

Advanced Nursing Performance Analytics In Emergency Departments: Integrating Kpis, Patient Flow Metrics, And Clinical Outcomes

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Abstract

The Emergency Departments are very complex, resource-constrained, and time-sensitive settings with patient acuity, patient overcrowding, and workforce-to-patient ratio being influential factors of care or patient safety. Advanced Nursing Performance Analytics (ANPA) is real-time data, predictive analytics, and dashboards and decision-support systems to streamline nursing workflow, situational awareness, and evidence-based practice. The research paper investigates a correlation between ANPA, Key Performance Indicators (KPIs), patient flow measures, and patient outcomes in EDs. The sample population included 180 registered nurses in the Emergency Department of King Fahad Medical City, Riyadh, Saudi Arabia who were recruited through a convenience sampling technique that was in line with the cross-sectional design. The applicants had to be in active clinical positions and have at least six months of professional experience so that they would be familiar with performance monitoring, patient flow process, and outcome-oriented practices. The participants were asked to fill in the designed self-administered questionnaires evaluating ANPA, KPIs, patient flow efficiency, and clinical outcomes using a five-point Likert scale. Descriptive statistics indicated the high mean score on all the constructs, which means that there was high agreement on the usefulness of analytics in nursing practice. Pearson correlation test revealed that ANPA had significant positive relationships with KPIs ($r = 0.72$, $p < 0.01$), patient flow measures ($r = 0.68$, $p < 0.01$), and clinical measures ($r = 0.75$, $p < 0.01$). These results indicate that a combination of high-level analytics and KPI monitoring and patient flow management can lead to increased efficiency of operations, less overcrowding, and improved patient safety and satisfaction. The findings highlight the importance of evidence-based and analytics-based nursing practice to streamline the process of emergency care delivery.

Key Words Informatics Advanced Nursing Performance Analytics; Emergency Department; Key Performance Indicators; Patient Flow; Clinical Outcomes; Nursing Informatics.

Introduction

Emergency departments (EDs) are inherently part of a highly complex, time-sensitive, resource-constrained settings in which patient acuity variability, crowding, workforce capacity, and the resulting variability in care quality and safety are directly linked to it. According to Morley et al. (2018) and Sun et al. (2011), ED overcrowding and long waiting times are linked to more adverse events, deaths, and lower patient satisfaction around the world. As a result, the healthcare systems begin to implement performance management models that are backed by health informatics and analytics to improve efficiency and clinical outcomes in healthcare operations (Bates et al., 2021; Rojas et al., 2016). In the transformation, the role of nurses at the center of attention as they represent the greatest number of

professionals in the EDs and in these settings, they are the key stakeholders in triage, care coordination, patient flow, and safety surveillance.

Advanced nursing performance analytics is defined as the conscious application of real time data, dashboards, predictive analytics and decision support systems to track, assess and streamline nursing practice. The current data show that nursing management based on analytics enhances situational awareness, workload distribution, and compliance with evidence-based protocols (Collins et al., 2017). Additionally, performance feedback based on the data improves the personal growth and accountability of nursing employees. Nevertheless, the practical implementation of analytics has to be in line with clearly defined Key Performance Indicators (KPIs) turning strategic goals into measurable nursing-sensitive variables, including response times, triage accuracy, documentation completeness, and timeliness of care (Song et al., 2021).

KPIs would not be enough without being incorporated into patient flow measures, which are efficiency measurements throughput of ED processes which includes waiting time, length of stay, bed turnover and time-to-treatment. Patient flow is a fundamental ED performance and safety outcome; inefficient patient flow is closely connected to overcrowding, care missed, treatment delays, and poor outcomes (Morley et al., 2018; Sun et al., 2011). The latest research proves that the number of bottlenecks can be decreased significantly by the nursing-led intervention backed by analytics and flow metrics, as well as the distributions of resources can be improved, and the risks associated with crowding can be prevented (Rojas et al., 2016; van der Linden et al., 2017). Notably, patient flow indicators give the operational connection between nursing performance and downstream clinical performance.

