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Mapping the Informal Communication Networks of Medication Safety: A Social Network Analysis of Nurse-to-Nurse Error Reporting in a Saudi Hospital

Sultanah Awwadh Al-Mutairi, Corresponding Author:

Nurse Manager, Department of Nursing, King Fahad Medical City, Riyadh, Saudi Arabia, Sultanahalmutairi@gmail.com

Dr. Tukimin Bin Sansuwito

PhD, Senior Lecturer and Researcher, Faculty of Nursing, Lincolin University colleges Malaysia, tukimin@lincoln.edu.my

Abstract:-

Background: Medication errors are a continuing challenge to patient safety in healthcare systems around the world, and in Saudi Arabia. In spite of established formal error reporting systems, informal nurse-to-nurse communication is a vital, but poorly researched, participant in the process of medication-related risk detection, dissemination, and reduction.

Methods: This descriptive cross-sectional study used Social Network Analysis (SNA) to investigate the nature and form of informal networks of nurse communication in terms of medication safety in a 500-bed hospital in Hail, Saudi Arabia. A sociometric questionnaire was used to collect data on 120 registered nurses working in four departments (medical, surgical, intensive care, and emergency) of the hospital. The communication patterns were visualized by using UCINET 6.0 and Gephi 0.10 to analyze network metrics such as density, degree centrality, betweenness, and clustering coefficient.

Findings: The general network showed a medium density (0.42) and a high clustering coefficient (0.61), which means that people shared information locally quite often, but the communication between units was scarce. Both ICU nurses and senior charge nurses had high betweenness centrality, being key brokers in medication-related conversations. Poor inter-departmental relations were noted, which may hamper organizational learning.

Conclusions: Informal communication networks play an important role in the exchange and action of medication safety information. A reinforced inter-unit connection and strengthening key network brokers can improve the overall patient safety culture.

Keywords*: Social Network Analysis, Nurse Communication, Medication Errors, Patient Safety, Saudi Arabia, Informal Networks.*

1. Introduction

Medication safety has been one of the main issues in modern medicine since medication errors still lead to preventable patient harm on a global scale (1). The World Health

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Organization's Global Patient Safety Challenge on Medication Safety highlights the importance of halving severe, preventable medication-related harm worldwide (2). Medication errors, regardless of the hospital setting, are a concern in Saudi Arabia despite its strong national initiatives, including the creation of the Saudi Patient Safety Center (SPSC) and a focus on achieving healthcare quality objectives in Vision 2030 (3). Underreporting of medication incidents and minimal use of the formal reporting system in Saudi hospitals, as has been documented recently, have raised the need to investigate the underlying communication dynamics that may influence the reporting of errors and prevention of errors (4-6).

Nurses are the last point in the medication administration process and thus are central to preventing and detecting medication errors (7). Their capacity to perform effectively, however, is not only based on the knowledge and training they have but also the communication systems they have in their workplaces. Although there are formal forms of communication, in many cases, nurses use informal communication with co-workers to report near misses, clarify uncertainty, and share information related to safety (8). These informal contacts often happen in the course of shift change, coffee breaks, or bedside conversations, creating an unseen but significant communication network that may or may not foster the transfer of knowledge about safety-related issues (9).

2. Objectives

Conventional studies of safety have largely emphasized personal and organizational procedures, neglecting the social constructs that design the safety practice (10). Social Network Analysis (SNA) is a methodological framework that can be used to investigate these structures through mapping and analysis of relationships amongst individuals in a network (11-12). SNA is used in nursing settings to locate key players (influencers or brokers), communication teams, and nodes where information is not circulated effectively. Research into Western healthcare systems has shown that coherent and closely-knit networks within the nursing population are associated with greater safety performance, more rapid innovation diffusion, and more robust safety cultures (13). Nevertheless, these studies are limited in the Middle Eastern and especially Saudi setting, where a top-down organizational culture and cultural aspects might influence open communication and error reporting.

The role of Saudi nurses in sharing safety information via informal networks thus becomes critical to enhancing the practice of using medications safely. Through SNA, this paper aims at visualizing patterns of nurse-to-nurse communication concerning medication errors, which primary factors affect the communication patterns, and what are the opportunities to enhance organizational learning and safety culture across hospital units.

