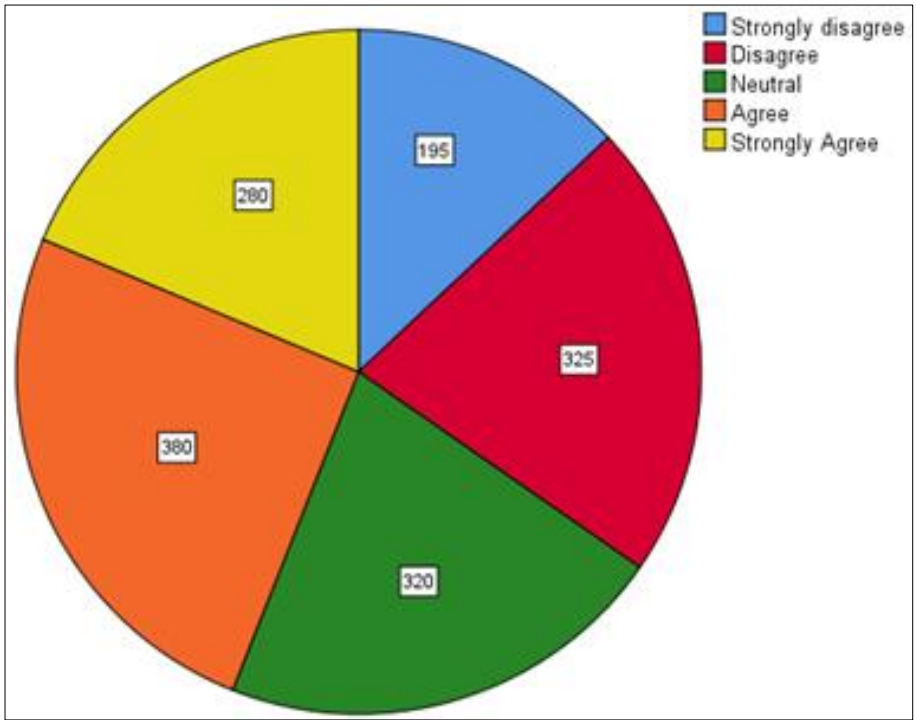

Fig 20: It is easy to interpret the measurements

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "It is easy to interpret the measurements". Out of 1500 respondents 195 are strongly disagreed this statement, 325 respondents disagreed, 320 respondents are not answered to this statement, 380 respondents agreed and 280 respondents strongly agreed this statement. Most of the respondents stated that it is easy to interpret the measurements.

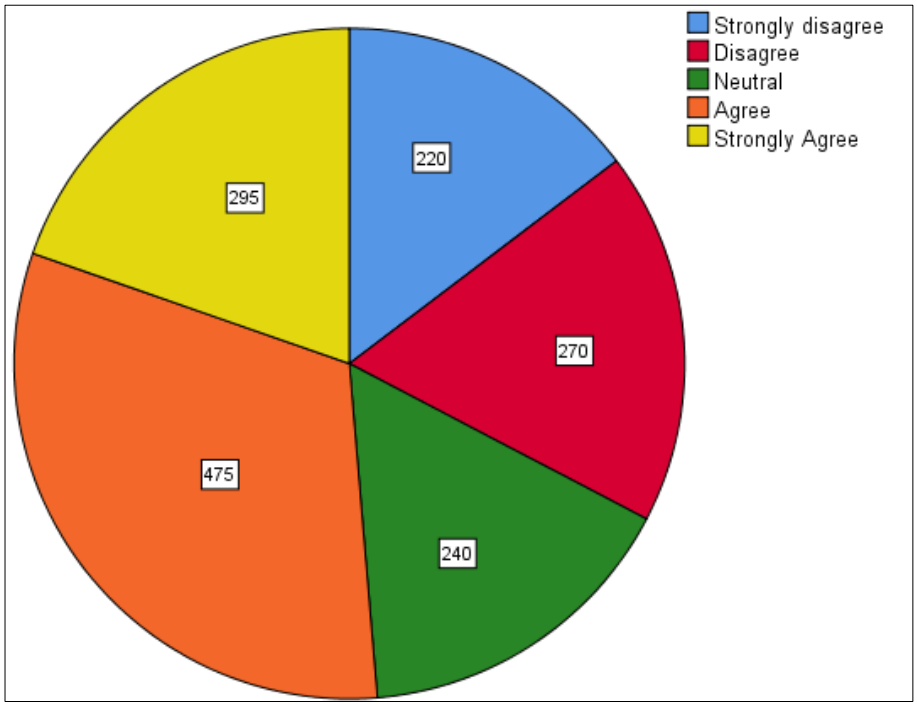

Fig 21: Equipment produce same results multiple times

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Equipment produce same results multiple times". Out of 1500 respondents 220 are strongly disagreed this statement, 270 respondents disagreed, 240 respondents are not answered to this statement, 475 respondents agreed and 295 respondents strongly agreed this statement. Most of the respondents stated that Equipment produce same results multiple times.