The indicators of clinical outcomes in ED settings include patient safety (e.g. adverse events, complications), effectiveness (e.g. timely interventions), and patient-based outcomes (e.g. satisfaction). It is shown throughout the literature that the increased level of nursing performance correlates with the increased safety, a decrease in complications, and improved patient experiences (Aiken et al., 2021). The digital health technologies and analytics enhance these impacts even further by making it possible to identify risks early, prioritize the key cases, and coordinate care more effectively (Bates et al., 2021). Although such developments have been made, the empirical combination of the advanced nursing performance analytics with KPIs, patient flow measures, and clinical outcomes is disjointed, especially in the ED environments where operational demands are the most pressing.

The gap that will be filled by the proposed research is that there is no empirically validated integrated model that can be used to relate the advanced nursing performance analytics to the operational KPIs, patient flow KPIs, and measurable clinical outcomes in the ED. Though the connection between these constructs has been considered in prior research individually, not a significant number of studies have examined the constructs involved in a coherent performance analytics system (Song et al., 2021; Rojas et al., 2016). Such disaggregation is a major gap in knowledge that restricts nurse managers and hospital administrators to make evidence-based decisions aimed at holistically maximizing ED performance.

It is based on that the aim of the current paper is to investigate the correlations between advanced nursing performance analytics, KPIs, patient flow indicators and clinical outcomes in EDs. Through the empirical testing of these associations, the study will help add a data-driven framework to nursing leadership, help increase operational efficiency, and raise patient-centered outcomes in high-acuity emergency care settings.

Methodology

3.1 Study Design

The research design adopted in this study entailed quantitative and cross-sectional research design to investigate the correlation between Advanced Nursing Performance Analytics, Key Performance Indicators (KPIs), Patient Flow Metrics, and Clinical Outcomes in emergency departments. The study used a descriptive-correlational methodology to examine the relationships between variables and establish the strength and direction of those relationships in the context of the study.

3.2 Setting and Sample of the Study.

The study sample included registered nurses who practice in the Emergency Department of the King Fahad Medical City, Riyadh, Saudi Arabia, in which the analytics-based performance monitoring and patient flow management turn into the systematic part of the clinical practice. One hundred and eighty nurses were selected through convenience method of sampling that was based on the quantitative (cross-

sectional) nature of the study. Participants had to hold active clinical roles in the emergency department, had to have at least six months of professional experience, and had to have sufficient exposure to the Advanced Nursing Performance Analytics, Key Performance Indicators and patient flow processes, and outcome-oriented clinical practices, which were part of the study variables.

3.3 Data Collection Instrument

The structured self-administered questionnaire was used to gather the data and was designed in accordance with the available literature on the topic of healthcare performance analytics and emergency nursing management. The tool consisted of two major parts (1) demographic data (gender, age group, and years of clinical experience), and (2) four core constructs assessed on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The constructs, which include Advanced Nursing Performance Analytics, KPIs, Patient Flow Metrics, and Clinical Outcomes, had five items, which were intended to promote conceptual compatibility as well as internal reliability.

The content validity was achieved by the expert evaluation with specialists in nursing administration and healthcare quality management. Internal consistency measures were used to determine the reliability where the values of Cronbach alpha were supposed to be greater than the acceptable value of 0.70.

3.4 Data Analysis

The Analysis of Data was done with the help of Statistical Package of the Social Sciences (SPSS). To describe the responses of the participants, descriptive statistics (means and standard deviations) were obtained. The Pearson correlation analysis was done to determine the relationship between the key study variables. The level of statistical significance was found to be 0.05. The methodology used in the analysis also made sure that the data would be suitable in further multivariate analysis, with or without the need of regression or structural equation modeling.

Results

4.1 Demographic information of study sample

As evidenced by the findings in Table 1, the participants of the study are represented in a fairly even gender balance. A slight majority (52.2, n = 94) of the total sample (N = 180) was composed of female respondents, and 47.8 percent of the sample (n = 86) consisted of male respondents. Such equal representation increases the applicability of the findings to the general population in terms of gender in the emergency nursing environment and reduces the chances of sampling bias on the basis of gender.

