An-Najah National University

Faculty of Graduate Studies

ASSESSING THE IMPACT OF CLINICAL ALARM MANAGEMENT PRACTICES ON PATIENT ’S SAFETY AS PERCEIVED BY NURSES: THE MODERATING ROLE OF JCI-ACCREDITATION

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This Thesis is Submitted in Partial Fulfillment of the Requirements for The Degree of Master of Engineering Management, Faculty of Graduate Studies, An Najah National University, Nablus-Palestine.

2024

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Dedication

To my father, the Engineer “Abdelelah Samara Abdelhadi,” who taught me to never give up and to always be ambitious.

To my beloved mother, Amal Shalabi, who loved me unconditionally and supported me every step of the way, to my dear wife, Shahd Surkaji, my other half, who supported me without limits, to the souls of our martyrs in beloved Gaza and West Bank.

Thank you for everything.

Acknowledgement

This thesis would never have seen the sun without the guidance of my supervisor and without the full support and help from friends and family. So, first of all, I would like to express my deepest gratitude and sincere thanks to my supervisor Dr. Yahya Saleh, for his excellent guidance, support, encouragement, and assistance throughout this research that has resulted in the completion of this thesis.

I am also grateful to my colleague Mr. Abdallah Ahmad Abdallah for his valuable help, late-night feedback sessions, and moral support.

Finally, I would like to express my appreciation to all of the academic staff of the Engineering Management program at An-Najah National University for helping me in overcoming program courses successfully; and guiding me to develop my background in subjects that are related to this research.

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

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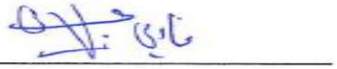
I declare that the work provided in this thesis, unless otherwise referenced, is the researcher’s own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Fadi Abdelhadi

Signature: 

Date: 29/09/2024

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ASSESSING THE IMPACT OF CLINICAL ALARM MANAGEMENT PRACTICES ON PATIENT ’S SAFETY AS PERCEIVED BY NURSES: THE MODERATING ROLE OF JCI-ACCREDITATION

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Abstract

This study investigates the impact of Clinical Alarm Management Practices and Knowledge (CAMPK) on Patient Safety as Perceived by Nurses (PSPN) and the moderating role of Joint Commission International (JCI) accreditation within Palestinian hospitals. To this end, the Health Technology Foundation (HTF) 2016 Clinical Alarms Survey, was used to collect data from 102 nurses across various departments in Palestinian hospitals. Collected data were analyzed using the partial least squares-structural equation modelling (PLS-SEM) via Smart PLS software.

The findings of the analysis revealed that effective CAMPK positively enhance the PSPN with value of ($p = 0.004$). Furthermore, the study shows the importance of reducing nuisance alarms and the use of smart alarm systems as major and important elements of CAMPK that positively impact PSPN.

JCI accreditation was found to have a minimum statistically significant effect on nurses’ perception of patient safety and a minimum moderating effect on the relation between CAMPK and PSPN. The analysis shows that the interaction effect between JCI and CAMPK on PSPN was not statistically significant $p = 0.486$ which is > 0.05. In order to enhance patient safety perceptions this study suggests that accreditation alone is insufficient and a comprehensive approach integrating CAMPK and tailored accreditation processes is necessary. The findings show the complexity of patient safety improvements and the need for ongoing evaluation and adjustment of clinical practices and accreditation standards.

The study's conclusion provides data highlighting the importance of effective Clinical Alarm Management Practices and Knowledge (CAMPK) in enhancing nurses' perceptions of patient safety (PSPN). Also this study provides the tools, for healthcare

policymakers and administrators in Palestinian healthcare sector as well as clinical staff, necessary for developing patient safety programs in the altered clinical settings, allowing one to comprehend the link between CAMPK, PSPN, and JCI accreditation.

As Palestinian hospitals have just recently begun to participate in international joint commission accreditation, accrediting processes require regular reviews and modifications. Administrators need to take a more active role in quality improvement initiatives in order to close any gaps that exist and ensure that clinical practice and accreditation criteria are in line with patient safety objectives.

Keywords*:* Clinical Alarm Management Practices and Knowledge (CAMPK), Patient Safety, Smart PLS, Palestinian healthcare sector, nuisance alarms, Health Technology Foundation (HTF).

Chapter One

Introduction and Literature Review

This section provides a summary of the study including an introduction to the research its context the issues it aims to address and its goals. It also explores the importance of the study and its thesis structure. Furthermore, this section presents an examination and evaluation of both empirical and theoretical information gathered from the literature review emphasizing the significance of CAMPK, its effects on the (PSPN), and how the role of JCI moderates this relationship. Drawing from the literature hypotheses for the study are also formulated in this section.

1.1 General Background

In modern healthcare sector environment, clinical alarm systems play important role in patient monitoring and safety. Medical device alarms are designed to alert clinicians of a hazardous condition and potential problems associated with patient. However, staff are exposed to noise-polluted environment as a result of medical equipment beeps, bells, chimes and horns. They are exposed to several hundred alarm signals per patient per day depending on the unit within the hospital, which are translated to thousands of alarm signals on every unit and tens of thousands of alarm signals throughout the hospital every day (Cvach, 2012).

The main purpose of clinical alarm systems is to alert health care providers to potential patient problems, but if not managed correctly, they can put patients at risk. This is a multi-faceted case. In some cases, individual alarm signals can be hard to identify. Many patient care areas have multiple alarm signals and the noise and information they display can desensitize staff leading them to miss, ignore, or even disable alarm signals. Other challenges to effective clinical alarm management include overloading devices with alarms, setting default settings that are below actionable levels and setting alarm limits too narrow.

These challenges vary significantly from hospital to hospital and even within individual units within a single hospital (Joint Commission International (JCI), 2020). Clinical Alarms Management Practice and Knowledge (CAMPK) forms the basis for strategies, policies and education aimed at improving the use of alarm systems within healthcare

settings. Effective CAMPK is important in mitigating the negative influence of nuisance alarms on nurses performance and improving overall patient safety. According to previous studies, nurse's perceptions and handling of clinical alarms are crucial to patient safety (Lee et al., 2021; Ruppel et al., 2018).

Nurses reactivity and the standard of patient care are directly impacted by their capacity to distinguish between actual and false alarms, as well as by their familiarity with alarm systems. Studies have highlighted the need for a multifaceted approach to improve clinical alarm management. Lee et al. (2021) found that the most significant issue nurses identified as challenging in alarm management is the high frequency of false alarms resulting in a decrease in attention or response when an alarm is triggered followed by the over reliance on alarms to alert to patient issues. Petersen and Costanzo (2017) concluded that clinical staff, particularly those working in Intensive Care Units (ICUs), are impacted by the complex issue of alarm management. Patient safety chiasms are brought about by a lack of understanding of nurses' perspectives on alarm fatigue and management.

These matters call for greater attention by decision-makers in health institutions to develop nurses skills by intensifying training on managing clinical alerts and enacting policies and procedures that regulate this process.

Moreover, in order to develop the management of clinical alarms, the use of advanced technology in medical devices is an urgent matter recently, as it directly contributes to reducing false clinical alarms, which helps health care providers manage these alarms more efficiently (Cosper et al., 2017). The management of clinical alarms is an essential process that needs to go forward despite the significant financial expenditures associated with implementing such advanced technological solutions. This is because the process will enhance patient safety and improve nursing performance (Poncette et al., 2019).

Bonafide et al. (2015) shed light on the way that nurses experiences with alarm systems such as how quickly they respond to the alarms may affect how patients perceive their safety. Regular training and the implementation of machine learning approaches to predict and reduce false alarms can significantly mitigate these issues and improve patient safety (Au-Yeung et al., 2019; Bridi et al., 2014). In addition to the use of smart

alarms systems, technological innovations and continuous training; institutional support through frameworks such as JCI accreditation plays a vital role in enhancing clinical alarm management and patient safety.

JCI is an independent, none profit organization; it identifies, measures, and shares best practices in quality and patient safety around the world, it provides leadership and innovative solutions to help health care organizations across all settings improve performance and outcomes. JCI has developed a national patient safety goal (NPSG.6) which aims to reduce patient harm associated with clinical alarm through improving the safety of clinical alarm systems (JCI, 2013).

Few studies have explored how the JCI affects the connections between CAMPK and patient safety, as perceived by nurses (PSPN), especially in difficult settings found in developing nations like Palestine. This study seeks to address the lack of knowledge in current research by offering factual understandings of the impact of CAMPK and JCI accreditation on patient safety from the perspective of nurses in Palestine's healthcare system.

1.2 Problem Statement

Medical Device Clinical Alarms in Hospital Areas were seen as a health technology risk and considered among the key instruments for notifying critical care nurses about urgent or possible dangers to critically ill patients before a serious incident happens. Managing these alarms effectively remains a difficulty for critical care nurses in different clinical environments regarding the selection, setup, and reaction to clinical alarms (Aysha & Ahmed, 2019). Noisy environments are clearly linked to caregiver destructions during performing tasks (Paparella, 2014). Clinical alarms are top ten health technology hazard, they consistently appeared as the first or second most critical hazards according to Emergency Care Research Institute (ECRI) since the first annual published in 2007 (Keller et al., 2011).

Unfortunately, in some cases the alarm is not being set according to patient type or appropriate care area, and this because either some hospitals have not established specific alarm setting protocol, or the hospital has established protocols, but did not understand or followed it. In other cases, two or more of the same model devices are being used to treat patients with similar clinical conditions in the same care area with

completely different (Keller et al., 2011). This in role puts the patients' lives at risk, for instance, a man aged 60 years died in an ICU of a hospital- not because of head injury he suffered from fallen from a tree branch- but from medical alarm system failure that led to delayed response to the alarm signal which indicated serious changes in his body condition**.**

Melo et al. (2020) identify patient safety as the absence of preventable harm to patients and minimize or avoiding of needless harm by healthcare practitioners. Regarding this, developing the culture of patient safety is considered as a successful strategy to raise patient safety. Shared values, behavioral norms and beliefs related to patient safety, that members, or unit adhere to, are referred to patient safety culture.

Lee et al. (2021) explores how hospital nurses views on clinical alarms and the overall culture of patient safety affect how they handle alarm management. They also look into how important clinical alarm problems are from the perspective of nurses in a hospital setting. When nurses perceive alarm positively it indicates that they understand the alarms correctly and they believe these alarms accurately reflect the patients' health status aiding in delivering quality nursing care. Furthermore, their positive perception of alarms also reduces their anxiety about alarms going off due to their comfort and expertise with the alarm system.

There’s no doubt that this is a critical safety concern. In the context of Palestinian healthcare sector where hospitals often face unique challenges such as limited resources, Scarcity of funding sources and the ongoing conflict greatly affects the development in the field of health care in terms of knowledge and skill of health care providers, which in turn is reflected in patient safety. Its essential that a hospital understands its unique circumstances and adopts a well-thought-out integrated approach to managing clinical alarm systems.

1.3 Research Questions

This study aims at answering the following two main research questions (RQs):

RQ.1: Is there a significant relationship between clinical alarm management practices and knowledge (CAMPK) and patient safety as perceived by nurses (PSPN) in Palestinian hospitals?

RQ.2: Does JCI accreditation significantly moderate the relationship between clinical alarm management practices and knowledge (CAMPK) and patient safety as perceived by nurses (PSPN) in Palestinian hospitals?

1.4 Research Objectives

The study major objectives are as the following:

1. Investigating the relationship between CAMPK and PSPN in Palestinian hospitals, considering the moderating role of JCI accreditation status.
2. A conceptual model developing that presents the relation between CAMPK and PSPN with the moderating role of JCI.

1.5 Research Hypotheses

H1: There is no significant relationship between CAMPK and PSPN in Palestinian hospitals.

H2: JCI-accreditation have no significant moderating role on the relationship between CAMPK and PSPN in Palestinian hospitals.

1.6 Significance of Research

This study is significant for analyzing the complex relationship between CAMPK and PSPS in Palestinian healthcare settings (Checkland & Scholes, 1999).We seek to provide a thorough knowledge of how accreditation status may affect the relationship between CAMPK and PSPS in by taking into account the moderating role of JCI accreditation.

As the study explores how external factors may moderate the relationship between CAMPK and PSPS, the introduction of JCI accreditation as a moderating factor adds another level of complexity (Cooper, 2018). Healthcare businesses trying to improve patient safety measures while adhering to accreditation standards must comprehend these complex relationships.

1.7 Thesis Structure

This research is structured into five sections. The initial section titled "Introduction and Literature Review" sets the stage for the thesis by offering a concise overview of the subject matter. It delineates the research issue at hand highlighting its significance. Also, it makes clear the goals of the study and the questions it aims to address. This section also features a literature review and a summary of previous studies that have investigated CAMPK, PSPN and the function of JCI as well as previous research that backs up the development of the hypotheses.

The second section “Research Methodology” presents the methodology that has been followed in this research through discussing data collection process used, the population targeted, sampling process, the instrument for data collection and the data analysis approach.

The third section “Data Analysis and Results” presents the results and findings which illustrate the analytical results of quantitative data and present the hypotheses testing results.

In the fourth section titled "Discussion and Conclusion" the outcome presented in chapter three are analyzed and concise summaries are provided regarding the outcomes of the hypotheses.

The fifth section named "Implications and Future Studies" explore both the practical and theoretical impacts of the study. Also, it acknowledge the challenges faced during study and proposes solutions and future research directions.