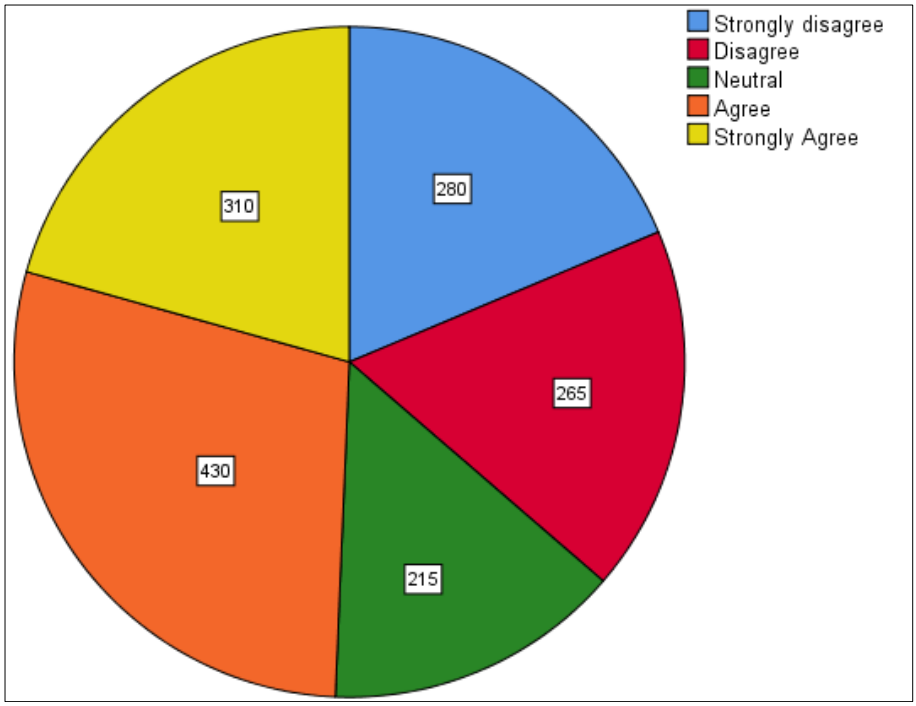

Fig 22: Bio-medical equipment is easy to move and flexible

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Biomedical equipment is easy to move and flexible". Out of 1500 respondents 280 are strongly disagreed this statement, 265 respondents disagreed, 215 respondents are not answered to this statement, 430 respondents agreed and 310 respondents strongly agreed this statement. Most of the respondents stated that biomedical equipment is easy to move and flexible.

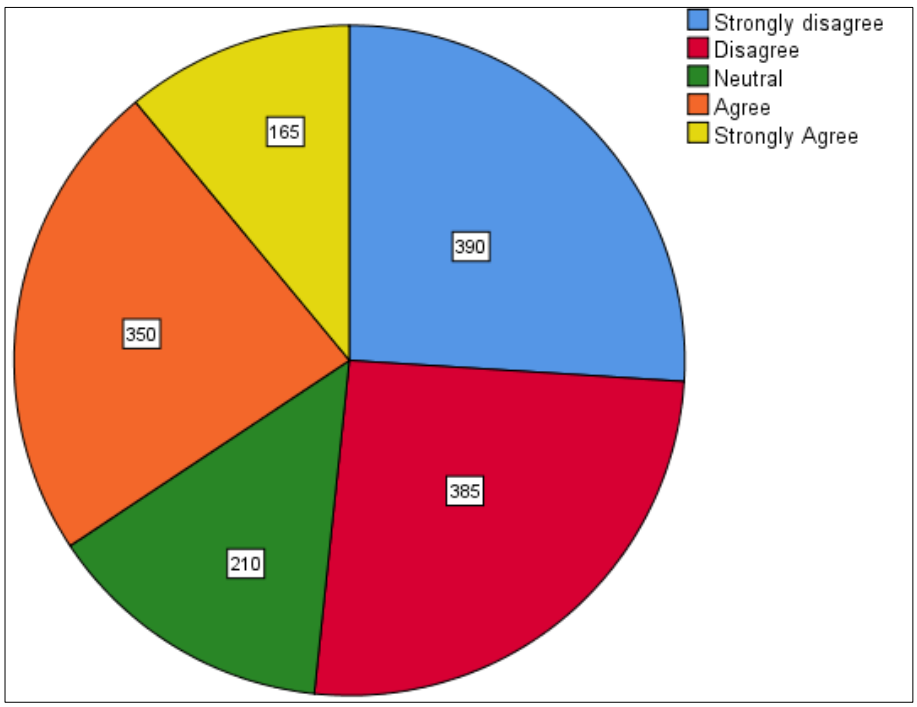

Fig 23: Instrument is accurate for application

The above pie chart shows the 'agree' and 'disagree' percentages of the statement "Instrument is accurate for application". Out of 1500 respondents 390 are strongly disagreed this statement, 385 respondents disagreed, 210 respondents are not answered to this statement, 350 respondents agreed and 165 respondents strongly agreed this statement. Most of the respondents stated that Instrument is accurate for application.