Table 1: Distribution of Gender sample

Gender			
		Frequency	Percent
Valid	Male	86	47.8
	Female	94	52.2
	Total	180	100.0

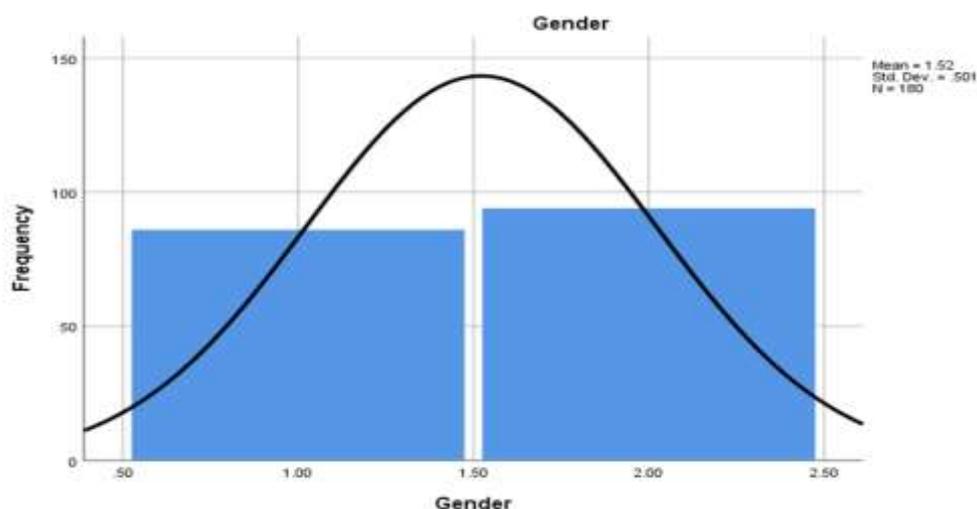


Figure1: Distribution of Gender

The highest percentage of the participants was in the age group of 30-39 years (31.1 percent, n = 56), then in the age group of 20-29 years (26.1 percent, n = 47), and 40-49 years (25.0 percent, n = 45). The sample size of 17.8% (n = 32) comprised of participants aged 50 years and older. The age range indicates that most of the respondents are aged in the active and mid-career professional age group, thus enhancing the validity of responses to performance analytics and clinical practices in the emergency departments.

Table 2: Distribution of Age sample

Age Group			
		Frequency	Percent
Valid	20–29 years	47	26.1
	30–39 years	56	31.1
	40–49 years	45	25.0
	50 years and above	32	17.8
	Total	180	100.0