1.8 Clinical Alarm Management Practice & Knowledge (CAMPK)

1.8.1 Nuisance Alarms (NA) and Clinical Alarm Management Practice

To assess how nuisance alarms (NA) affect nurses' views on how clinical alarms are managed and the overall culture of patient safety, a research project by Lee et al. (2021) aimed to explore the importance of alarm related issues among hospital nurses. The top challenge nurses mentioned in managing alarms was the frequent occurrence of false alarms resulting in a decrease in attention or response when an alarm is triggered followed by the over reliance on alarms to alert to patient issues. On the other hand, the least significant issue nurses identified is the difficulty in hearing an alarm when it is

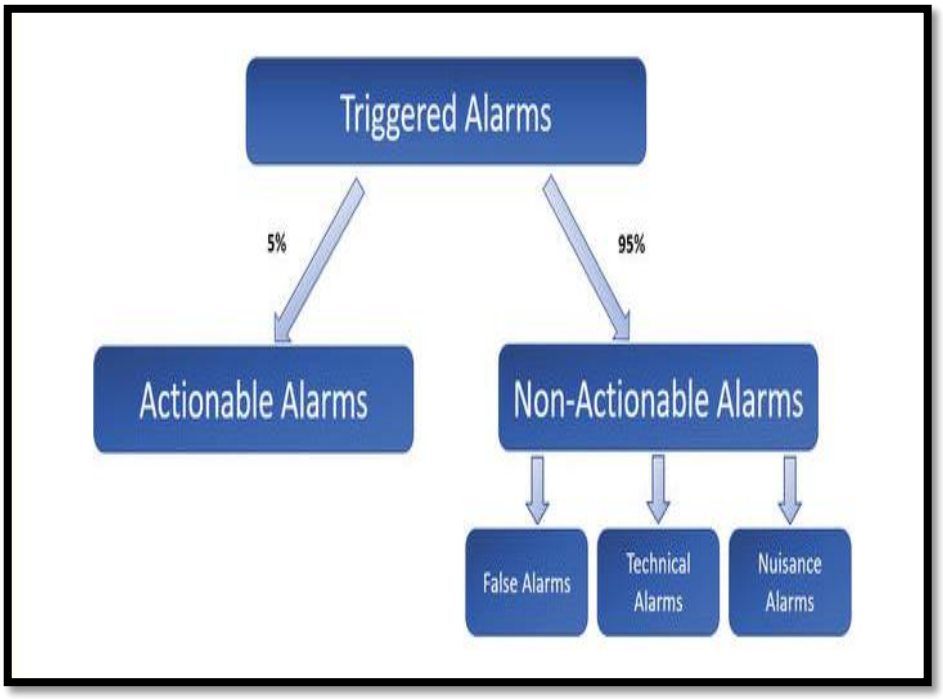
triggered. In order for clinical alarm management to be successful a multi layered approach is needed. This research show that encouraging nurses to have positive experiences with clinical alarms and fostering culture of patient safety can improve how nurses manage alarms at the individual level. It recommends developing a uniform tool to assess nurses' comprehension of clinical alerts and policies related to alarm management. For the organization training programs should be customized and specific to each unit.

Nguyen et al. (2019) mention that Clinically meaningless alerts that could impede patient care are referred to as nuisance alarms. The collective desensitization of hospital workers to these nonactionable alerts is a significant contributing factor to the risk of alarm fatigue. In order to minimize the stress on the responding clinical staff, the ideal alarm should be crystal clear and simple for healthcare professionals working in the patient care unit to identify.

Figure 1.1 show a schematic representation of the classification of alarm types triggered by various patient monitoring systems, including both actionable and nonactionable alerts.

Figure 1.1

Classification of alarm types triggered



Source: Nguyen et al. (2019)

Petersen and Costanzo (2017) concluded that clinical staff, particularly those working in ICU are impacted by the complex issue of alarm management. Patient safety chiasms are brought about by a lack of understanding of nurses' perspectives on alarm fatigue and management. They employ the Healthcare Technology Foundation's (HTF) Clinical Alarms Committee Survey to carry out a project aimed at enhancing quality focusing on the views of nurses regarding alarm fatigue. The survey revealed that the majority of nurses participating concurred that nuisance alarms (NA) are common, interrupting patient care and a deficiency in a uniform approach to alarm management was identified. This study suggests to organize annual training for nurses on alarm management and continuous assessment of alarm management and improvement.

Another study was conducted by Ruppel et al. (2018) aimed to identify how nurses and healthcare providers perceptions of alarms have changed in certain period.They found, after conducting three survey in different years, that in the last survey most nurses were more likely to agree that NA occur frequently and disrupt patient care and this prompts continuing to enhance nurses knowledge in managing clinical alarms which in turn contributes significantly to raising the level of patient safety.

Also, a research project carried out by Yue et al. (2017) aimed to assess how effective nurse education program are in improving the response and management of clinical alarms. The investigation looked into the impact of learning about various types of alarms including general alarms, single alarms and sequential alarms and alarm of medium severity and they found that such training have a positive impact. Nurses who received musical training were found to respond to alarm more swiftly and accurately. The study highlighted the critical role nurses play in handling clinical alarm and challenging environment they face due to high volume of alarms including those that are not relevant (nuisance alarms) and other issues. This underscore the need to improve the awareness of clinical alarm management among both undergraduate and practicing nurses.

The purpose of a study done by Shaoru et al. (2023) was to comprehensively assess clinical nurses levels of medical equipment alarm fatigue and the factors that influence it. After a total of 14 cross sectional studies were included with a total sample of 2,848 nurses they conclude that clinical nurses had a moderate amount of alarm fatigue. Managers and policy makers should increase their staff members awareness of alarm

safety, strategically assign nurses, provide training to improve their ability to manage alarms and optimize the frequency and level of alarm on their equipment in order to lower the nuisance alarms and alarm fatigue experienced by clinical nurses.

When technology used in a clinical context there is a high frequency of false alarms which known as alarm fatigue. This can lead to increased distraction among nurses which could compromise the safety of patients. Alarm fatigue is a common problem that impact on many practice areas. It is advised that nurses enroll in an educational program to understand how to handle nuisance alarms and alarm fatigue. Nurses must receive individualized training and instruction in order to handle alerts in an efficient manner (Al-Quraan et al., 2023).

1.8.2 Clinical Alarm Management Improvement (CAMI) and Institutional Requirements (IR)

Hospital administrators could also focus more on nurse's needs, recognizing the critical context for improved patient safety and work productivity. CAMPK focuses on continues training and improvement of the staff knowledge. Sowan et al. (2015) investigate the perception and practice of transplant/cardiac ICU American Nurses towards clinical alarms. A total of 39 nurses completed a 5-point Liker type questionnaire designed by the HTF. The tool measured perception of clinical alarms signal and potential issues interfering with alarm recognition. The results showed that 95%-98% of nurses believed false alarms are common, interfere with care and decrease trust in the alarm system resulting in nurses inappropriately disabling them. About 60% of nurses reported insufficient training on bedside and central cardiac monitors. The correlation showed the need for training on cardiac monitors especially for older nurses.

This study suggests the need for a multi method approach to reduce alarm fatigue and improve alarm system safety. In order to move forward in the process of improving clinical alarms management, (Sowan et al., 2016) have conducted a study to see if changing the default alarm settings of cardiac monitors and training nurses on how to use them in an ICU could lead to lower alarm rates and better nurses attitudes and practices when it comes to clinical alarms. The results showed significant difference between nurses towered changing in cardiac monitor parameters and 50% of nurses reported needing additional training on cardiac monitors parameters during the follow

up period. This indicates the need to increase the health institutions interest in developing policies, procedures and skills related to the management of clinical alarms by nurses and the knowledge related to them.

More postgraduate training, monitor training and tailoring alarms to the patients health status are all necessary for nurses to reduce false alarms. Considering the environment, professional factors, and patient state is a difficult process when determining how to respond to an alarm (López- Espuela et al., 2022).

Also, a research study was conducted by Bi et al. (2020) to evaluate the effectiveness of training on managing alarm systems specifically designed to reduce alarm fatigue among nurses in critical care units using the theory of planned behavior. A total of 93 ICU clinical nurses were randomly assigned to two groups. The experimental group consisting of 47 nurses underwent a 12 week alarm management training program. The control group also of 47 nurses received continuous training. A questionnaire was administered to measure the nurses alarm fatigue levels before and after the training period. The study also documented the total number of alarms those that were not actionable and the actual alarms throughout the duration. The results indicates that the alarm management training grounded in the theory of planned behavior effectively diminished alarm fatigue among ICU nurses. It is important for hospital management to recognize the importance of nurses in the medical monitoring system. To enhance the skills of nursing supervisors in alarm management and decrease alarm fatigue among ICU nurses the researchers suggest that more ICUs should implement similar training programs.

Lewandowska et al. (2020) found that for patients and nursing staff alarm fatigue can have detrimental effects. Establishing an alarm fatigue threshold and implementing an alarm management plan are crucial. A sample of 389 nurses who worked in various intensive care units were examined with using the HTF questionnaire in the trials that were analyzed and the result was that ICU nurses believe that alarms are too frequent and cumbersome which makes it difficult to provide patients with the care they need and erodes confidence in alarm systems. They feel as though they have too many responsibilities and are always being alerted to dangers. Nurses would rather spend their time tending to their patients rather than operating the more sophisticated technological systems. Clinical alarm are intended to notify health care providers of a patients

physiological state that is not acceptable and to warn them of broken medical equipment. Clinicians may experience alarm fatigue and desensitization if they are overloaded with clinical alarms especially those alarms which are not actionable.

A quality improvement project was conducted by Bosma and Christopher (2023) in order to reduce alarm fatigue and improve nursing competency in clinical alarms managing. a representative from the alarm manufacturer performed in service training sessions and the device was equipped with the evidence-based alarm management package known as CEASE (Communication, Electrodes, Appropriateness, Setup and Education). 115 nurses working in the unit were given a clinical alarm survey created by the Healthcare Technology Foundation HTF. To look for changes between the preintervention and postintervention times descriptive and inferential statistics were employed. They note that nurse participants assessments of alarm functionality, settings, reaction time and policy adherence significantly improved as a result of their increased alarm management expertise. and the CEASE bundle was proven to have an impact on nursing practice.

In order to evaluate the effect of educational intervention for reducing false and non actionable alarm and alarm fatigue in nurses Nyarko et al. (2022) found on their study that the solution to nurses alarm fatigue might be found in educational intervention. Alarms are unavoidable because of the rapidly growing use of medical technology in hospitals. It is important to establish efficient and ongoing educational and training initiatives for nurses in the areas of clinical alarm management and increasing their knowledge of alarm fatigue.

This matter calls for greater attention by decision-makers in health institutions to develop nurses' skills by intensifying training on managing clinical alerts and enacting policies and procedures that regulate this process.

1.8.3 Smart Alarms (SA) and Clinical Alarm Management Practice

In order to develop the management of clinical alarms, the use of advanced technology in medical devices is an urgent matter recently, as it directly contributes to reducing false clinical alarms, which helps health care providers manage these alarms more efficiently**.**

Cosper et al. (2017) found that false or nonactionable clinical alarms are one of the main concern's main topic of his article, as is the kind of information that may be used to determine which of these alarms is most common in particular hospital units. Since decisions about data capture will be made based on this process, it is first outlined how to identify the essential data. Also he mention that the quick advancement of technology has enormous potential to enhance patient care and alarm management. Hospitals, and medical equipment manufacturers are putting new and inventive ways to track, log, and handle device alerts into practice. Staff alarm fatigue could be decreased and clinical alarm managing can enhance with the help of new innovations and smart system integration.

Despite the high financial costs of employing such advanced technological systems, the process of managing clinical alarms must move forward because it will increase patient safety and improve both nursing and patient satisfaction. Figure 1.2 show central patient monitoring system which collect the vital singe data in real time for a group of patients in the same time which led to improving and better response from the nursing team to any critical changes in vital Signe of patient.

Figure 1.2

Patient central monitoring system

Source: Drägerwerk AG & Co. KGaA, 2021

Poncette et al. (2019) assess feedback from ICU nurse staff on current patient monitoring capabilities and expectations for future new technology advancements to better understand clinical alarm needs and obstacles to the deployment of future patient monitoring. This study was done at three ICUs of a German university hospitals with ICU staff. The ICU staff evaluated the patient monitoring system used in these critical ICUs based on usability criteria such as intuition and visualization and the researchers found that poor alarm management and monitoring cable entanglement were identified as potential patient safety concerns. This study suggests encouraging rapid and sustainable adoption of new advanced medical monitoring systems in ICU and focusing more on user-generated insights in order to enhance alarm management and reduce the influence of alarm fatigue.

Another study by Mosch et al. (2024) aimed to comprehend how staff members interact with the patient monitoring system and alarm management procedures in order to

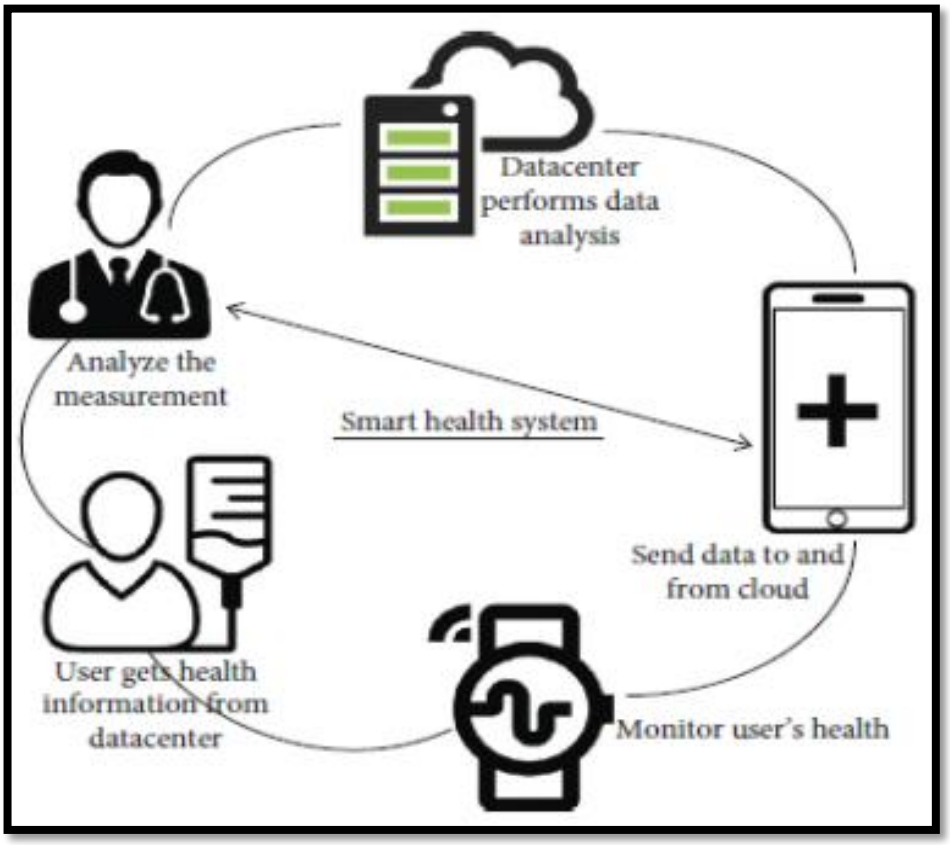
design and implement long-lasting solutions for alarm management in intensive care units (ICUs). They found that the majority of the workday and tasks, according to nurses and doctors, were spent working with the continuous vital sign monitoring system. There were no set guidelines for handling alerts; instead, doctors and nurses said that alarms were handled by impromptu responses, which they considered to be troublesome. Although employee opinions on smart alarm management were not all the same, they did emphasize the value of clear and traceable recommendations to foster a culture of trust. This study concludes that ICU operations and clinical decision making heavily depend on staff members interactions with the ubiquitous patient monitoring system and associated smart alarms. It has been demonstrated that smart alarm management procedures and standards are inadequate. Changes appear necessary based on our observations and staff feedback. The main components of alarm management solutions should include people, workflows, and real-world data.