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3. Methods

Study Design

Social Network Analysis methodology was employed as a guiding factor in a descriptive, cross-sectional research design. In this way, communication patterns among nurses in terms of medication safety can be quantified and visualized. These criteria were followed by the STROBE and BMC Nursing guidelines on observational studies.

Setting

The research was carried out in a 500-bed hospital in Hail, Saudi Arabia, that offers specialized services in various departments. There were four large nursing units: medical, surgical, intensive care (ICU), and pediatrics. Every unit has its hierarchy, headed by charge nurses and assisted by staff nurses whose duties are to administer medications, record, and report any incidents.

Participants

The study involved 120 registered nurses, which is about 80 percent of the nursing personnel in the four units. Eligibility criteria were full-time employment in the units of choice and a minimum of six months' experience at the hospital. Excluded were agency nurses and probationally contracting nurses. The responses were anonymous and participation was voluntary.

Data Collection Tool

A sociometric questionnaire as a roster was constructed and adapted to earlier created Social Network Analysis (SNA) instruments common to healthcare safety research. The tool was to be used to document the demographic information as well as the communication styles among the nurses as it relates to medication safety. The demographic section gathered the data concerning age, sex, department, years of clinical experience, and the professional post, i.e., staff nurse, charge nurse or unit head. The second segment involved mapping communication networks and respondents were asked to identify colleagues with whom they discuss medication safety concerns, potential or actual medication errors or consult with them regarding safe medication administration practices. All the named colleagues were the directed communication between two nurses (A → B) in the context of the flow of information regarding safety-related issues. The frequency of these interactions was also requested to be specified by the participants in terms of daily, weekly or monthly to aid in illuminating the level of intensity in communication within the network. To make the questionnaire clear and culturally and contextually relevant, the questionnaire was piloted on ten nurses (in different units) prior to actual data collection. The pilot feedback resulted in certain words and layouts being tweaked in order to understand it better. Pilot testing

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indicated good internal consistency with a Cronbach alpha coefficient of 0.86 indicating reliability of the instrument to be utilized in the rest of the study.

Data Collection Procedure

The paper-based surveys engaged in data collection were administered in a six-week timeframe during planned shift handovers to increase access and response rates. Unit charge nurses aided the distribution of the questionnaire by making sure that all the eligible participants never had to receive the questionnaire in a coercive manner. The research team collected completed surveys in sealed, coded envelopes and collected them at specific drop boxes in each department. This approach was utilized to keep anonymity and reduce the possible peer effect or bias in the hierarchical direction. A written and oral explanation of the purpose of the study, the voluntary nature of the participation, and the tools to protect confidentiality were given to participants before they filled out and submitted the questionnaire. There was no collection of any personal information, and all of the responses were coded numerically so that they could not be associated with specific individuals. The data collection took place outside the hours of direct patient care to prevent any disturbance of the working process and provide the respondent with comfort and privacy.

Data Analysis

The filled questionnaires were checked to be complete and added to the UCINET 6.0 software to analyze the data quantitatively as a Social Network (14). The data was then exported to Gephi 0.10 to create network visualizations and sociograms. To characterize the dynamics and structure of nurse-to-nurse communication in terms of medication safety, a set of main network measurements was derived. Network density was calculated to estimate the ratio of existing ties to all potential ties, giving a measure of the extent of connectedness of the network (15). The degree centrality was calculated to determine how many direct communication links each nurse had, and it was used to identify those involved who were well-connected or influential in sharing information related to safety. Betweenness centrality was examined to reflect the degree to which any given nurse performed the role of a bridge or intermediary between groups that would otherwise be inaccessible (16). Also, the clustering coefficient was used to determine the extent of subgroups' development and unification within units. Separate analysis was also done on the departmental sub-networks in order to determine the within-unit and cross-unit communication patterns. Color coding was used to visually depict sociograms by department distinction, with node size based on degree centrality to show the relative centrality of each nurse in the medication safety communication network.

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Ethical Considerations

The Institutional Review Board of the Hail Health Cluster granted us ethical approval (Approval No IRB: 2025-103). All participants gave informed consent. Data collection was voluntary, and the data were coded in order to maintain anonymity. Network visualizations did not include any identifying information. The research was conducted in accordance with the ideas of the Declaration of Helsinki.