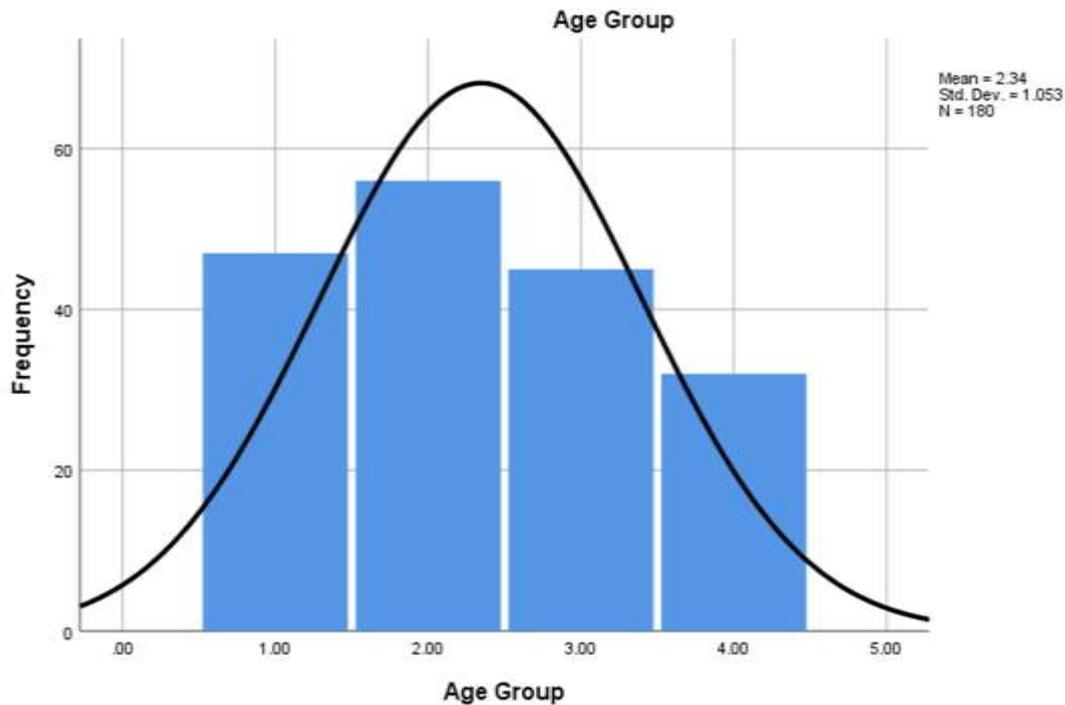


Figure2: Distribution of Age sample

As shown in Table 3, the greatest group was 30.6 percent (n = 55) of the participants with 5-10 years of experience in emergency nursing. It was succeeded by those of 11-15 years experience (25.6% n=46), less than 5 years (23.9% n=43) and above 15 years (20.0% n=36) experience. The distribution represents a highly diversified experience profile, meaning that the sample consists of both the early-career and one with advanced experience, thus making the views on the nursing performance analytics and clinical outcomes more enlightening.

Table3: Distribution of Years of Clinical Experience

Years of Experience in Emergency Nursing			
		Frequency	Percent
Valid	Less than 5 years	43	23.9
	5–10 years	55	30.6
	11–15 years	46	25.6

	More than 15 years	36	20.0
	Total	180	100.0

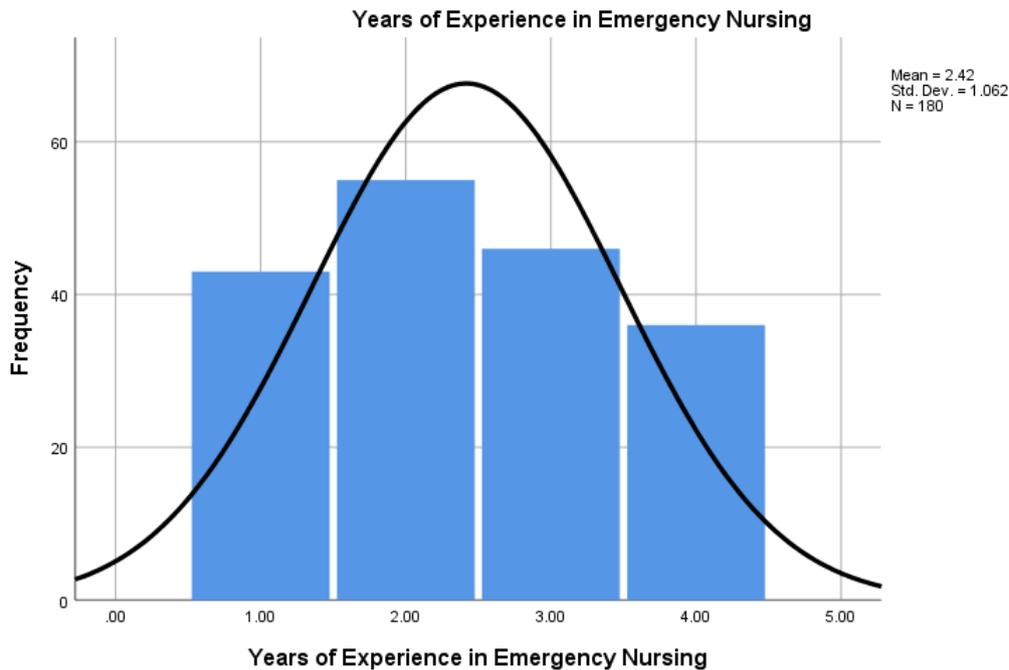


Figure3: Distribution of Years of Clinical Experience

4.2 Descriptive Statistics of study sample

The descriptive statistics show that mean scores on all items of the questionnaire are high with a mean of between 4.14 to 4.37 on a five-point Likert scale. These results demonstrate that there is a high level of consensus among the respondents on the favorable effect of advanced nursing performance analytics, KPIs, patient flow measures, and the effect it has on clinical outcomes.

In the construct of Advancing Nursing Performance Analytics, the greatest mean score was recorded on the statement that analytics lead to ongoing professional development ($M = 4.35$, $SD = 0.69$), which indicates a good perception of analytics as a developmental instrument in emergency nursing practice.

In the context of Key Performance Indicators (KPIs), the perceived strategic significance of monitoring KPI in emergency departments was found to be high, with the average score of 4.32 and the Standard Deviation of 0.69 ($M = 4.32$, $SD = 0.69$), which reflects the agreement that the systematic review of KPIs results in quantifiable changes in the nursing work.