A. S. Poncette et al. (2020) in his study focused on the contentment of ICU personnel on the present patient monitoring system and their recommendations for future enhancements. This study aimed to determine which parts of monitoring interfere with patient care, what equipment are available for remote monitoring, what applications artificial intelligence (AI) and smart alarm systems may be used for, and whether or if staff members in the intensive care unit (ICU) are eager to become more digitally literate or to help enhance patient monitoring. the objective was also to discern variations in the reactions of distinct groups of professionals. They found that Reducing false alarms, putting hospital alarm standard operating procedures into place, introducing wireless sensors, getting ready for the use of AI, and improving the digital literacy of ICU staff should be the top priorities for hospital providers and medical equipment makers. The findings could aid in the user-centered implementation of digital technology to mitigate difficulties in the field of critical care medicine.

Alekya, R., et al. (2020) focused on their study on (IoT) internet of things techniques in order to made it possible for clinicians to monitor their patients in remote areas on an ongoing basis via wireless sensors. Figure 1.3 show applications of IoT cycle in healthcare for patient alarms monitoring.

Figure 1.3

Application of IoT in Healthcare



Source: Alekya, R., et al. (2020)

1.9 Patient Safety as Perceived by Nurses (PSPN)

1.9.1 Alarm Notification (AN), Experiences with Alarm Systems (EAS) and Patient Safety

Timely intervention for patients with critical events is ensured by alarm notifications systems. However, alarm fatigue is significantly contributed to by the high volume of alarms, many of which are false or meaningless. Studies have indicated that the high number of alarms in ICU nursing causes a condition known as alarm fatigue. As a result, nurses become desensitized and response times are delayed (Cvach, 2012; Drew et al. 2014). Also, Cvach (2012) suggested that regular alarm management training could help improve a nurses ability to distinguish the true from the false alarms and therefore make the annular safer improve patient safety.

It was noted in a study by Cho and Steege (2021) that the overall work burden and stress levels for nurses are affected by too frequent alarms. As a result, the research

indicates that nurse weariness has a detrimental impact on organizational, patient and nurse outcomes. The development and application of fatigue and alarm management methods for nurses are strongly supported by these findings. (Cho & Steege, 2021). Likewise, Au-Yeung et al. (2019) found that a machine learning approach for predicting and reducing false alarms among ICU nurses could bring a significant reduction in alarm fatigue.

Bridi et al. (2014) found that it is unsettling that the equipment meant to save patients may actually cause more noise in the hospital which could lead to alarm fatigue, divert attention from important tasks, disrupt productivity, and ultimately provide the impression that everything is under control. Through proper monitoring, the staff will become less overly accustomed to noise and will understand the true urgency of responding to alarms. They will also gain confidence in the clinical significance and urgency of these devices. Furthermore, efforts aimed at lessening the noise produced by alarms will be advantageous to patients admitted to intensive care units. Thus, as long as the staff properly programs, configures, adjusts, and values the alarms they can be beneficial for intensive care (Bridi et al., 2014).

A study conducted by Bonafide et al. (2015) looks into the relationship between a child hospitals reaction time by nurse staff and exposure to nonactionable physiologic monitor alarms. It sheds light on the way that nurses experiences with alarm systems such as how quickly they respond to alerts may affect how patients perceive their safety and found that most alarms were nonactionable, and response time increased as nonactionable alarm exposure increased.

In order to assess the expectations and experiences towered alarm monitoring systems and patient safety, Rayan et al. (2024) found that before patient monitoring systems can be effectively used in the intensive care unit there are obstacles to be addressed. ICU nurses are leaders in the use monitoring systems technologies and their knowledge and expertise is invaluable in determining the advantages, disadvantages and future directions of research and development. Furthermore, the experiences, obstacles, and expectations of intensive care unit nurses about the existing patient monitoring system have a considerable influence on the efficacy and adoption of these technologies in the critical care context.

Another study showed that the unsuitable and poor design of monitoring alarm systems can cause staff error and harm patients (Kim et al., 2023).This study was aimed to evaluate the difference in user experience for 2 alarm monitoring system models and through the user experience evaluation they found that the design of the user interface can affect system usability and workload and also will contribute to improving patient safety by reducing usage errors and false alarms.

Also, a study conducting by Wang et al. (2023) aimed to delineate the physiologic monitor clinical alarm frequencies and explore the perspectives and actions of nurses concerning clinical alarms in intensive care units. continuous 24-hour nonparticipant observation research was carried out. When the alarms on the ECG monitor went off, observers saw it happen and noted the specific details, he found that to enhance patient safety and nursing quality, it is advised to use smart medical equipment and alarm notification systems, create and execute standardized alarm management rules and norms, and bolster alarm management education and training. So as remark, Alarm notification system reduce response time and improve intervention accuracy.

The objectives of the research conducted by Allan et al. (2017) was to improve patient safety within a cardiovascular surgical critical care unit by improving the alert systems. This study examined nurses' perception of clinical alarm signals and evaluated their aptitude to distinguish between different kinds of audible warning signals and produced a comprehensive list of safe techniques for lowering alarm noise levels without compromising patient safety. The findings indicate that strategies such as introducing brief delays for alarms to self-correct adjusting the default alarm thresholds using secondary device to notify staff about alarms and training staff on customizing alarm settings for individual patients could help reducing false alarms. Therefore, effective alarm notification systems contribute to better patient outcome and increased satisfaction among nurses.

Therefore, to study the relation between CAMPK and PSPN, particularly in Palestinian hospitals, the following hypothesis is proposed:

H1: There is no significant relationship between CAMPK and PSPN in Palestinian hospitals.

1.9.2 Joint Commission International Accreditation (JCIA) and Patient Safety

JCI is an independent, not-for-profit organization; it identifies, measures, and shares best practices in quality and patient safety around the world, it provides leadership and innovative solutions to help health care organizations across all settings improve performance and outcomes. When healthcare providers strive to improve patient safety in hospitals, urgent care centers, and other such facilities its crucial they identify the unique hot spots and then propose potential solutions for each. The Joint Commission publishes the National Patient Safety Goals (NPSG), which are updated yearly, with that goal in mind. The National Patient Safety Goals (NPSGs) were established in 2002 to help organizations address key areas of concern in regard to patient safety. The Joint Commission chooses the greatest priority concerns about patient safety, such as NPSGs, based on feedback from practitioners, suppliers, buying groups, customer associations and additional parties involved. The Joint Commission created the National Patient Safety Goals (NPSGs) in an effort to improve patient safety in all healthcare settings globally. These objectives pinpoint crucial places where advancement can lower mistakes and patient dangers. A key component of keeping an eye on and reacting to changes in patient status, especially in critical care settings like intensive care units, is enhancing the safety of clinical alarm systems, which is the emphasis of NPSG 6. Clinical alarms are essential for warning medical staff of potentially fatal changes in a patient's condition, such as irregular heartbeats, breathing problems, or low oxygen levels.

In order to solve this issue, NPSG 6 offers recommendations to hospitals on how to enhance the administration of their alarm systems, making sure that alerts are dependable, useful, and do not overburden personnel. The order of alarms according to their significance and possible patient risk is one of the main components of this objective. More importance must be given to critical alarms than less urgent ones, such as those pertaining to heart rates or oxygen saturation. This makes it possible to guarantee that personnel react quickly to alerts indicating potential threats to patient safety. An additional crucial element is to standardize the alarm settings throughout the medical center. Standard settings lower the chance of errors by preventing staff confusion and ensuring that alarms are consistent across all units.

NPSG 6 places significant emphasis on the ongoing evaluation and enhancement of alarm systems. Healthcare companies need to monitor alarm-related issues, assess the efficacy of their alarm management procedures on a regular basis, and make the required improvements to reaction times and results. Hospitals can also concentrate on preventing alarm fatigue by implementing technology advancements and techniques like centralized monitoring systems, which can assist in lowering the number of unnecessary alarms. One such invention that helps achieve this goal is smart alarm technology, which can filter out false or non-urgent alarms, reducing excessive noise and freeing staff to concentrate on actual patient needs.

Healthcare organizations may find it difficult to implement NPSG 6 in settings with limited manpower or resources. It can be challenging to strike a balance between the requirement for effective alerts and not overburdening staff, and constant adjustment of alarm settings necessitates careful observation of patient situations. Implementation success can also be hampered by resistance to changes in alarm procedures, especially when new technologies or systems are introduced.

Make cautious use of alarms because there are so many alarm signals in patient care environments, there is frequently noise and information shown, which can make people less sensitive to alarms overall. The unfavorable result is that employees might overlook, dismiss, or even turn off alert signals. Other issues include an excessive number of alarm-equipped devices, alarm limitations that are too small, and default settings that are not at an actionable level. Creating a methodical, coordinated approach to clinical alarm system management is an excellent place to start, even though there are no universal answers. After establishing a strategy, it's crucial to confirm the alerts are functional. In order to guarantee that alarms will sound, biomedical clinical engineering labels can assist health systems in tracking and communicating crucial safety, maintenance, calibration, and inspection information.

Cameron and Little (2018) carried out a project aimed at enhancing the quality of care by developing putting into action and assessing how effective alarm management policies and training sessions were influencing nurses' views and actions regarding alarm management in critical care areas of hospitals. To fulfill the standards set by the NPSG.06.01.01 the hospital introduced alarm management education grounded in practices supported by evidence (JCI, 2013)

Noisy environments are clearly linked to caregiver distracted during performing tasks (Paparella, 2014). Hospitals average expose of sound during the daytime is 72 decibels and 60 decibels at nighttime, which is far in excess of the 40 decibels have been recommended by the World Health Organization (WHO). Moreover, the noise level is consistently rising since 1960.

According to Cvach (2012), the medical device alarms are designed to alert clinicians of a hazardous condition and potential problems associated with patient. However, staff is exposed to noise-polluted environment as a result of medical equipment beeps, bells, chimes and horns. They are exposed to several hundred alarm signals per patient per day depending on the unit within the hospital, which is translating to thousands of alarm signals on every unit and tens of thousands of alarm signals throughout the hospital every day.

As a result of alarm fatigue; the health caregiver might be disrupting on their usual workflow, adjust the setting outside the limits that are safe and appropriate for the patient, turn the alarm volume down, or even turn it off- all these reactions can have serious or fatal consequences on patients' lives.

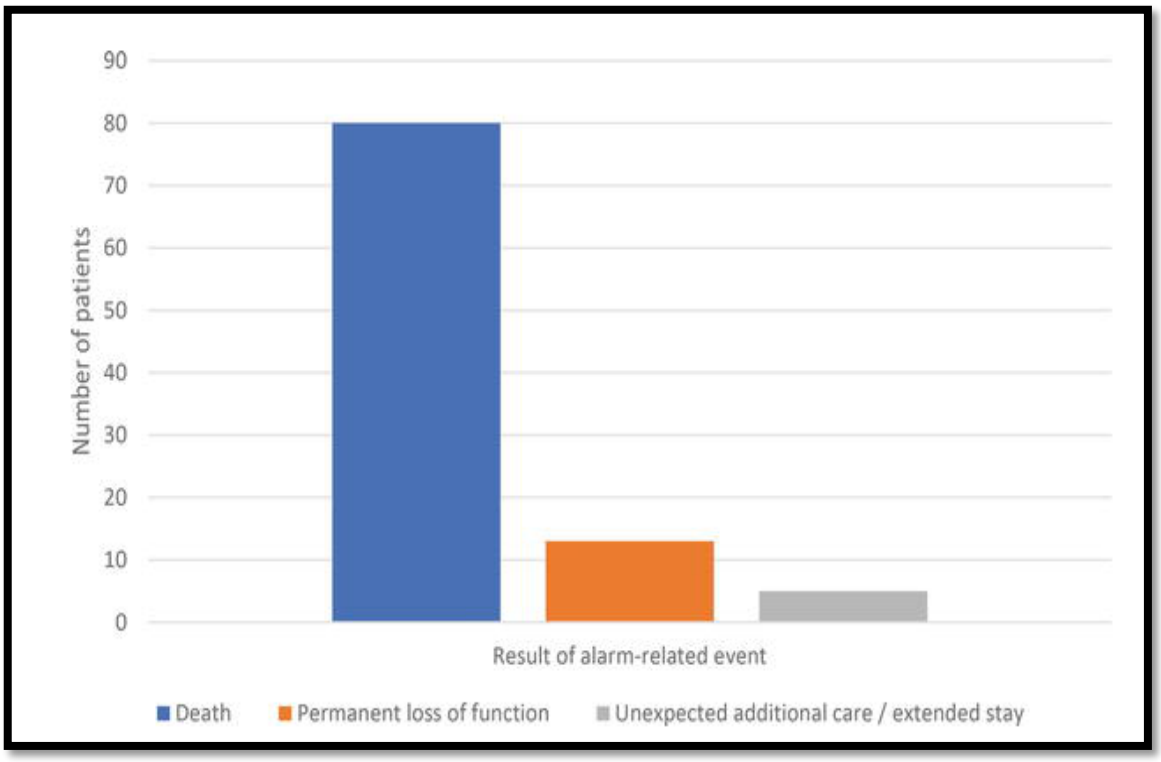
Clinical alarms are top ten health technology hazard, it is consistently appeared as the first or second most critical hazard according to ECRI institution since the first annual published in 2007 (Keller et al., 2011). However, there are instances where the alarm is not set in accordance with the type of patient or the correct treatment area. This is a result of either hospital failing to establish a specific alarm setting protocol or other factors. Or hospitals may have created protocols, but they may not have been understood or adhered to.

The occurrence of alarm fatigue and (subsequent habituation) can be caused by a significant percentage of nonactionable alarms in a typical modern clinical setting. Due to its significant prevalence in almost all healthcare settings AF has been the focus of extensive research. An acknowledged difficulty is the underreporting of alarm-related occurrences; it should be remembered that recorded incidents probably represent a very small fraction of real events. 98 alarm-related incidents were reported between January 2009 and June 2012, according to statistics retrieved from the Joint Commission's

Sentinel Event Database (Nguyen et al., 2019). Figure 1.4 show Alarm-related events and subsequent results from January 2009 to June 2012.

Figure1.4

Alarm related events and subsequent results from Jan 2009 to Jun 2012



Source: Joint Commission's Sentinel Event Database 2013

According to figure 1.4, it's clearly shown that the number of deaths is relatively high due to the alarm fatigue. Furthermore, alarm fatigue is still a critical problem in healthcare settings due to the large number of nonactionable alarms. Underreporting and the possibility for affecting patient safety highlight the need to improve alarm management system and staff training. Continued research and awareness are important to mitigate the risk associated with AF and to ensure timely response to the alarms.