4. Results

One hundred and twenty (120) nurses were involved in the study, which provided an 80 percent response rate to the eligible population in four clinical departments. The sample of respondents represented the heterogeneous staffing of Saudi tertiary hospitals. Most respondents were females (82%), and the mean age of the respondents was 33.7 years (SD = 6.4). Two-thirds (67%) of them had a bachelor's degree in nursing, 18 per cent had a diploma, and 15 per cent had postgraduate qualifications. The average number of years of professional practice was 8.2 (SD = 3.1), with a range of 2-22 years. Departments were equally represented, with 35 medical unit, 30 surgical units, 25 intensive care (ICU) and 30 emergency nurses.

Demographic and professional traits of the participants are summarized in Table 1 and indicate that the ICU nurses were the most experienced (10.1 years), then the medical nurses (8.9 years), surgical nurses (7.5 years), and pediatric nurses (6.3 years).

Table 1. Demographic and Professional Characteristics of Participants (n = 120)

Variable	Category	Frequency (n)	Percentage (%)	Mean ± SD
Gender	Female	98	81.7	—
	Male	22	18.3	—
Age (years)		—	—	33.7 ± 6.4
Educational Level	Diploma	22	18.3	—
	Bachelor's	80	66.7	—
	Postgraduate	18	15.0	—
Years of Experience		—	—	8.2 ± 3.1
Department	Medical	35	29.2	—
	Surgical	30	25.0	—
	ICU	25	20.8	—

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	Pediatrics	30	25.0	—

Network-Level Structure

The entire communication network had 120 nodes (that describe individual nurses) and 1,080 directed ties, which is the reported communication links with regard to medication safety. This total network density was determined to be 0.42, or about 42% of the total number of potential communication relationships between nurses. This implies that it has a moderately interconnected network where information can be spread effectively only partially in all departments and not everywhere.

Mean degree (number of direct communication links per nurse) was 8.4 with a range of 2 to 23. This implies there would be a great deal of difference in the extent to which nurses discussed medication safety. Only a few well-connected people controlled the network, whereas some nurses, particularly new employees, were found to be more distant. The clustering coefficient came out as 0.61 showing that there were cohesive subgroups that demonstrated that there used to be a communication between and within departmental teams but not between the units.

The mean path length - the number of steps the information has to take to reach any pair of nurses - was 2.7, which means that most of them had a limited number of links to others, so information spread rather quickly when cross-unit links were present.

Departmental Sub-Networks

When these were analyzed by department, there were significant structural differences. The network of ICU was the densest (0.59) and clustering coefficient (0.72), indicating high internal communication and collaboration. The medical unit was the most densely connected, followed by surgical (0.38) and pediatric (0.33), indicating that they were more fragmented or the primary communicators.

The ICU network was also the one with the largest average degree centrality (10.8), indicating that, on average, the nurses in the ICU were more connected in communication than other departments. Pediatric nurses showed the lowest degree centrality (6.1) as expected in their more closed communication patterns. Table 2 summarizes the major SNA measures per department.

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Table 2. Summary of Network Metrics by Department

Department	Density	Average Degree Centrality	Betweenness Centrality (Mean)	Clustering Coefficient	Average Path Length
Medical	0.45	8.2	0.36	0.59	2.6
Surgical	0.38	7.4	0.29	0.54	2.9
ICU	0.59	10.8	0.41	0.72	2.3
emergeny	0.33	6.1	0.24	0.47	3.1
Overall Network	**0.42**	**8.4**	**0.33**	**0.61**	**2.7**

Centrality and Key Actors

The degree and betweenness centrality analysis showed that a few nurses were central in the exchange of information. Three charge nurses with the highest degree centrality scores (>20) worked in the ICU and in the medical ward, and they were the ones most frequently contacted with references to medication safety. Similarly, an ICU senior staff nurse was the central node (in a centralization sense of betweenness centrality) who played an important role as a contact point between the ICU cluster and other departments (0.48).

Further examination revealed that the nurses in these central positions had a higher number of than ten years of professional experience, and were perceived as friendly and knowledgeable by peers. They served as an informal power not only within their unit, but also within the flows of information between units. Nevertheless, the presence of a few central figures also meant that it might be vulnerable; in case these people were not there or had to leave the organization, the effectiveness of communication within the network could drastically decrease.