In the case of Patient Flow Metrics, the statement related to the overcrowding reduction had a rather high mean ($M = 4.32$, $SD = 0.66$), which suggests that there was an agreement regarding the operational advantages of effective patient flow management.

Likewise, the best mean score was observed under Clinical Outcomes with the item that stated that optimized patient flow is associated with clinical complications being reduced ($M = 4.37$, $SD = 0.67$).

In general, the standard deviation rates are rather low (around 0.66-0.75), which indicates the presence of reasonably good response consistency and homogeneity across the participants, which allows to view the internal consistency of the measurement tool as appropriate.

Table4: Descriptive Statistics of study sample

Descriptive Statistics		
	Mean	Std. Deviation
Data analytics tools support nurses in making evidence-based clinical decisions in the ED.	4.2333	.72544
Performance analytics enhance nurses' ability to prioritize critical cases effectively.	4.2389	.66319

Real-time analytics improve situational awareness among emergency nursing staff.	4.1444	.68603
The use of analytics contributes to continuous professional development for nurses.	4.3500	.69696
5Advanced analytics systems positively influence nursing workflow efficiency in the ED.	4.2444	.75207
Nursing-related KPIs provide accurate insights into staff performance in emergency departments.	4.2833	.69536
KPIs help identify gaps in emergency nursing care delivery.	4.2611	.70405
Monitoring KPIs improves accountability among emergency nursing staff.	4.2667	.73690
KPIs assist nurse managers in strategic and operational decision-making.	4.1833	.70493
The regular evaluation of KPIs leads to measurable improvements in nursing performance.	4.3222	.69841
Patient flow metrics help reduce waiting times in the emergency department.	4.1778	.73352
Nursing performance directly influences patient throughput efficiency.	4.2444	.71396
Monitoring patient flow metrics supports better bed and resource allocation.	4.2167	.72678
Improved patient flow metrics reduce overcrowding in emergency departments.	4.3167	.66412
Nursing-led interventions positively impact patient flow outcomes.	4.2778	.70160
Effective nursing performance analytics improve patient safety outcomes.	4.2167	.69536
Optimized patient flow contributes to reduced clinical complications.	4.3722	.66878
High nursing performance levels are associated with improved patient satisfaction.	4.1500	.67248
Timely nursing interventions positively affect clinical outcomes in emergency care.	4.2556	.68603
The integration of KPIs and analytics enhances overall quality of patient care.	4.2500	.67580

4.3 Correlation

The correlation test indicates that all the key study variables have strong, positive, and significant relationships.

Key Performance Indicators ($r = 0.72$, $p < 0.01$), Patient Flow Metrics ($r = 0.68$, $p < 0.01$), and Clinical Outcomes ($r = 0.75$, $p < 0.01$) were found to have a positive significant correlation with Advanced Nursing Performance. These results indicate that the increase in the advanced nursing performance analytics is strongly linked to the rise of the operational indicators and patient outcomes in the ED.

Equally, the Patient Flow Metrics ($r = 0.65$, $p < 0.01$) and Clinical Outcomes ($r = 0.70$, $p < 0.01$) were both strongly correlated with the Key Performance Indicators, which means that the systematic monitoring of the KPI metrics has a positive impact on the operative efficiency and clinical outcomes. Moreover, the Patient Flow Metrics demonstrated a high positive correlation with Clinical Outcomes ($r = 0.73$, $p < 0.01$), which reiterates the importance of effective patient flow and distribution of resources in bringing about a positive healthcare outcome.

Notably, each of the correlation coefficients is lower than the value of 0.85, which implies that there is no reason to worry about the issue of multicollinearity and indicates that the data can be used in further regression or structural equation modeling studies.