Pre-tests and post-tests were conducted to assess the effectiveness of the alarm management education and changes in nurses' perception and practice of clinical alarms. This study suggests to reinforce the advantages of continuing alarm training for nurses. Nurses who work in a bedside setting are an important part of a multi-disciplinary alarm management team, as they are responsible for patient safety and are most likely to experience alarm fatigue. Although accreditation from organizations such as JCI might be seen by medical facilities as beneficial for improving employee

performance there are few established metrics to assess the effectiveness of the process and results, resulting in a limited amount of proof to ascertain the true effect of hospital accreditation. (Al-Alawy et al., 2021). Also, the study by Al-Alawy et al. (2021) found that in order to verify the potential impact of accreditation on lowering non-compliance and enhancing clinical performance indicators, accreditation performance metrics are required.

Another study by Pater et al. (2020) mention that JCI have developed work procedures in order to improve the patient safety through enhanced clinical alarm management. In their study, they found that it took over a 4 year-period in using technological advances and QI (quality improvement) methodology to reduce successfully the alarm notifications while preserving patient safety. Which clearly indicates that any followed procedure or international accreditation requires a significant period of time to obtain the desired results through time series evaluation of improvement.

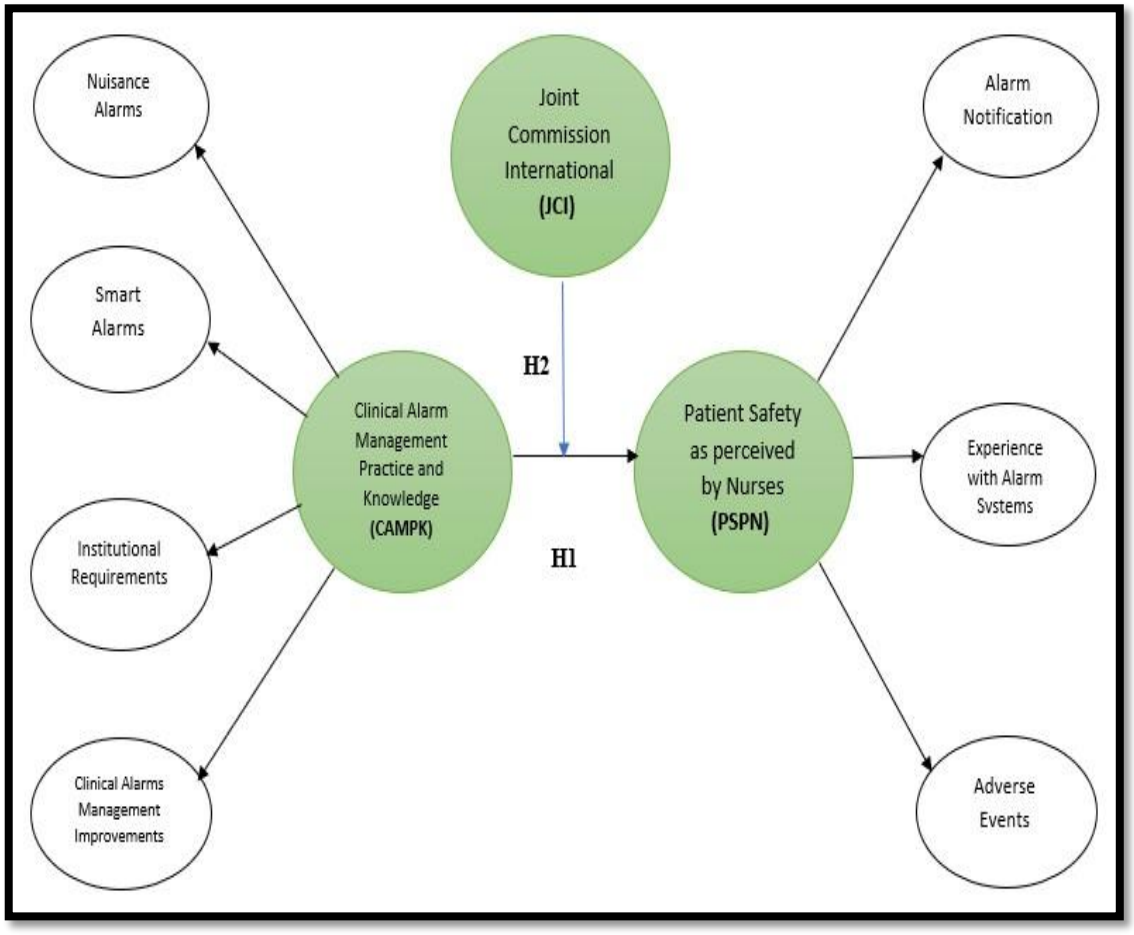
The lag time in regard to the impact of the given program can also be explained through the same literature, as (Melo, 2016) which indicates that there is a need for longitudinal consideration to better understand accreditation outcomes' influence on patient safety perception and the time-dependent nature of accreditation outcomes. The following hypothesis is put forth in light of the lack of research that experimentally examines the moderating effect of JCI on the relation between CAMPK and PSPN in Palestine:

H2: JCI-accreditation have no significant moderating role on the relationship between CAMPK and PSPN in Palestinian hospitals.

Two hypotheses were developed to create the model that is shown in Figure 1.5 based on the discussion that has been offered thus far.

Figure 1.5

Conceptual research model and hypotheses



As presented in above figure, (CAMPK) variable represents nurses understanding and familiarity with clinical alarm systems and disruptions caused by alarms. It is a latent construct that is formed by multiple observable indicators, such as nurses ability to set alarm parameters, recognize alarms signals, implementing alarm improvement initiatives and troubleshoot alarms issues. Therefore, it is reflective construct in nature.

On other side, (PSPN) represents nurses subjective perceptions of patient safety within their healthcare setting. It is a latent construct that is formed by multiple observable indicators, such as the frequency of adverse events and the experience of alarm systems. Therefore, this construct is reflective in nature. In the same way (JCI) represents the accreditation status of healthcare institutions by the Joint Commission International. It is a binary variable indicating the presence or absence of the role of JCI-accreditation. As it is not directly formed by underlying indicators

but rather serves as a categorical moderator, it is considered a formative construct. Finally, the decision of whether to measure a construct reflectively or formatively is not clear-cut (Hair et al., 2011).

Table C.1 in Appendix C presents the overviews of relevant literature and the integrated model's dissection of connected indicators.

Chapter Two

Methodology

2.1 Overview

The research design in this chapter aims to address specific inquiry answers to certain research questions and evaluate and test the suggested theories. It primarily explores the procedures involved in the process of data collecting, selecting participants from specific groups, and designing survey instruments. Since there are almost no studies about the moderating role of JCI on the relationship between CAMPK and PSPN in Palestinian hospitals, exploratory research was established to explore how CAMPK impact PSPN with the moderating effect of JCI.

2.2 Research Approach

Typically, the research topic influences the researcher's choice of the best research methodology to employ in light of the data numerical or textural that are required for the study. According to Creswell (2014) a research approach consists of protocols and plans that cover every stage, from making assumptions to acquiring, analyzing, and interpreting data. Three types of research procedures are frequently employed: mixed methods, qualitative research, and quantitative research. In this research a quantitative technique was chosen whenever the study subject calls for numerical data. The qualitative method was used when the research issue calls for textural data. In order to address the study topic that calls for both numerical and textural data, mixed techniques were used (Williams, 2007).

2.2.1 Quantitative Approach

When using a quantitative approach, researchers usually collect numerical data and analyze it using mathematical models (Williams, 2007). The quantitative approach is "an approach for testing objective theories by examining the relationship among variables," according to Creswell (2014). The researchers employ a deductive method in this technique, beginning with the testing of theory through the use of numerical data and statistical analysis procedures to enable the ability to replicate and apply the findings. According to Creswell (2014), a research report typically includes introduction, hypotheses, procedures and literature, results and conclusion.

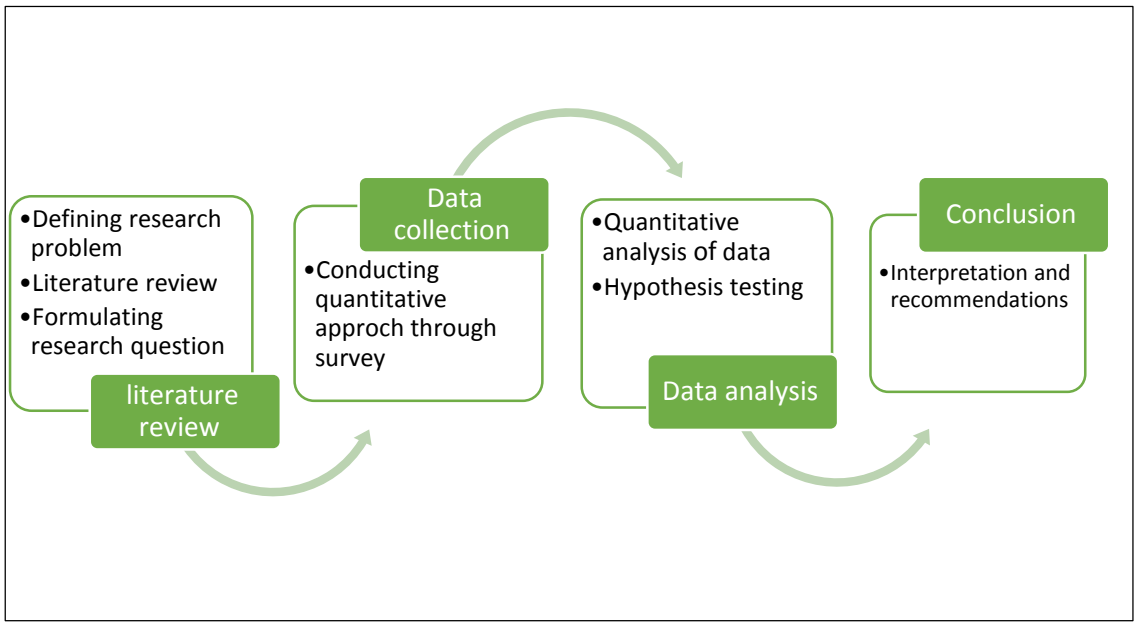
Creswell (2014) concentrated on two main categories of quantitative research methodologies: survey research which offer a statistical overview of population pattern, viewpoints and beliefs by examining a subset through either longitudinal or cross-sectional studies and experimental research which explores the impact of an intervention on a result.

Data for the current study were gathered using a quantitative technique approach. By using this approach, more information was provided about the clinical alarm management expertise and practice of nurses, as well as their duties regarding patient safety and the moderating influence of Joint Commission international standards in the Palestinian healthcare system.

As shown in figure 2.1 the first part was offering a concise overview of the subject matter of the study objectives, purpose of the study and the research problem. After that literature review was done in order to review CAMPK, PSPN and the role of JCI, then formulate hypotheses and research questions. Then, in the second part the data collection was done through an on-line survey (Google form). So, 102 google survey forms were completely done in health sector (private hospitals accredited and not accredited from JCI) in West Bank. The survey participants were full-time registered nurses who provide direct contact with patients in hospitals. The third part, were presents the results and findings and present the hypotheses testing results. The conclusion and suggestions were included in the fourth and last section. Figure 2.1 provides a summary of the research technique used in this study.

Figure 2.1

Research methodology



2.3 Target Population and Sampling Procedure

The Palestinian private hospitals in West Bank in 2024 (including private hospitals with and without JCI accreditation) made up the study population. Private sector hospitals were chosen for this study due to their focus on the quality of health service provided and patient safety and their interest in developing their health staff in terms of professionalism. Finding the minimal sample size needed for surveys and other statistical procedures is essential to extrapolating the findings to the entire population (Saunders et al., 2009).

To obtain a statistically representative sample size of population, the sample size was calculated using G power software, where the effect size = 0.3, the power =0.95, and alpha = 0.05. About 148 participants were needed to perform and complete the study including an attrition rate of 10%. The data was collected from February 2024 to April 2024 through an electronic questionnaire, as mentioned before. A 69% response rate was obtained from 102 valid answers to 148 issued surveys.

2.4 Questionnaire Design

A self-administered questionnaire in the English language was used to collect the data to ensure optimal understanding of the nurses. The HTF 2016 Clinical Alarms Survey was used. The HTF survey has been used in several other studies like Casey et al., (2018); Cho et al. (2016); Jeong and Kim, (2022); Mirhafez et al. (2019) and Petersen and Costanzo, (2017). This instrument consists of two main sections.

The first section seeks demographic information including the type of hospital and critical care department. The second section is for alarm-related information and consists of general statements about clinical alarms and asks respondents to rate their level of agreement with the statements on a five-point Likert scale (Strongly agree to Strongly disagree) and (Yes or No). More specifically, this section consists of seven groups of question which are GROUP 1: Nuisance Alarms (NA), GROUP 2: Experience with Alarm Systems (EAS), GROUP 3: Alarm Notification (AN), GROUP 4: Smart Alarms (SA), GROUP 5: Institutional Requirements (IR), GROUP 6: Clinical Alarms Management Improvements (CAMI) and GROUP 7: Adverse Events (EA). A permission was granted from the HTF to use the instrument and to make adaptations as necessary. (Appendix A) includes the HTF 2016 Clinical Alarms Survey.

2.5 Data Analysis Techniques

To evaluate the relationship between the research models and investigate the outcomes of the proposed hypotheses, partial least squares structural equation modeling (PLS-SEM) was employed. The model utilized both first-and second-order constructs and indications were assigned to each construct using a repeated indicator technique. PLS computations were then carried out to confirm the validity and reliability of the individual indicators as well as the overall model, utilizing the tests and threshold values to evaluate each test. Following that bootstrapping was done to ascertain each relationship's significance in order to assess the hypotheses.

When it comes to model evaluation, Smart PLS has two methodological components. Reliability testing is used to assess the measurement model that includes the reflective model first. where the convergent validity is assessed using the following metrics: average variance extracted (AVE), indicator reliability (item loading) and composite reliability (CR) of internal consistency dependability.

The Fornell-Larcker criterion and cross loadings are included in the discriminant validity test, which is an additional component of the validity test. Moreover, assessing the formative measurement models by the calculation of the indicators' collinearity Variance Inflation Factor (VIF). and verifying the importance of every indication by looking at the outside loading and outer weight.

Second, the structural model is evaluated using the path coefficients (hypotheses test), effect Size (F2), predictive relevance (Q2), and coefficient of determination (R2). Moreover, the research examined the moderating analysis.

Chapter Three

Data Analysis and Results

3.1 Overview

The quantitative data gathered through questionnaires is analyzed and presented in this chapter. The first section examines CAMPK, PSPN and the moderating effect of JCI on the association between clinical alarm management procedures and nurses' perceptions of patient safety. Next the results of descriptive statistics and hypothesis testing using the (PLS-SEM) program are presented in this chapter. This study assesses how clinical alarm management practices currently affect patient safety as perceived by nurses with JCI accreditation playing a moderating role in Palestinian hospitals.