Figure 1 shows the communication network on the level of the whole structure, including central actors (larger nodes) and their relations to different departments.

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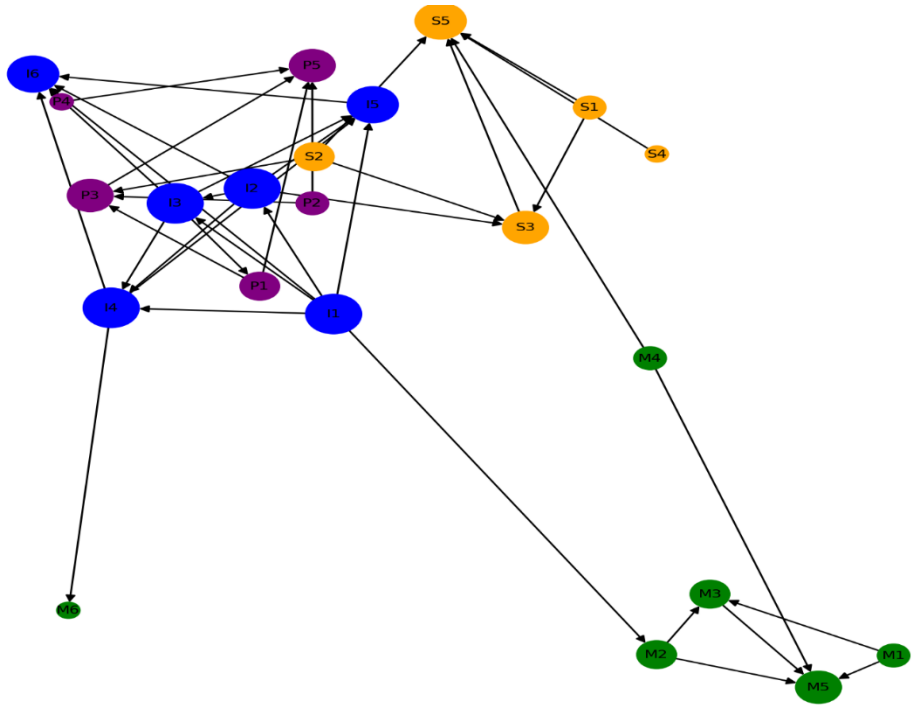

Figure 1. Overall Nurse Communication Network on Medication Safety

Figure 1 presents a sociogram of the entire network, generated using Gephi 0.10. Each node represents a nurse, color-coded by department (blue = ICU, green = medical, orange = surgical, purple = pediatrics). Node size corresponds to degree centrality, illustrating the influence of key communicators. The ICU cluster appears at the network's center, surrounded by dense intra-departmental connections. Several bridging ties extend from ICU nurses to the medical and surgical departments, while the pediatric unit appears relatively peripheral with limited external communication links.

Communication Frequency and Nature

Communication frequency analysis showed that 56% of the reported communication was using weekly frequency, 28% was using daily frequency, and 16% was using monthly or less frequency. The majority of the safety conversations occurred in an informal setting (64% of all), which included shift handover (64%), nursing lounge (21%), and bedside rounding (15%). These trends indicate a notion that informal conversations are part and parcel of medication safety communication, which exists beyond the scope of official reporting mechanisms.

This interpretation was supported by thematic content based on open-ended responses to the survey. Nurses explained informal communication as an expedient means of finding solutions, as a confided area of airing out issues, and as a less threatening method of fault-

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finding. Nonetheless, other respondents were willing to note that informal channels could occasionally result in discrepancies in message delivery or restricted dissemination of knowledge to only the immediately involved.

Cross-Unit Connectivity

Cross-unit communication was limited but strategically important. Approximately 18% of all ties occurred between departments, predominantly linking ICU nurses with colleagues in the medical and surgical units. These cross-unit connections often involved experienced nurses who had previously rotated between departments or held dual responsibilities such as medication safety champions. To visualize these interconnections, Figure 2 depicts a simplified interdepartmental network, emphasizing cross-unit communication density.