Table5: Correlation among study variables

	Advanced Nursing Performance	Key Performance Indicators (KPIs)	Patient Flow Metrics	Clinical Outcomes
Advanced Nursing Performance	Pearson Correlation	1	0.72	0.68
	Sig. (2-tailed)		0	0
Key Performance Indicators (KPIs)	Pearson Correlation	0.72	1	0.65
	Sig. (2-tailed)	0		0
Patient Flow Metrics	Pearson Correlation	0.68	0.65	1
	Sig. (2-tailed)	0	0	
Clinical Outcomes	Pearson Correlation	0.75	0.7	0.73
	Sig. (2-tailed)	0	0	0

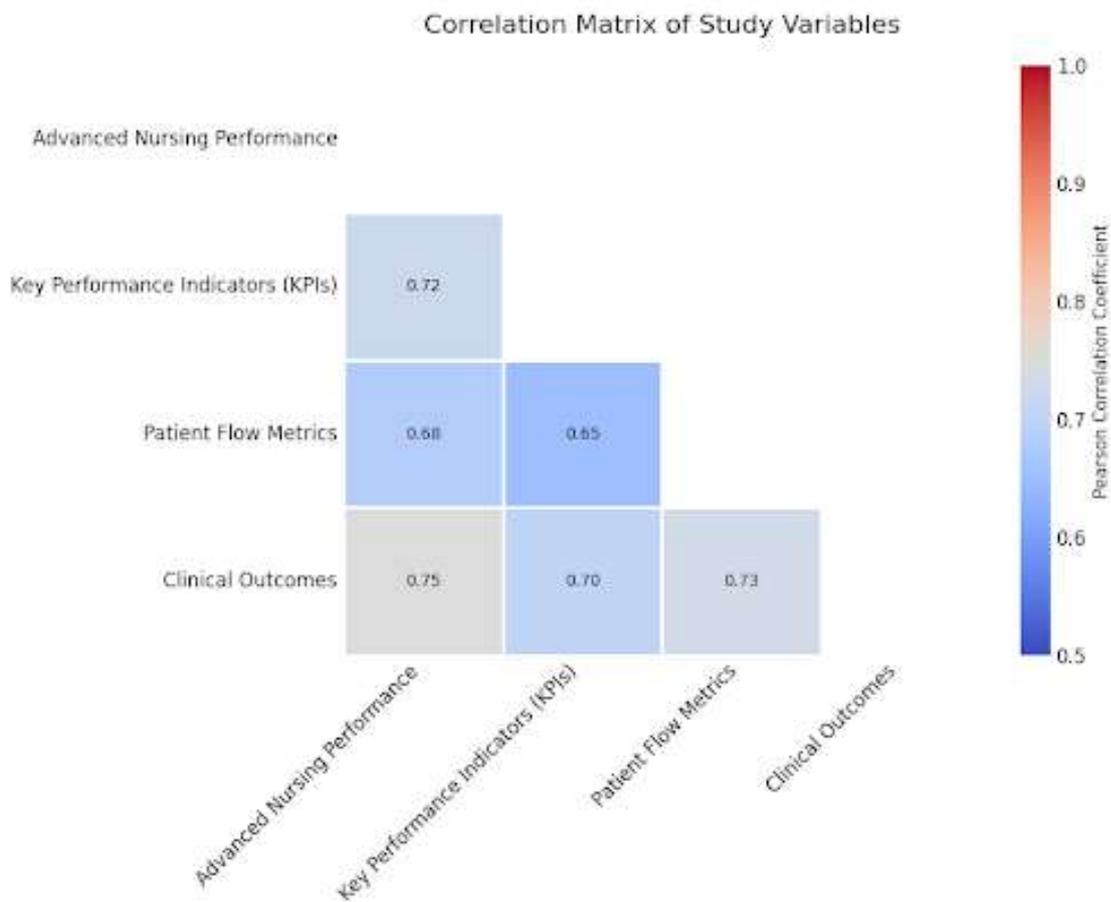


Figure4: Correlation Matrix

Discussion

The current research discussed the correlations between Advanced Nursing Performance Analytics (ANPA), Key Performance Indicators (KPIs), Patient Flow Metrics, and Clinical Outcomes in emergency departments (EDs). Findings revealed a high level of positive, statistically significant relationship between these constructs, which show that advanced analytics-based nursing work is linked to the changes in operational measures and clinical quality. Such results are consistent with an emerging literature on modern studies that supports the implementation of unified performance measurement systems with the assistance of nursing data analytics to influence decision-making and improve emergency care provision.