3.2 Questionnaire Analysis

A self-administered questionnaire in the English language was used to collect the data to ensure optimal understanding of the nurses. So, the Survey was used HTF 2016 Clinical Alarms.

To investigate the relationship between CAMPK, PSPN, and the moderating role of JCI on the relationship between clinical alarm management practices and patient safety as perceived by nurses, Smart PLS 3.2.7 program was used.

Smart PLS is a leading software tool for partial least squares structural equation modeling (PLS-SEM). Cho et al. (2009) explained that SEM is a multivariable analysis technique designed to measure cause-and-effect relationship. Additionally, SEM is a useful technique for path modeling and prediction, according to Ali et al. (2018). PLS-SEM particularly useful when the data distribution is unnormal and the size of sample is small. Given the relatively small sample size in this study the PLS-SEM technique was chosen to analyze the data. The analysis was conducted in two main steps:

Step 1: Measurement model assessment, which included validity and reliability analysis.

Step 2: Evaluation of the structural model, involving model parameter determination and hypothesis testing (Hair et al., 2016).

3.2.1 Demographic Analysis Results

The demographic analysis of the data demonstrated that most of the respondents 50% were intensive care unit nurses. The hospitals participating in the survey were divided into two groups, the first of which had an international accreditation certificate JCI and the second of which did not. It was revealed that the two groups participation rates were roughly equal to 50%. On the other hand, participants experience levels on the questionnaire ranged from less than two years to more than ten years, with participants with more than ten years of experience making up the largest percentage 25.5% of the sample. A 69% response rate was obtained from 102 valid answers to 148 distributed questionnaires. Table 3.1 provide a comprehensive summary of the respondents' demographic information.

Table 3.1

Demographic characteristics

Characteristic	Distribution	Frequency (n=102)	Percentage
Facility Accreditation	The Hospital Accredited from Joint Commission International (JCI)	52	51%
	The Hospital Not Accredited from Joint Commission International (JCI)	50	49%
Hospital Department	Emergency Department	7	6.9%
	General Care Area	4	3.9%
	ICU	51	50%
	Labor/Birth	1	1%
	Nursery	13	12.7%
	OR/Anesthesia	1	1%
	Other	24	24%
	Progressive Care/Tel	1	1%
Job Title	LPN (licensed practical nurse)	5	4.9%
	Nurse's Aide or Orderly	4	3.9%
	Others	3	2.9%
	RN (Registered nurse)	90	88.2%
Number of years of healthcare experience	Less than 2 years	9	8.8%
	2 to less than 4 years	20	19.6%
	4 to less than 6 years	20	19.6%
	6 to less than 8 years	15	14.7%
	8 to less than 10 years	12	11.8%
	10 years or more	26	25.5%

3.2.2 Assessment of Constructs Implementation

A general description was used to evaluate the level of implementation of CAMPK and PSPN and the moderating role of JCI (Joint Commission International) on the relationship between clinical alarm management practices and patient safety as perceived by nurses in Palestinian hospitals in West Bank. The Likert scale was set at five points: (1) for "strongly agree & agree" (2) for "neutral" and (3) for "strongly disagree & disagree." Each latent variables implementation level was determined by grading the responses into three equal categories. These scores were determined by dividing the number of levels (i.e., three levels) on the Likert scale by the response range (1 for "strongly agree" minus 3 for "strongly disagree"). The following formula represent this calculation $(3 - 1) / 3 = 0.66$. Table 3.2 display the intervals together with the corresponding level of implementation.

Table 3.2

Intervals of levels of implementation

Interval	Level of implementation
1 - 1.66	High
1.67 - 2.33	Moderate
2.34 - 3	Low

Table 3.3 demonstrates the level of implementation in descending order. The results show that overall mean implementation levels for CAMPK, PSPN and the moderating role of JCI were 1.556, 1.551 and 1.33 respectively. These results show a high level of implementation for both CAMPK and PSPN as well as a high level of implementation for JCI.

For CAMPK, the utilization of smart alarm systems in healthcare settings has the highest level with 1.392, followed by nuisance alarms experienced by nurses in clinical settings 1.441, Clinical Alarms Management Improvements 1.651 and institutional requirements to be implemented at the lowest level (1.740). In terms of Patient Safety as perceived by Nurses, the methods used by healthcare institutions to notify staff of alarm conditions has the highest level with 1.443, followed by Experience with Alarm Systems by nurses which influence their effectiveness in patient safety with 1.445 and

Adverse Events to have the lowest level with 1.764. For the moderating role of JCI, the results revealed that the accreditation status of healthcare institutions have a high level with 1.333.

Table 3.3

Level of implementation of the CAMPK, PSPN, and the moderating role of JCI

Construct	Mean	Standard deviation	Level of implementation
Total for Clinical Alarm Management practices & knowledge (CAMPK)	1.556	0.784	High
Nuisance Alarms	1.441	0.718	High
Smart Alarms	1.392	0.674	High
Institutional Requirements	1.74	0.893	Moderate
Clinical Alarms Management Improvements	1.651	0.854	High
Total for Patient Safety as perceived by Nurses (PSPN)	1.551	0.777	High
Alarm Notification	1.443	0.729	High
Experience with Alarm Systems	1.445	0.724	High
Adverse Events	1.764	0.88	Moderate
Total for JCI (Joint Commission International)	1.333	0.568	High

3.2.3 Assessment of the Measurement Model

The relationship between the indicators and their construct, which is investigated using confirmatory factor analysis (CFA), is studied using the measurement model. According to Hair et al. (2016), evaluating the construct's validity and reliability is essential for evaluating the reflective measurement approach. The overall measure consistency, which ensures that the experiment will provide the same results when repeated under the same conditions is referred to as "reliability" by Sekaran and Bougie (2010). Sekaran and Bougie (2010) define validity as the extent to which a variable captures the intended meaning. Assessing the reflective measurement model's validity, dependability, and internal consistency is its goal.

Cronbach's alpha and composite reliability are used to assess internal consistency and convergent and discriminant validity are used to measure validity. Construct reliability is measured by composite reliability (CR), with a CR value above 0.708 seen as a positive indicator (0.6-0.7 is deemed acceptable in exploratory research). (Hair and others, 2011). As shown in the table below, Table C.2 in Appendix C presents the findings of the reliability and validity analysis. All of the constructs are deemed reliable because their CR values above 0.743. The internal consistency is thus deemed acceptable. Additionally internal consistency is measured using Cronbachs alpha. according to Hansjosten (2015), Internal consistency description based on Cronbach's alpha test ($\alpha < 0.5$ Unacceptable, $0.5 \leq \alpha < 0.7$ Acceptable, $0.7 \leq \alpha < 0.9$ Good, $\alpha \geq 0.9$ Excellent).

As shown in Table C.2, the Cronbach's alpha value for all constructs ranges from (0.549 - 0.814), therefore internal consistency is approved.

Analyses of discriminate and convergent validity are used to evaluate the validity of the indicators and their construct. "The degree to which a measure correlates positively with alternative measures of the same construct" is the definition of convergent validity (Hair et al., 2016, p.137). Convergent validity is quantified using average variance extracted (AVE), which is calculated by calculating average squared indicator loading. The AVE value needs to be more than 0.5 in order to validate the construct's validity (Hair et al., 2011)

The outer loading denotes the extent to which an item contributes to its construct; it is commonly known as indication reliability. Hair et al. (2016) state that the loading of the components ought to be more than 0.7. The items loading ranged from (0.609-1.00), as shown in Table C.2, indicating an acceptable degree of indication dependability, except items (IR3) and (EAS4) which is the outer loading is below 0.7 (IR3 = 0.402, EAS4 = 0.571) but still the total (CR) values for the constructs (Institutional requirement & Experience with Alarm Systems) in the acceptable range as shown in Table C.2. Thus, the internal consistency value are acceptable.

As shown in Table C.2, the AVE value for all constructs ranges from (0.474 - 0.746) therefore convergent validity is approved. The relation between the indicators in various constructs was demonstrated by discriminant validity.

3.2.3.1 Discriminant validity

Fornell and Larcker (1981) explained that discriminant validity can be assessed by calculating the square root of the average variance extracted (AVE) for a construct. This value should be higher than the correlations between the construct and any other constructs. Furthermore, discriminant validity test is employed to ascertain the degree to which a particular construct differs from others and guarantees that the construct is distinct and encompasses facets of the phenomenon that are not reflected by other constructs within the model (Hair et al., 2011). As shown in Table 3.4 the square root of the AVE for each construct is higher than its correlations with other constructs which confirming discriminant validity.

Table 3.4

Discriminant validity check

Construct	AE	AN	CAMI	EAS	IR	NA	SA
AE	1.000						
AN	0.203	0.724					
CAMI	0.300	0.421	0.864				
EAS	0.080	0.578	0.186	0.689			
IR	0.149	0.248	0.508	0.166	0.715		
NA	0.159	0.331	0.106	0.572	0.008	0.803	
SA	0.171	0.664	0.469	0.536	0.282	0.214	0.758

(square root of AVE is shown on the diagonal in bold)

The multi-collinearity factor was measured by using the variance inflation factor (VIF). Table 3.5 illustrates the variance inflation values of first -order constructs for Clinical Alarm Management practices & knowledge (CAMPK). As per Brien (2007) threshold of 10, the VIF value for every factor in the result indicates the absence of multi-collinearity.

Table 3.5

Assessment of independent variable

Second-order construct	First-order construct	VIF
CAMPK	CAMI	1
	IR	1
	NA	1
	SA	1

3.2.4 Assessment of the Structural model

Analyzing the structural model comes next following validation of the reflective measurement model. It is crucial to assess the outcome of the structural models in order to verify our theory. The connections and theories between the constructs are depicted in the structural model sometimes referred to as the inner model. Evaluation of four essential elements is the main goal of structural assessment: the effect size (f^2), path coefficients (β value) and their T-statistics the coefficient of determination (R^2), and the model's predictive relevance (Q^2).

The first step in assessing the structural model is to examine the coefficient of determination (R^2) which indicates the extent to which variation in an endogenous construct is explained by its associated predictors. According to Hair et al. (2011), R^2 values of 0.75, 0.50 and 0.25 are considered high, moderate and weak respectively. The R2 value for PSPN is 0.453 which is classified as moderate as Table 3.6 illustrates. This indicates that the predictor CAMPK accounts for 45.1% of the variance in PSPN. It's crucial to take the Stone-Geisser Q^2 criterion into account in addition to assessing the R2 value. By measuring how well the path model can predict the endogenous variable the Q^2 value of which is ascertained through the blindfolding process this metric illustrates the predictive relevance of the model.

A Q^2 value larger than zero for a reflecting endogenous construct indicates, in accordance with Hair et al. (2011) recommendations, that the exogenous constructions have predictive importance for that specific construct. The Q2 value for PSPN is 0.458, as can be seen in Table 3.6, suggesting that the model has predictive relevance. In addition to the R^2 and Q^2 values, the effect size (f^2) must be computed. In order to

evaluate the extent to which a predictor explains the endogenous construct, the f^2 calculates the effect of each external latent variable on the endogenous construct. According to Cohen (1988) the predictor variable's minor, medium, and large impacts are represented by f^2 values of 0.02, 0.15, and 0.35, respectively. As reported in Table 3.6, the f^2 values for CAMPK and JCI in explaining the endogenous variable PSPN are 0.278 and 0.060, respectively. Thus, the effect size of CAMPK on PSPN is medium, while that of JCI (moderator) on PSPN is small.

Table 3.6

Results of R^2, f^2 and Q^2 value

Construct	$R^2_{adjusted}$	Q^2	f^2 PSPN
CAMPK	-	-	0.278 (medium)
PSPN	0.453(moderate)	0.458	-
JCI (Moderator)	-	-	0.060 (small)

3.2.4.1 Hypotheses Testing Results

The current study aims to explore the effect of CAMPK on Patient Safety as PSPN, and the moderating role of JCI on the relationship between clinical alarm management practices and patient safety as perceived by nurses in Palestinian hospitals in West Bank. Standardized path coefficient (β-values) must be examined in order to evaluate the degree of relationship between the latent variables. This can be accomplished by applying factor analysis as the weighting scheme and executing the PLS algorithm with the default 300 iterations. According to Hair et al. (2016) the β-values should range from -1 to +1 with values nearer +1 (or -1) signifying a stronger relationship. The PLS algorithm results for the research model are shown in Figure 8.

The bootstrapping technique was done with 500 subsamples as the default setting in order to get the t-value which was used to test the hypotheses and confirm the significance of the correlations between the constructs. A relationship is deemed significant, according Hair et al. (2016) if the p-value is less than 0.05 and the t-value is equal to or greater than 1.96 at the 5% significance level (two-tailed). Table 3.8 presents the results which demonstrate that CAMPK significantly improves PSPN ($\beta = 0.511$, $t = 2.906$, p-value = 0.004). Consequently, hypothesis H1,1 is confirmed. This result

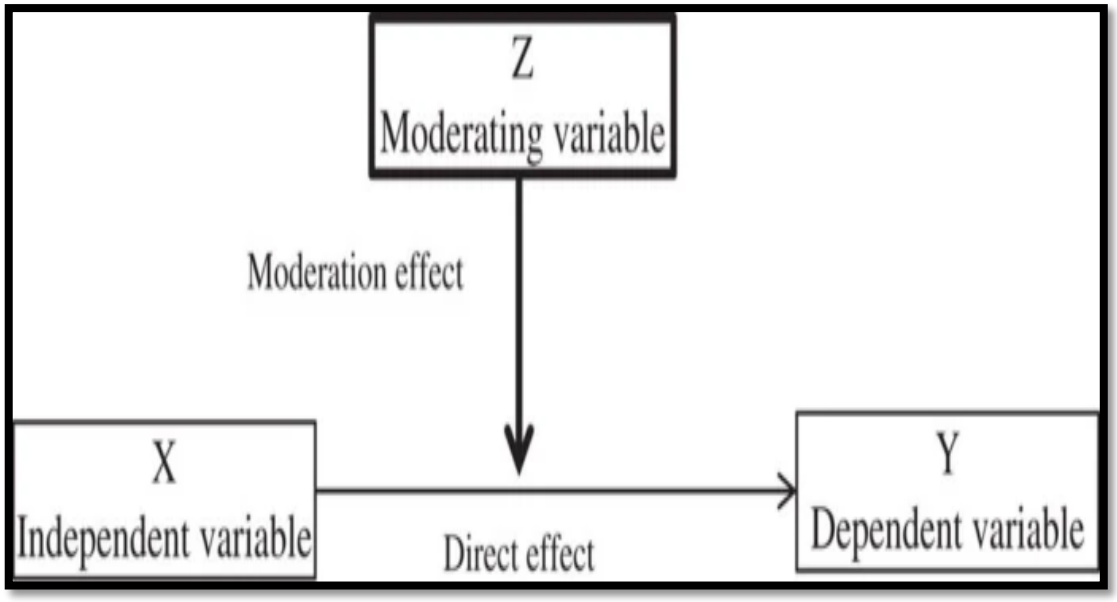
complies with study of Alsuyayfi & Alanazi (2022) which used the same tool for this research *(Healthcare Technology Foundation (HTF) clinical alarm survey among clinical nurses)* and also found that patient safety is directly related to the proper use of the alarm system and Nurses' perceptions and practices regarding alarms can be improved considerably by promoting evidence-based practice through development of proper procedures, policies and appropriate training.