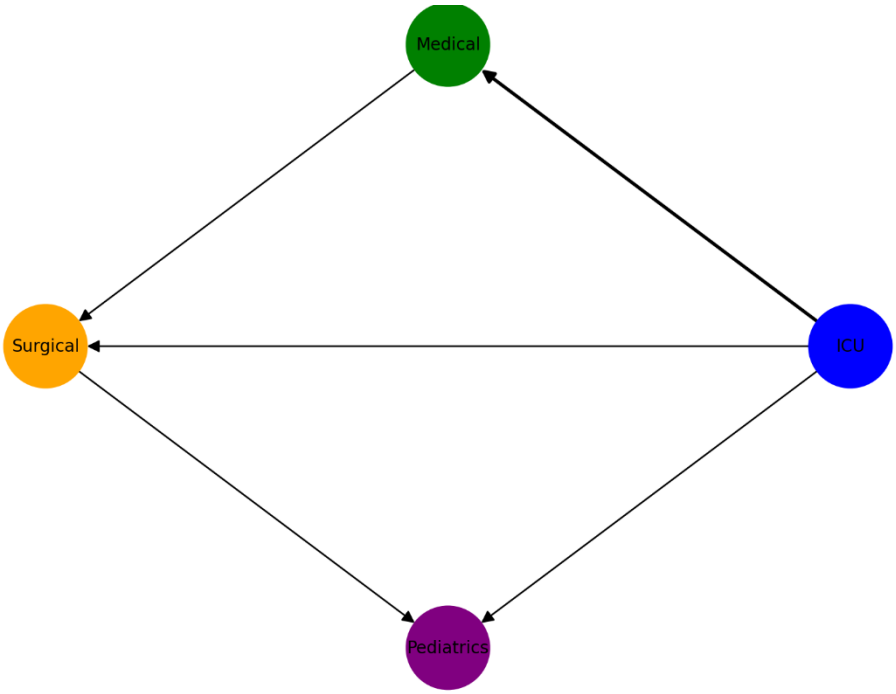

Figure 2. Interdepartmental Communication Network

Figure 2 illustrates aggregated inter-unit ties. Line thickness represents communication intensity (number of ties), and circle size corresponds to department size (number of nurses). The ICU shows the thickest outbound and inbound connections, serving as a communication hub across the hospital. The pediatric unit, by contrast, exhibits minimal outward ties, suggesting a compartmentalized communication pattern that may restrict organizational learning related to medication safety events.

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Peripheral and Isolated Nodes

These results also found 11 nurses (9%) who played peripheral roles in the network, which is someone with fewer than three links. Most of these nurses were new expatriates or working on night shifts, meaning that they did not get an opportunity to have regular safety discussions. The isolation or low connectivity of nodes could signify lost chances of inclusive communication and team integration, especially among employees who could be the greatest beneficiaries of peer learning.

The evidence suggests that the medication safety communication network between nurses working in the Saudi tertiary hospital is moderate in terms of cohesion and has a hierarchical and department-centric structure. Close collaboration between units, especially those in the ICU, promotes localized safety learning, but minimal connectivity across units inhibits the widespread transmission of medication safety knowledge. The following structural patterns outline the strong points and areas to improve in the hospital communication culture.

5. Discussion

This paper mapped informal communications among nurses in terms of medication safety in one Saudi tertiary hospital, based on Social Network Analysis (SNA). The results indicate that communication between nurses regarding medication safety is mediocrely dense and strong, with an intra-departmental relationship and a small number of cross-unit relationships. The general network density of 0.42 shows that the information flows within the departments are efficient, yet, there is still a chance to enhance the collaboration between the departments and cross-learning. This is not the first study to find that informal communication networks are essential in ensuring patient safety, particularly in the context of perceived punitive or bureaucratic formal reporting systems (17, 18).

The high level of cohesion in the ICU sub-network (density = 0.59; clustering coefficient = 0.72) indicates that the riskier settings encourage more compact communication patterns, probably because they share situational awareness and teamwork established practices. Other researchers have found similar trends, indicating that critical care units demonstrate denser informal communication as a response to high task interdependence and high frequency of joint decision making (19). In turn, relatively low connectivity among pediatric and surgical departments suggests structural fragmentation which can restrict the circulation of the information related to safety. Hierarchy and respect to authority figures, which are part of the Saudi culture, can also limit open conversation especially between junior nurses or expatriate nurses, which will result in peripheral or isolated nodes in the communication network.