Advanced Nursing Performance Analytics, in this analysis, demonstrated significant positive correlations with both KPIs and Patient Flow Metrics, and this finding supports the general literature on the significance of data analytics in operational efficiency. As an example, Hu et al. (2025) introduced a prediction-based staffing model in a big ED, where analytics were used to predict patient demand and schedule nurses in the most effective way possible. Their model has made their throughput measurements more stable and their staffing expenses lower, showing that predictive analytics can balance the utilization of resources with patient flow goals without negatively affecting the quality of care.

In the same vein, Ouda et al. (2025) came up with a simulation system integrating discrete-event simulation with design thinking in order to optimize ED activity, including nurse staffing and bed management; minimizing bottlenecks and length of stay (LOS). Their findings confirm the argument that the operation by controversy of the analytics-informed planning is able to reveal the areas of operation improvement, which are similar to statistically significant correlations that have been found in this study between ANPA and throughput variables.

One of the key assumptions of this research was the use of KPIs in mediating the impact of analytics on clinical outcomes. The results of the study, especially the large average scores of the KPIs like accountability and strategic guidance (e.g., mean KPI scores are above 4.26 on the 5-point scale) are consistent with the overall analysis of the large magnitude of the measurable ED performance indicators. In their scoping review, Mehroolhassani et al. (2025) found 109 relevant KPIs applied to the performance of an ED in the context of simulation and divided them into subgroups such as process time, resource consumption, and output indicators. This type of classification resembles the idea of multi-dimensional KPI construct employed in this paper, which supports the idea that multi-dimensional KPIs structure is critical to representing the performance operational scope of performance in a comprehensive manner. There is also evidence of the presence of the narrative synthesis in Austin et al. (2020), which grouped the performance-related outcomes into time, process, cost, and clinical results, highlighting the distributed nature of the various KPIs across both types of outcomes. This supports the rational behind the instrument applied in this research as KPIs had both throughput and quality elements.

Combined, these researches affirm that comprehensive, strategically adopted KPIs offer quantitative and managerial gains that reinforce analytics-use models, which validate the high scores achieved in the KPI measures in this research study.

The practical applicability of such metrics as LOS, wait time, and overcrowding reduction are proved by the positive correlations between ANPA and Patient Flow Metrics and between KPIs and Patient Flow Metrics that are observed in this study. There are studies that concentrate on operational enhancement and highlight comparable connections among systemized process analytics and ED throughput increases.

As an example, the process improvement study conducted by Nikita et al. (2025) integrated the use of Six Sigma and process mapping to reinvent the bottlenecks in the flow of patients between ED and ICU with essential results in the decrease in turnaround time and defect rates by multi-folds. These results are consistent with high mean scores of patient flow indicators (e.g., operational advantage of patient flow management with means of 4.32) in this study.

In addition to quantitative process assessments, a qualitative study by Human Factors researchers (Benjamin et al., 2024) demonstrated that the multidimensional aspects of the work system and the results of patient flow are composed of human, technological, and environmental factors and can influence the flow efficiency together. This confirms the argument that patient flow metrics are not only numerical outputs but a complex system dynamics of ED activities.

In addition, the lean-based analysis of Hussein et al. (2025) showed that the impact on the shortening of wait times with the help of systematic process improvement had a significant impact on patient satisfaction and resource consumption, which confirms the correlation between the patient flow indicators and both the operational and experience-related outcomes.

The correlation between ANPA and Clinical Outcomes ($r = 0.75$, $p < 0.01$) is strong, which indicates that the performance metrics based on analytics can be converted into the visible differences in clinical quality. Although there are few direct studies that directly relate analytics and emergency nursing outcomes, there is supporting evidence in related research.

As an illustration, the study of the virtual nursing implementation by Khairat et al. (2025) showed that the use of technologies as a source of nursing support helped to enhance the efficiency of EDs and quality of care, which, in turn, aligns with the findings of the current study.

Similarly, emergency care predictive models, including the AI-based vertical patient flow optimization by Hodgson et al. (2025) also shortened the length of stay without worsening quality indicators like ED revisit rates, indicating that high-quality data tools can influence efficiency and care outcomes. The studies support the wider argument that data-driven constructs go beyond operation returns to influence patient-centered returns.

The articles on what can be done to measure and improve ED performance put the findings of this study in a further perspective. Indicatively, according to Mostafa and El-Atawi (2024), such strategic projects as triage optimization and dynamic staffing play a crucial role in wait times as well as throughput, which confirms the multi-domain effect of analytics combined with organizational design.