3.3 Moderating test

According to Andersson et al. (2014) the general moderating model presented in Figure 3.1

Figure 3.1

Typical relationships in a within - level moderation model



Source: Andersson et al. (2014)

The current study found that JCI moderate the connection between PSPN and CAMPK. H2 is therefore suggested. The structural equation model (SEM) offers an understanding of the relationship between Clinical Alarm Management practices & knowledge (CAMPK), Patient Safety as perceived by Nurses (PSPN), and the moderating role of JCI.

The analysis reveals a statistically significant effect of Clinical Alarm Management practices & knowledge (CAMPK) on Patient Safety as perceived by Nurses (PSPN) with a path coefficient of 0.511. This show that for every one-unit increase in CAMPK,

PSPN is expected to increase by 0.511 units, show a strong relationship. The T-statistic of 2.906 underscores the strength of this relationship while the p-value of 0.004 < 0.05 confirms its significant. As shown in Table 3.7, The effect size **(f^2)** of 0.278 indicates that Clinical Alarm Management practices & knowledge (CAMPK) approximately 27.8% of the variance in Patient Safety as perceived by Nurses (PSPN)levels, indicating a moderate effect size.

In addition, the effect of JCI on Patient Safety as perceived by Nurses (PSPN) appears weaker. The path coefficient of 0.023 suggests a small direct effect, implying that changes in JCI have a relatively little impact on PSPN concentrations. This effect fails to achieve statistical significance, as evidenced by the T-statistic of 0.912 and the relatively high p-value of 0.362. Additionally, the negligible effect size **(f^2)** of 0.000 indicates that JCI explains virtually none of the variance in Patient Safety as perceived by Nurses PSPN levels.

Then the interaction effect between JCI and CAMPK, PSPN is tested, which show in Table 3.8 that the path coefficient value is 0.149. Although this interaction demonstrates a positive association, it fails to reach statistical significance, as indicated by the T-statistic of 0.698 and the p-value of 0.486. The effect size (f-Square) of 0.060 suggests that the interaction between JCI and CAMPK accounts for only approximately 6.0% of the variance in PSPN levels, which is relatively small compared to the direct effect of CAMPK. Therefore, H2,0 is supported.

Table 3.7

Results of the structure equation model

RELATIONSHIP	B-VALUE	T-STATISTIC	P-VALUE	F-SQUARE
CAMPK -> PSPN	0.511	2.906	0.004	0.278
JCI -> PSPN	0.023	0.912	0.362	0.000
JCI X CAMPK -> PSPN	0.149	0.698	0.486	0.060

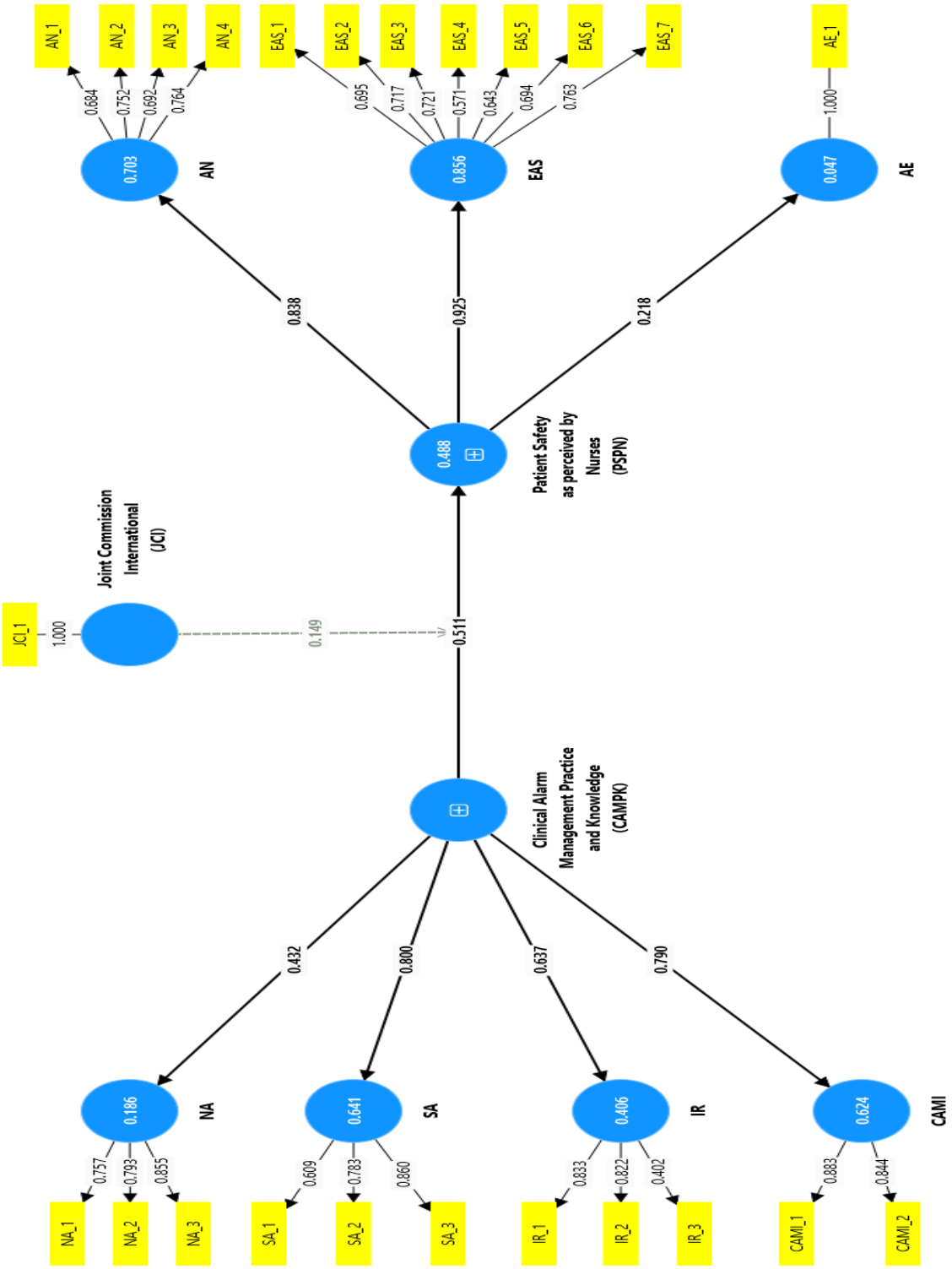
Table 3.8

Hypothesis testing results

PATH	HYPOTHESIS	B-VALUE	T- VALUE	P-VALUE	DECISION
CAMPK→PSPN	H1,1	0.511	2.906	0.004	Supported
JCI X CAMPK -> PSPN	Moderation H2,0	0.149	0.698	0.486	Supported

Figure 3.2

The results of PLS - algorithm for research model



Chapter Four

Discussion and Conclusion

4.1 Overview

The present chapter proceeds to the in-depth discussion of the results obtained during the research on CAMPK and PSPN and the moderating role of JCI within Palestinian hospitals. As it has been pointed out in the Chapter 4, the study, which relied on the use of (PLS-SEM), focused on the revelation of how much Clinical Alarm Management Practices and Knowledge can affect the Patient Safety as perceived by Nurses and how the JCI accreditation can moderate these connections.

The findings inferences allow suggesting important aspects about the effectiveness of the present practices. Finally, the present chapter emphasizes the increased need to develop strategies form patient safety improvement and JCI certification maximization when cooperating with Palestinian healthcare facilities.

4.2 Discussion

The analysis of the data collected has provided several salient findings about Clinical Alarm Management Practices and Knowledge and Patient Safety as perceived by Nurses and the moderating role of Joint Commission International accreditation. Primarily, looking at demographic data indicates that the participants in this survey were very diverse. First, there was an equal number of respondents from JCI-accredited hospitals and non-accredited ones. Second, there were considerable differences in the experience of nurses in terms of work.

Study has shown that Clinical Alarm Management Practices and Knowledge significantly improve perceptions of patient safety by nurses. However, this result is similar to prior research by Alsuyayfi and Alanazi (2022), who found that nurses' perceptions of safety may be greatly enhanced through systematic training and efficient planning and highlighted that appropriate clinical alarm management is crucial for patient safety.

Furthermore, the results showed that nuisance alarms and the use of smart alarm systems are major and important elements of CAMPK that impact PSPN. Nuisance alarms, which interrupt patient care, but generate distrust to the alarm systems, were one

of the most significant elements and problems. However, smart alarm systems, which do not trigger false alarms, are the most extensively used element or the most highly implemented one, which proves their effectiveness in raising and improving patient safety. This goes well with the previous findings that the alarm systems should be optimized and the pointless notifications should be kept low in order to let the therapy become more effective. (Cvach, 2012; Funk et al., 2014).

We also analyzed the moderating influence of JCI accreditation. Despite having a fairly high degree of implementation, JCI accreditation had the minimum statistically significant effect on nurses' perception of patient safety. The effect of the relationship between Clinical Alarm Management Practices and Knowledge on JCI certification was not statistically significant, while it had a favorable influence on PSPN. Therefore, this suggests that the relationship between PSPN and CAMPK is not affected by JCI accreditation even though it offers advantages. Previous studies show that enhancing patient safety calls for comprehensive solutions rather than just accreditation.

In addition, one should consider the Palestinian hospital context, where JCI is among the newest accreditation programs. The insignificant impact of the degree of JCI accreditation implementation on the particular latent variable PSPN can be justified by the specificities of the implementation of a new type of accreditation. The nature of the JCI accreditation, as well as the content and type of its implementation, are still quite new for the Palestinian hospitals, which is why it can take more time for it to use all advantages of the achievement of this level. The lag time in regard to the impact of the given program can also be explained through the same literature, as Melo (2016) writes that the specificities of the relationship between the accreditation achievement and the improved clinical measures or perception of safety require some time to manifest.

To provide effective means of improving patient safety it is necessary to continue evaluating and adjusting the clinical alarm management and knowledge management as well as accrediting procedures. Health care institutions will increase the efficiency with which they are able to help the nurses with their vital task of ensuring the patient safety by addressing the immediate problems caused by the nuisance alarms as well as aiming for the long-term objective of maximizing accreditation impact.

4.3 Conclusions

The study's conclusion provides data highlighting the importance of effective Clinical Alarm Management Practices and Knowledge (CAMPK) in enhancing nurses' perceptions of patient safety (PSPN). Our findings emerge to the surface the necessity of reducing annoying alarms and utilizing smart alarm systems technologies to produce noticeable improvements in patient safety outcomes. Although Joint Commission International Accreditation (JCI) has an admirably high implementation level in the setting under study, it doesn't seem to play much of a moderating function between CAMPK and PSPN.

In earlier research, Alsuyayfi and Alanazi (2022) note the importance of structured training and policy frameworks in supporting nurses' safety perceptions. Consistently, CAMPK could improve. Simultaneously, the recognition of such alerts as an important issue seems noteworthy given the body of research that pays much attention to the negative outcomes of alarm fatigue for patient care results (Cvach, 2012) (Braithwaite et al., 2015). At the same time, the importance of smart alarm systems technologies for reducing false alarms and increasing responses of clinical staff is evident; for instance, Funk et al.(2014) in their work stress the value of new technology in improving nurse practitioners' perception of patient safety.

Although we commend the progress made in JCI accreditation implementation, our research suggests that a more comprehensive analysis of its impact on the CAMPK and PSPN moderates is needed. The minimal impact observed highlight the complexity present in accreditor standards must be evaluated and how well it connects with frontline clinical practice. Our results indicate that the observed minimal moderation impact could be the lack of influence for these experiences. Our idea is consistent with the study by Melo (2016) which indicates there is a need for longitudinal consideration to better understand accreditation outcomes' influence on patient safety perception and the time-dependent nature of accreditation outcomes.

In conclusion, the current research underscores the multidimensional nature of the process associated with enhancing nurses' patient safety perceptions in healthcare settings. Thus, a balanced approach that aims at a synthesis between the best practices of clinical staff, technology, and the framework created by accrediting agencies is

required. The results of the study provide the tools for healthcare policymakers and administrators as well as clinical staff involved in developing patient safety programs in the altered clinical settings, allowing one to comprehend the link between CAMPK, PSPN, and JCI accreditation.

4.4 Practical Implications

This study has critical practical consequences for policymakers, administrators and other stakeholders in the healthcare. Firstly, the importance of funding organized clinical alarm management procedures cannot be underestimated. The study results demonstrate the ways to maximize patient safety at hospitals and other healthcare facilities by prioritizing activities and practices that try to reduce the amount of nuisance alarms and apply new technologies of smart alarms systems. By solving these issues, facilities will be able to change nurses' perception of patient safety, thus, increasing alertness and preventability in risk management.

Although international accreditation standards, like those set by the JCI, are admirable, our research implies that JCI might have a limited effect on enhancing the association between clinical alarm management practices and perceptions of patients' safety. As a result, it is advisable to suggest that healthcare facilities develop their program by combining compliance with regulatory requirements with dedicated actions to strengthen clinical alarm management policies and procedures.

On the other hand, it should be noted that since Palestinian hospitals have only recently started engaging in joint commission international accreditation, accreditation procedures need to be reviewed and modified continually. Administrators need to be more involved in quality improvement projects to address any existing gaps preventing patient safety goals from being met and establish the alignment between accreditation standards and clinical practice on the ground.

The important role of healthcare providers, especially nurses, is essential in guaranteeing the efficient implementation of clinical alarm management protocols and procedures. As a result, Specialized training courses ought to be created to provide nurses with the abilities, skills and information they need to operate the smart alarm systems and interacting suitably with healthcare alerts.

4.5 Theoretical Implications

By providing empirical data, this research contributes to the current literature on the critical importance of effective clinical alarm management. It confirms that there is a scientific evidence base in the theory that structured and properly applied alarm management practices lead to nurses' better perceiving patient safety. In addition, the result allows claiming the importance of international accreditation standards, such as the Joint Commission International; however, they may have limited direct influence on improving the relationship between alarm management practices and patient safety perception.