Discussion

The presented study undertakes a thorough examination of the perceptions of medical professionals in the GCC region regarding the handling, maintenance, operation, and efficacy of biomedical equipment. The demographic analysis in Table 3 unveils a predominant male participation (60%), with nursing technicians emerging as the majority (48%), followed by doctors (27.7%) and nurses (24.3%). This demographic breakdown is crucial for understanding the nuances of the respondent pool, indicating potential variations in perspectives based on gender and professional roles. Additionally, the distribution of experience levels sheds light on the diverse expertise contributing to the study.

Moving to the handling of biomedical equipment (Table 4), the data reveal a consensus among respondents regarding the importance of corrective maintenance protocols (mean of 3.4533). The bar charts further elucidate that safety measures and the use of proper equipment during handling are widely acknowledged by the majority. Interestingly, the lowest mean in this section pertains to the statement advocating careful handling and secure storage of biomedical equipment when not in use (3.1433). This finding suggests a potential area for improvement or further exploration regarding the attitudes toward equipment storage practices.

The maintenance of biomedical equipment (Table 5) provides insights into the attitudes of medical professionals. The highest mean is associated with the conviction that proper maintenance is essential for sustained benefits and capital preservation (3.4333). The pie charts emphasize the broad consensus on the importance of equipment maintenance activities. It's worth noting that the presented findings align with broader industry perspectives emphasizing the critical role of maintenance in ensuring equipment longevity and performance.

Table 6, focusing on the operation of biomedical equipment, identifies a strong consensus regarding the importance of securing connections before operation (mean of 3.6733). The bar charts further highlight the agreement on the necessity of proper authorization for operating biomedical equipment. Interestingly, the lowest mean in this section is linked to the statement advocating the use of personal protective equipment (PPE) during operation (3.12). This nuanced finding may warrant further exploration into the factors influencing attitudes toward PPE usage during equipment operation.

Finally, the efficacy of biomedical equipment (Table 7) is explored, revealing a notable consensus on the repeatability of results (mean of 3.2367). The pie charts underscore the agreement on the ease of interpreting measurements and the perceived flexibility of biomedical equipment. However, the statement affirming the accuracy of the instrument for application receives a notably lower mean (2.6767), suggesting potential concerns or variations in perspectives regarding equipment accuracy.

In summary, this comprehensive analysis delves into the multifaceted landscape of biomedical equipment perceptions among medical professionals in the GCC region. The findings offer valuable insights into areas of alignment and potential areas for improvement or further investigation, providing a solid foundation for future research and policy considerations in the healthcare technology domain.

Conclusion

In conclusion, this study contributes to the evolving landscape of Biomedical Equipment Maintenance Management by showcasing the tangible impact of Artificial Intelligence (AI) across multiple domains. The findings underscore the effectiveness of predictive maintenance models in minimizing downtime and optimizing equipment reliability, aligning with existing literature on the transformative potential of AI in healthcare. The demonstrated efficiency of robotic automation in routine tasks, the facilitation of seamless communication through Natural Language Processing, and the high diagnostic accuracy achieved with Image Recognition Technologies further solidify the role of AI in enhancing maintenance operations. While acknowledging the challenges, including ethical considerations and the need for skilled personnel, this research emphasizes the practical implications of AI integration in biomedical equipment maintenance, providing a foundation for future advancements and improved healthcare facility management. Ultimately, the study advocates for the continued exploration and strategic implementation of AI technologies to propel Biomedical Equipment Maintenance Management into an era of increased efficiency, reduced downtime, and heightened diagnostic precision in healthcare settings. Training from the supplier during installation ensures proper understanding of equipment functionality. Regular refreshment trainings for end-users enhance long-term efficacy and optimize data retrieval. This is crucial for precision medicine, ensuring accurate analysis and tailored treatments for patients.

Future Scope and Direction

The future of Biomedical Equipment Maintenance Management (BEMM) lies in the continued exploration and advancement of Artificial Intelligence (AI) applications. Further research can focus on refining predictive maintenance models and incorporating more sophisticated machine learning algorithms to enhance accuracy and reliability. Robotic automation systems can be optimized for a broader range of maintenance tasks, and the integration of advanced sensors can enable real-time monitoring and data collection for improved decision-making. Additionally, future directions may involve refining Natural Language Processing (NLP) capabilities to foster more intuitive interactions between technicians and AI systems. Image Recognition Technologies can be extended to cover a wider array of fault types, contributing to a comprehensive diagnostic framework. Addressing ethical concerns, ensuring data security, and developing standardized guidelines for AI implementation in healthcare settings is imperative. Collaborative efforts among researchers, healthcare professionals, and technology developers are essential to harness the full potential of AI in BEMM, ultimately paving the way for more efficient, proactive, and technologically advanced biomedical equipment maintenance practices.

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