The centrality analysis also indicated that there were a few well connected nurses, mostly charge nurses and senior personnel, who act as informal opinion leaders and knowledge brokers within the network. These people connect subgroups and the flow of information

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related to safety between departments. Although this type of structure has the advantage of facilitating effective communication, it also poses a risk of dependency. Without these key players, the flow of information may be interrupted. Past research on SNA in health care has also determined that networks that are highly dependent on several central nodes are susceptible to bottlenecks in communication (20). Hence, the goal of leadership development programs should be to spread the influence of communication among a greater proportion of staff to create redundancy and robustness in safety communication networks.

The study also highlights a significance of informal communication in the Saudi nursing practice. Medication safety issues were often discussed by nurses during handovers and informal meetings, as they stated such places were more reliable and conducive than official reporting. This can be compared to the global findings that informal networks can become parallel systems of real-time sense-making, emotional support, and quick information exchange (21). The use of informal channels to early identify medication risks is especially critical in the Saudi healthcare setting where the hierarchical relationships and cultural sensitivity could hinder formal reporting. However, when overused, informal conversations can lead to a decrease in the documentation of near-miss events and inhibit the organization to learn through systematic error. Formal safety systems may address this gap by integrating informal insights into formal safety systems, including through the use of team briefings, reflective debriefing and peer-to-peer mentoring.

Peripheral and isolated nurses discovered and identified, many of them new recruits or on night shifts, have theoretical and practical implications on patient safety and integration of the workforce. The peripheral roles in communication networks relate to less access to safety knowledge and fewer safety behaviors (22). Since Saudi Arabia relies on the work of an expatriate nursing workforce, it is possible to increase inclusiveness by means of a specific induction program and cross-shift communication intervention, so that all nurses receive equal access to information on safety.

Findings are consistent with Saudi Vision 2030 goals to improve the quality of healthcare by developing human resource and promoting a better safety culture. The conceptualization of communication networks based on SNA is an evidence-based guideline to define informal leaders and implement interventions to maximize connectivity among the team. SNA findings can be used by hospital management to facilitate multidisciplinary collaboration, name safety champions, and develop continuing education programs to improve inter-unit linkages.

Strengths and Limitations

The application of SNA methodology was one of its strengths to a real-world nursing communication system in the Saudi context and presented quantitative and visual information of relational dynamics normally not too noticeable in traditional surveys. Accuracy of the

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data was boosted through the use of a roster based sociometric instrument that captured the directional ties and ties based on frequency.

Limitations, however, are the use of self-reported data, which can be affected by recall bias and social desirability bias. The sample of the study was also through only one hospital which could have restricted the generalization to other hospitals with different organizational culture and staffing model. Future studies need to study longitudinal SNA designs to understand the progression of communication patterns after specific intervention or policy reforms aimed at promoting safety.

Implications for Practice

The findings show that increasing interdepartmental communication and empowering peripheral workers can greatly improve pharmaceutical safety culture. Nurse leaders and hospital administrators should work to create formal opportunities for cross-unit communication, such as interdisciplinary safety rounds or interdepartmental case reviews. Additionally, recognizing and rewarding highly central nurses as formal safety mentors can help to spread excellent practices throughout the institution.

Overall, the study underscores the importance of informal communication networks in the patient safety ecosystem. By mapping and comprehending these unseen structures, hospitals may create contextually relevant interventions that use their nursing teams' collective knowledge to reduce prescription errors and enhance patient outcomes in the Saudi healthcare system.

Conclusion

This study shows that the informal nurse-to-nurse communication networks are critical to medication safety in Saudi hospitals. With the idea of Social Network Analysis, we were able to define a fairly well-connected but departmentally focused network, and several individuals were identified as key bridges between units. Although the level of intra-departmental communication was quite high, the level of cross-unit communication was limited, which made the organization's learning more broad. The results point to the dual significance of using informal communication and reinforcing formal structures to increase safety culture. Communication between nurses across departments should be inclusive, open, and cross-departmental, and knowledge and experience should move not only along the hierarchical and unit lines. The implementation of SNA knowledge in daily quality improvement may aid the detection of communication deficiencies and the creation of specific interventions. Finally, enhancing network connectivity and strengthening all nurses as direct participants of safety dialogue will facilitate the national vision of developing a learning and resilient healthcare system in Saudi Arabia.

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