These findings are consistent with theoretical perspectives that emphasize patient security improvement is complex and multifaceted, considering how organizational policies and frontline activity mirror one another, as well as the question of regulatory agency frameworks warranting further thought (Braithwaite et al., 2015). Our study verifies these theoretical assumptions in practice, and provides a deeper insight into the interactions at work within patients' perceptions of their own security. More importantly, it also highlights an urgent need for customized methods which incorporate into this picture not only regulatory requirement fulfillment but also actual frontline medical intervention techniques.

4.6 Limitations and Future Research

Similar to other researches, the present study has some limitations. First of all, despite it being adequate for carrying out PLS-SEM work the size of the sample was around (70 %), Which might alter the generalizability of results. Future studies can use a larger sample size to further validate these results.

In future research it is recommended to study how installation of advanced alarm systems and ongoing training programs in Palestinian hospitals changes patient safety as perceived by nurses over time. A helpful way to get a more comprehensive picture of those variables affecting the relationship between nurses perceptions of patient safety and clinical alarm management practices or knowledge would be for further research into other potential moderating variables like organizational culture or staff involvement level.

Also, Joint Commission International accreditation standards (JCIA) is relatively new in this region, and present a great opportunity to explore its long-term effects on clinical practices, patient safety outcomes and perceptions among healthcare practitioners.

In conclusion, this study support a comprehensive strategy that integrate clinical alarm management procedures and regulatory compliance to improve patient safety as perceived by healthcare providers. Healthcare organizations can raise patient safety perception and eventually improve the quality of care delivery by implementing evidence based way to improve clinical alarm management and coordinating joint commission international accreditation efforts with corporate goal.

List of Abbreviations

Abbreviation	Meaning
CAMPK	Clinical Alarm management practice and knowledge
PSPN	Patient safety as perceived by nurses
JCI	Joint commission international
JCIA	Joint commission international accreditation
PLS-SEM	Partial least squares structural equation modeling
HTF	Health technology foundation
NPSG	National patient safety goal
NA	Nuisance Alarms
SA	Smart Alarm
CAMI	Clinical Alarm management improvement
IR	Institutional requirement
AN	Alarm Notification
EAS	Experiences with alarm systems
AE	Advertising Events
CR	Composite Reliability
AVE	Average Variance Extracted
VIF	Variance Inflation Factor
WHO	World Health Organization
ECRI	Emergency Care Research Institute’s

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Appendices

Appendix A

Questionnaire

HTF 2016 Clinical Alarms Survey

This survey has two sections: A. Work-related demographics and B. Alarm-related information, with a total of 37 multiple choice and free-text questions. Please base your answers to questions on your own experience. It should take you no more than 15 minutes to complete the survey.

Participation in this study is completely voluntary. This anonymous survey does not track participant information or IP address. No identifiable information will be obtained.

You should not expect any direct benefit as a result of participating in this research, and you will not be compensated for your participation. The results of this survey will help to inform the healthcare community about the current status of issues related to clinical alarms and perhaps provide ideas for targeted areas for improvement.

A. WORK-RELATED DEMOGRAPHICS

1. Facility Type: Facility Type:

- o Acute Care Hospital
- o Ambulatory Care Facility or Surgery Center
- o Home Care
- o Long-term Care/Nursing Home
- o Other (please specify)

2. Hospital department (if applicable):

- o ICU
- o Progressive Care/Telemetry Unit
- o Emergency Department
- o OR/Anesthesia
- o Labor/Birth
- o Nursery
- o Respiratory Care
- o General Care Area

- Risk/Safety Management
- Support Services
- Healthcare Technology Management/Clinical Engineering
- Other (please specify)

3. Job title:

- RN
- LPN
- Respiratory Therapist
- Physician
- Nurse's Aide or Orderly
- Paramedical e.g. Radiology/Laboratory/Pharmacy
- Monitor Watcher
- Information Technology
- Clinical Engineer
- BMET
- Other (please specify)

4. Are you a manager or administrator?

- Yes
- No

5. Number of years of healthcare experience:

B. ALARM-RELATED INFORMATION

The remaining questions elicit alarm-related information and your opinions. These questions are divided into seven groups, with a box for your comments at the end of each group of questions. There is also an opportunity for you to provide general comments at the end of the survey.

GROUP 1: Nuisance Alarms

Nuisance alarms include both false and non-actionable alarms. False alarms occur when there is no valid triggering event, whereas non-actionable alarms correctly sound, but for an event for which no clinical intervention or action would be taken.

6. Nuisance alarms occur frequently:

- Strongly agree

- Agree
- Neutral
- Disagree
- Strongly disagree

7. Nuisance alarms disrupt patient care:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

8. Nuisance alarms reduce trust in alarms and cause care givers to inappropriately turn alarms off at times other than during setup or procedures:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

9. Comments regarding Nuisance Alarms:

GROUP 2: Experience with Alarm Systems

10. Properly setting alarm parameters and alerts is overly complex in existing devices:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

11. Newer monitoring systems (e.g., less than three years old) have solved most of the previous problems we experienced with clinical alarms:

- Strongly agree
- Agree

- Neutral
- Disagree
- Strongly disagree

12. The alarms used on my floor/area of the hospital are adequate to alert staff of potential or actual changes in a patient's condition:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

13. There have been frequent instances where alarms could not be heard and were missed:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

14. Clinical staff is sensitive to alarms and responds quickly:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

15. When a number of devices are used with a patient, it can be confusing to determine which device is in an alarm condition:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

16. Background noise has interfered with alarm recognition:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

17. Comments regarding Experience with Alarm Systems:

GROUP 3: Alarm Notification

18. Does your hospital use alarm notification systems such as pagers, cell phones, or other wireless devices to communicate alarm conditions?

- Yes
- No
- Not sure

19. Alarm integration and communication systems using pagers, cell phones, or other wireless devices are useful for improving alarm management and response:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

20. Does your institution use "monitor watchers" in a central viewing area to observe and communicate alarm conditions to caregivers?

- Yes
- No
- Not sure

21. Central alarm management staff (“monitor watchers”) responsible for receiving alarm messages and alerting appropriate staff is helpful:

Strongly agree

- Agree
- Neutral

- Disagree
- Strongly disagree

22. Comments regarding Alarm Notification:

GROUP 4: Smart Alarms

23. Does your institution use systems that employ smart alarms (e.g., where multiple parameters, rate of change of parameters, and signal quality, are automatically assessed in their entirety)?

- Yes
- No
- Not sure

24. Smart alarms (e.g., where multiple parameters, rate of change of parameters, and signal quality, are automatically assessed in their entirety) would be effective to use for reducing false alarms:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

25. Smart alarms (e.g., where multiple parameters, rate of change of parameters, and signal quality, are automatically assessed in their entirety) would be effective to use for improving clinical response to important patient alarms:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

26. Comments regarding Smart Alarms:

GROUP 5: Institutional Requirements

27. If you are responsible for clinical alarms, have you been educated on the purpose and proper operation of alarm systems?

- Yes
- No

- Not sure

28. Is there a requirement in your institution/unit to document that the alarms are set and are appropriate for each patient?

- Yes
- No
- No sure

29. Clinical policies and procedures regarding alarm management are effectively used in my facility:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

30. Comments regarding Institutional Requirements:

GROUP 6: Clinical Alarms Management Improvements

31. Has your institution developed clinical alarm improvement initiatives over the past two years (e.g. policies and procedures, education, special projects, new technology)?

- Yes
- No
- Not sure

32. Has your institution instituted new technological solutions to improve clinical alarm safety?

- Yes
- No
- Not sure

33. Comments regarding Clinical Alarms Management Improvements:

GROUP 7: Adverse Events

34. Has your institution experienced adverse patient events in the last two years related to clinical alarm problems?

- Yes

- No
- Not sure

35. The Joint Commission's National Patient Safety Goal on Alarm Management that became effective in 2014 has reduced adverse patient events:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

36. Comments regarding Adverse Events:

37. General Comments:

Appendix B

Approvals

IRB Approval

An-Najah National
University
Faculty of Medicine &
Health Sciences
Institutional Review Board

جامعة النجاح الوطنية
كلية الطب وعلوم الصحة
لجنة اخلاقي البحث العلمي

Ref: Mas. March 2024/24

IRB Approval Letter

Title of Research:

Assessing the impact of clinical alarm management practices on patient 's safety as perceived by nurses: The moderating role of JCI-accreditation

Submitted by:
Fadi Abdelhadi

Supervisor:
Dr. Yahya Salahat

Approved:
21st March. 2024

Your Study Title "**Assessing the impact of clinical alarm management practices on patient 's safety as perceived by nurses: The moderating role of JCI-accreditation.**" reviewed by An-Najah National University IRB committee and was approved on 21st March 2024.

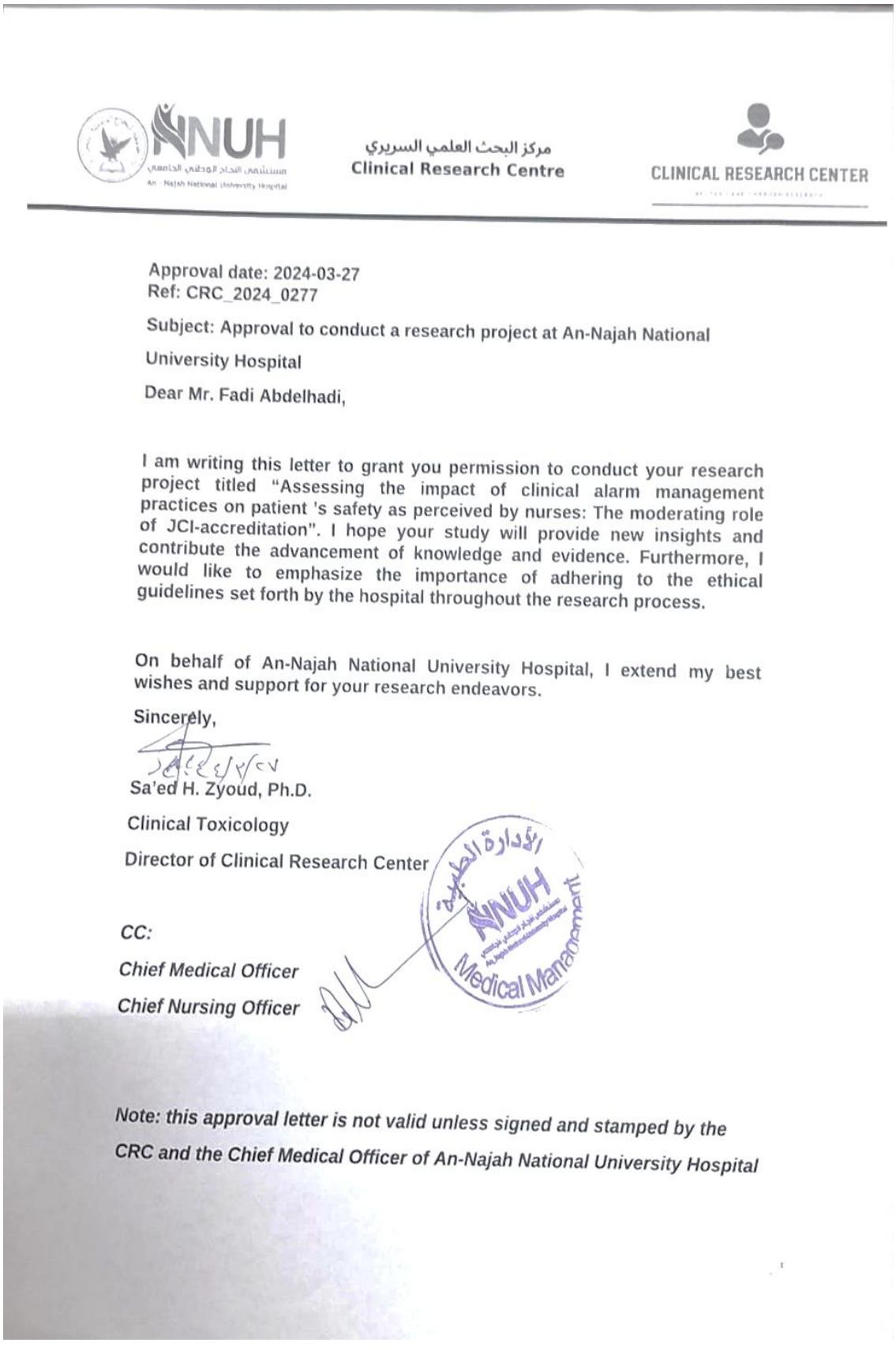
Hasan Fitian, MD

IRB Committee Chairman

IRB
Institutional Review Board

Nablus - P.O Box :7 or 707 | Tel (970) (09) 2342902/4/7/8/14 | Faximile (970) (09) 2342910| E-mail : IRB@najah.edu

NNUH - Clinical Research Center Approval



مركز البحث العلمي السريري
Clinical Research Centre

CLINICAL RESEARCH CENTER

Approval date: 2024-03-27
Ref: CRC_2024_0277

Subject: Approval to conduct a research project at An-Najah National University Hospital

Dear Mr. Fadi Abdelhadi,

I am writing this letter to grant you permission to conduct your research project titled "Assessing the impact of clinical alarm management practices on patient 's safety as perceived by nurses: The moderating role of JCI-accreditation". I hope your study will provide new insights and contribute the advancement of knowledge and evidence. Furthermore, I would like to emphasize the importance of adhering to the ethical guidelines set forth by the hospital throughout the research process.

On behalf of An-Najah National University Hospital, I extend my best wishes and support for your research endeavors.

Sincerely,

Sa'ed H. Zyoud, Ph.D.
Clinical Toxicology
Director of Clinical Research Center

CC:
Chief Medical Officer
Chief Nursing Officer

Note: this approval letter is not valid unless signed and stamped by the CRC and the Chief Medical Officer of An-Najah National University Hospital

Policy-2016 Alarm Survey Usage GCEA

HTF Healthcare Technology FOUNDATION

GLOBAL CLINICAL ENGINEERING ALLIANCE

2016 Alarm Survey and Data Usage

The 2016 Alarms Survey is the exclusive property of the Healthcare Technology Foundation. We encourage the utilization of this asset to further the improvement and research into alarm issues. The survey, beyond that which has already been made publicly available, may be provided to interested parties subject to the following conditions:

1. A nominal donation is made to HTF. Please see https://www.globalcea.org/htf-home?hsLang=en for donation instructions or contact the HTF Treasurer at treas@thehtf.org.

2. A brief specific proposal must be submitted to HTF stating the intended use of the survey.

3. Anyone receiving the survey must agree that:

   i. it will be used only for the originally proposed purpose
   ii. it will not be shared with anyone else except through publicly accessible publications or presentations
   iii. any publications or presentations based on the survey will include a clear acknowledgement that the source of the survey is the Healthcare Technology Foundation

Proposals to access the survey, including specific agreement to the above terms, may be made in writing to the HTF President.