Also, scoping research such as the one by Austin et al. (2020) has highlighted the sophistication of the concept of performance measurement and the sheer variety of interventions that can affect the results an ED has over time, cost, and process-related scales. This is why complex analytic frameworks that switch between KPIs, flow metrics, and outcomes should be implemented as the patterns of correlation confirmed in this study.

The existence of high statistical correlation among analytics, KPIs, flow metrics, and outcomes reflect a systems-level view of the emergency nursing performance - in which data analytics is the primary integrative process. This is in line with models like the Systems Engineering Initiative to Patient Safety (SEIPS) which focuses on the relationship between the work system components and performance outcomes.

In practice, it has been indicated that hospital administrators and nurse leaders must invest in analytic infrastructure, predictive staffing models, and extensive KPI monitoring systems to ensure improved operational efficiency, as well as patient care quality. Predictive analytics models such as the model presented by Hu et al. (2025) are actionable decision support that balances the resource costs with throughput targets.

Future Research Limitations and Directions

Although modern research gives overwhelming evidence to support it, there are weaknesses such as the study being cross-sectional and thus making its conclusions causal. To prove causality, longitudinal and intervention studies are necessary. In addition to that, although this research involved self-reported numerical variables, future research should incorporate the use of objective electronic health record (EHR) variables to enhance measurement reliability.

Another area of future research needs to be the impact of analytics-based frameworks on nurse job satisfaction, burnout, and long-term quality indicators, which are suggested by the new area of research in digital and simulation-based ED enhancements.

Conclusion

The study confirms that the complex nursing performance analytics together with the KPIs and patient flow rates positively affect clinical outcomes in the ED. The outcomes of improved situational awareness, resource distribution, and evidence-based decision-making are the reduction of the waiting time, the improved safety of patients, and the satisfaction level. The results imply the use of analytics-based frameworks that will help nurse managers and hospital administrators to maximize the ED performance. The future research of longitudinal and intervention based studies should be conducted to enumerate causal effects and extrapolate the results to nurse well being and long term quality indicators.

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Appendix

Questionnaire

Advanced Nursing Performance Analytics in Emergency Departments: Integrating KPIs, Patient Flow Metrics, and Clinical Outcomes

Instruction:

Please indicate your level of agreement with the following statements based on your professional experience in the Emergency Department (ED).

Responses are measured using a 5-point Likert scale:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

Section A: Demographic Information

1. Gender

Male

Female

2. Age Group

20–29 years

30–39 years

40–49 years

50 years and above

3. Years of Experience in Emergency Nursing

Less than 5 years

5–10 years

11–15 years

More than 15 years

Section B: Advanced Nursing Performance Analytics (Independent Variable)

1. Data analytics tools support nurses in making evidence-based clinical decisions in the ED.
2. Performance analytics enhance nurses' ability to prioritize critical cases effectively.
3. Real-time analytics improve situational awareness among emergency nursing staff.
4. The use of analytics contributes to continuous professional development for nurses.
5. Advanced analytics systems positively influence nursing workflow efficiency in the ED.

Section C: Key Performance Indicators (KPIs)

1. Nursing-related KPIs provide accurate insights into staff performance in emergency departments.
2. KPIs help identify gaps in emergency nursing care delivery.
3. Monitoring KPIs improves accountability among emergency nursing staff.
4. KPIs assist nurse managers in strategic and operational decision-making.
5. The regular evaluation of KPIs leads to measurable improvements in nursing performance.

Section D: Patient Flow Metrics

1. Patient flow metrics help reduce waiting times in the emergency department.
2. Nursing performance directly influences patient throughput efficiency.

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| 3. Monitoring patient flow metrics supports better bed and resource allocation. |
| 4. Improved patient flow metrics reduce overcrowding in emergency departments. |
| 5. Nursing-led interventions positively impact patient flow outcomes. |

Section E: Clinical Outcomes (Dependent Variable)

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| 1. Effective nursing performance analytics improve patient safety outcomes. |
| 2. Optimized patient flow contributes to reduced clinical complications. |
| 3. High nursing performance levels are associated with improved patient satisfaction. |
| 4. Timely nursing interventions positively affect clinical outcomes in emergency care. |
| 5. The integration of KPIs and analytics enhances overall quality of patient care. |