PROPOSAL

Title of thesis: Assessing the impact of clinical alarm management practices on patient 's safety as perceived by nurses: The moderating role of JCI-accreditation

A cross-sectional, descriptive study design is adopted to assess the level of awareness about clinical alarm system among nurses for master degree purpose. The research aimed to examine the extent of nurses' understanding and familiarity with clinical alarm systems in their healthcare settings, considering the moderating role of JCI accreditation. and to investigate the relationship between clinical alarm management practices and nurses' perceived impact on patient safety.

The study will be conducted to cover the nurses who were in four Palestinian hospitals, two of them are JCI accredited hospitals and two are non-accredited hospitals.

Improve healthcare delivery outcomes by promoting the development, application and support of safe and effective healthcare technologies.

About 148 participants will be needed to perform the study including an attrition rate of 10%. 37 participants for each selected hospital, the selection of participants will be selected through a random sample. The inclusion criteria will be full-time registered nurses who provide direct contact with patients in hospitals.

I agree on all terms you mention in this form

Best Regards

Signature 27/11/2023 Date 27/11/2023

Print Name: **Fadi Abdelhadi**

Institution: **An -Najah National University Hospital (NNUH)**

Improve healthcare delivery outcomes by promoting the development, application and support of safe and effective healthcare technologies.

HTF (Heath Care Technology Foundation) Approval

Fadi Abd Elhadi <fadi.abdelhadi@najah.edu>

National Clinical Alarms Survey Request

9 messages

Jennifer Ott <jennifer.ott@northstarmgmt.com> Wed, Nov 29, 2023 at 12:48 AM
To: "fadi.abdelhadi@najah.edu" <fadi.abdelhadi@najah.edu>
Cc: "Ott, Jennifer C" <Jennifer.Ott2@mercy.net>

Dear Fadi Abd Elhadi – Thank you for your patience. I am away from my regular computer for HTF GCEA activities and had to develop a work around to get you the survey questions. Thank you for submitting your proposal and donation. Please find attached the questions in Word format for the 2016 survey. Let me know if you have any further questions.

We would love to hear more about your results. We are always looking for ways to improve education on alarms globally!

Jennifer C. Ott, CCE, FACCE

Secretariat

HTF Healthcare Technology Foundation

GLOBAL CLINICAL ENGINEERING ALLIANCE

https://www.globalcea.org/htf-home?hsLang=en

C. 314.800.8565

2016 HTF Clinical Alarms Survey.docx
178K

Fadi Abd Elhadi <fadi.abdelhadi@najah.edu> Wed, Nov 29, 2023 at 10:30 AM
To: Jennifer Ott <jennifer.ott@northstarmgmt.com>
Cc: "Ott, Jennifer C" <Jennifer.Ott2@mercy.net>

Dear Jennifer

Thank you very much for your cooperation ..i will keep in contact with you for further questions and for sure i will share my research result with you .

Thanks again .
Best regards
[Quoted text hidden]

Appendix C

Tables

Table C.1

Literatures overviews and related indicators dissection

Author and year	Construct	Related Indicator	Short Relationship Discussion	Remark
Cvach (2012)	Clinical Alarm Management Practices & Knowledge (CAMPK)	Nuisance Alarms (NA)	Effective management practices reduce nuisance alarms leading to decreased alarm fatigue and improved nurses ability to manage alarms effectively	Reducing nuisance alarms improves nurses ability to differentiate between real and false alarms.
Sendelbach, S., & Funk, M. (2013).	Clinical Alarm Management Practices & knowledge (CAMPK)	Nuisance Alarms (NA)	Management strategies aimed at reducing nuisance alarms increase the reliability of alarm systems enhancing nurses operational efficiency.	Alarm fatigue reduction leads to better compliance with alarm protocols.
Gazarian (2014 b)	Clinical Alarm Management Practices & knowledge (CAMPK)	Nuisance Alarms (NA)	Implementing policies to address nuisance alarms ensures that nurses are less distracted and can focus on true clinical alarms.	Consistent management of nuisance alarm helps maintain a high standard of clinical practice.
Cvach (2012)	Clinical Alarm Management Practices & knowledge (CAMPK)	Smart Alarms (SA)	Integrating smart alarms into clinical practice reduces false alarms and improves the accuracy of alarm systems helping nurses in effective alarm management.	Smart alarms filter out non critical alarms allowing nurses to focus on significant alerts.
Drew et al. (2014 c)	Clinical Alarm Management Practices & knowledge (CAMPK)	Smart Alarms (SA)	Smart alarm systems utilize advanced algorithms to minimize false positives thereby improving the efficiency of clinical alarm management.	Improved technology reduces the cognitive load on nurses.

Author and year	Construct	Related Indicator	Short Relationship Discussion	Remark
Graham & Cvach (2010)	Clinical Alarm Management Practices & knowledge (CAMPK)	Institutional Requirements (IR)	Education and documentation requirements ensure nurses are knowledgeable about alarm systems developing their ability to manage alarms effectively.	Education and standardized practices improve nurses knowledge and response to alarms.
Sowan et al. (2015)	Clinical Alarm Management Practices & knowledge (CAMPK)	Institutional Requirements (IR)	Regular training and documentation will improve the overall alarm management skills of nursing staff.	Continuous education keeps nurses updated on best practices in alarm management.
Lewandowska et al. (2020c)	Clinical Alarm Management Practices & knowledge (CAMPK)	Clinical Alarms Management Improvements (CAMI)	Improvements in alarm management practices and training and technologies reduce alarm fatigue and improve nurses effectiveness in managing alarms.	Alarm management improvement leads to better allocation of nursing resources and attention to critical alarms.
A. S. Poncette et al. (2020)	Clinical Alarm Management Practices & knowledge (CAMPK)	Clinical Alarms Management Improvements (CAMI)	The survey identifies key improvements for ICU monitoring including reducing false alarms, implementing standard procedures, integrating wireless sensors and preparing for AI and improving staff digital literacy. These changes aim to improve ICU staff practices and patient care.	These improvements can streamline ICU operations reduce alarm fatigue and elevate care quality through effective technology integration and improved staff practices.
Wang et al. (2023)	Patient Safety as Perceived by Nurses (PSPN)	Alarm Notification (AN)	Effective alarm notification systems, such as central monitoring systems develop nurses ability and quality to respond	Alarm notification system reduce response time and improve intervention

Author and year	Construct	Related Indicator	Short Relationship Discussion	Remark
			immediately to alarm conditions so that positively influencing patient safety perceptions.	accuracy.
Allan et al. (2017)	Patient Safety as Perceived by Nurses (PSPN)	Alarm Notification (AN)	adding short delays to allow alarm self-correction and use centralized alarm notification systems reduce alarm fatigue by filtering non critical alarms and alerting nurses only to significant events improving patient safety.	Efficient alarm notification systems lead to better patient outcome and nurse satisfaction.
Rayan et al. (2024b)	Patient Safety as Perceived by Nurses (PSPN)	Experience with Alarm Systems (EAS)	Nurses experience with alarm systems including their sensitivity to alarms and ability to respond quickly influences their perceptions of patient safety.	Experience with alarm systems improves nurses confidence in managing patient care.
Becking-Verhaar et al. (2023)	Patient Safety as Perceived by Nurses (PSPN)	Experience with Alarm Systems (EAS)	Nurse engagement and perceived usefulness influence technology adoption and patient safety. Early detection for deteriorating patients during continuous vital sign monitoring improve nurse experience despite device connectivity barriers thereby reducing adverse events and improving patient safety perceptions.	Enhancing device connectivity can improve nurses experiences with continuous monitoring and boosting patient safety.
Vikan et al. (2023)	Patient Safety as Perceived by Nurses	Adverse Events (AE)	This scoping review explored the relation between patient safety culture scores and	Improving patient safety culture correlates with

Author and year	Construct	Related Indicator	Short Relationship Discussion	Remark
	(PSPN)		adverse event rate in healthcare. It found that higher PSC scores are generally linked to reduced AE rates highlighting the critical role of patient safety practice in improving healthcare outcomes.	lower adverse event rates underscoring its important role in improving healthcare quality and outcomes.
Lewandowska et al. (2020d)	Patient Safety as Perceived by Nurses (PSPN)	Adverse Events (AE)	Addressing alarm related adverse events through targeted improvements in alarm systems and protocols can surely improve patients safety perceptions by nurses.	Reducing alarms related adverse events is important for enhancing patient safety and nurses trust in alarm system.

Table C.2

Results of reliability and validity analysis

Construct	Item NO.	Reflective Indicators	Item Loading	CR	AVE	Cron. Alpha
Nuisance Alarms (NA)				0.844	0.644	0.73
	NA1	Nuisance alarms occur frequently	0.757			
	NA2	Nuisance alarms disrupt patient care.	0.793			
	NA3	Nuisance alarms reduce trust in alarms and cause caregivers to inappropriately turn alarms off at times other than during setup or procedures	0.855			
Smart Alarms (SA)				0.799	0.574	0.621
	SA1	Institutions use systems that employ smart alarms	0.609			
	SA2	Smart alarms would be effective to use for reducing false alarms.	0.783			
	SA3	Smart alarms would be effective to use for improving clinical response to important patient alarms.	0.86			
Experience with Alarm Systems (EAS)				0.862	0.474	0.814

Construct	Item NO.	Reflective Indicators	Item Loading	CR	AVE	Cron. Alpha
	EAS1	Properly setting alarm parameters and alerts is overly complex in existing devices	0.695			
	EAS2	Newer monitoring systems have solved most of the previous problems we experienced with clinical alarms	0.717			
	EAS3	The alarms used on my floor/area of the hospital are adequate to alert staff of potential or actual changes in a patient's condition	0.721			
	EAS4	There have been frequent instances where alarms could not be heard and were missed	0.571			
	EAS5	Clinical staff is sensitive to alarms and responds quickly	0.643			
	EAS6	When a number of devices are used with a patient, it can be confusing to determine which device is in an alarm condition	0.694			
	EAS7	Background noise has interfered with alarm recognition	0.763			

Construct	Item NO.	Reflective Indicators	Item Loading	CR	AVE	Cron. Alpha
Alarm Notification (AN)				0.815	0.524	0.698
	AN1	Hospital use alarm notification systems such as pagers, cell phones, or other wireless devices to communicate alarm conditions	0.684			
	AN2	Alarm integration and communication systems using pagers, cell phones, or other wireless devices are useful for improving alarm management and response	0.752			
	AN3	Institutions use "monitor watchers" in a central viewing area to observe and communicate alarm conditions to caregivers	0.692			
	AN4	Central alarm management staff (“monitor watchers”) responsible for receiving alarm messages and alerting appropriate staff is helpful	0.764			
Institutional Requirements (IR)				0.743	0.511	0.549
	IR1	Education on the purpose and proper operation of alarm systems	0.833			

Construct	Item NO.	Reflective Indicators	Item Loading	CR	AVE	Cron. Alpha
	IR2	Requirement to document that the alarms are set and are appropriate for each patient	0.822			
	IR3	Clinical policies and procedures regarding alarm management are effectively used	0.402			
Clinical Alarms Management Improvements (CAMI)				0.854	0.746	0.66
	CAMI1	Developing clinical alarm improvement initiatives over the past two years (e.g. policies and procedures, education, special projects, new technology)	0.883			
	CAMI2	Instituted new technological solutions to improve clinical alarm safety	0.844			
Adverse Events (AE)	AE1	The institution experienced adverse patient events in the last two years related to clinical alarm problems	1	-	-	-

جامعة النجاح الوطنية
كلية الدراسات العليا

تقييم تأثير ممارسات إدارة الإنذارات السريرية على سلامة المريض من قبل الممرضين: الدور الوسيط للاعتمادية الدولية المشتركة JCI

إعداد
فادي عبدالهادي

إشراف
د. يحيى صلاحات

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية،
من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس – فلسطين.

2024

تقييم تأثير ممارسات إدارة الإنذارات السريرية على سلامة المريض من قبل الممرضين: الدور الوسيط للاعتمادية الدولية المشتركة JCI

إعداد

فادي عبدالهادي

إشراف

د. يحيى صلاحات

الملخص

تتناول هذه الدراسة تأثير ممارسات ومعرفة إدارة الإنذارات السريرية (CAMPK) على سلامة المرضى من وجهة نظر الممرضات (PSPN) والدور الوسيط لاعتمادية الدولية المشتركة (JCI) داخل المستشفيات الفلسطينية.

ولتحقيق هذه الغاية، تم استخدام مسح الإنذارات السريرية لعام 2016 الذي أجرته مؤسسة التكنولوجيا الصحية (HTF) لجمع البيانات من 102 ممرض وممرضة من مختلف الأقسام في المستشفيات الفلسطينية. تم تحليل البيانات المجمعة باستخدام (PLS-SEM) عبر برنامج Smart PLS و كشفت نتائج التحليل أن CAMPK الفعال يعزز بشكل إيجابي PSPN. علاوة على ذلك، أظهرت الدراسة أهمية الحد من الإنذارات المزعجة واستخدام أنظمة الإنذار الذكية كعناصر رئيسية ومهمة في CAMPK والتي تؤثر بشكل إيجابي على PSPN.

وجد من خلال هذه الدراسة أن JCI له تأثير ذو دلالة إحصائية منخفضه على إدراك الممرضات لسلامة المرضى وتأثير وسيط منخفض على العلاقة بين CAMPK وPSPN. يوضح التحليل أن تأثير التفاعل بين JCI وCAMPK على PSPN لم يكن ذا دلالة إحصائية.

من أجل تعزيز تصورات سلامة المرضى، تشير هذه الدراسة إلى أن الاعتمادية الدولية وحدها غير كافيه وأن اتباع نهج شامل يدمج CAMPK وعمليات الاعتماديات الدولية المخصصة أمر ضروري. تظهر النتائج مدى تعقيد عملية تحسين سلامة المرضى والحاجة إلى التقييم المستمر وتعديل الممارسات السريرية ومعايير الاعتماديات.

توفر هذه الدراسة الأدوات اللازمة لواضعي سياسات الرعاية الصحية والإداريين في قطاع الرعايــة الصــحية الفلسطيني وكذلك الطاقم الطبي، اللازمة لتطوير برامج سلامة المرضى في البيئات السريرية المتغيــرة، ممــا يسمح للشخص بفهم العلاقة بين اعتماد CAMPK وPSPN وJCI.

الكلمات المفتاحية: ممارسات ومعرفة إدارة الإنذار السريري (CAMPK)، سلامة المريض، نظــام Smart PLS، قطاع الرعاية الصحية الفلسطيني، أجهزة الإنذار المزعجة، مؤسسة تكنولوجيا الصحة (HTF).