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Optimizing ICU Care: Advancing Nursing Diagnoses with a Decision Support System

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Abstract. The Nursing Process (NP) is a multi-step, structured framework, that enables nurses to integrate scientific knowledge and optimize patient care. Establishing a Nursing Diagnosis (ND) is a fundamental step of this process, enabling the selection of appropriate interventions. This study presents the development of VIGIL Care, a clinical decision support system designed to enhance NP in intensive care units (ICUs). Using a Delphi method, 13 experts reviewed the 277 nursing diagnoses (NDs) from the latest NANDA-I taxonomy (2024–2026) and selected 32 as relevant for ICU care, and with high criticality or high prevalence. In a second step, a panel of three nursing experts and one internal medicine physician refined the diagnostic indicators associated to the 32 NDs as described in NANDA-I, selecting those deemed highly or moderately relevant. VIGIL Care integrates patient data and employs logical rules to propose patient-specific NDs, while offering an explainable user interface allowing for nursing decisional autonomy preservation. The assessment of 10 NDs across 20 randomly-selected patient cases demonstrated that VlGIL Care achieved 86% sensitivity and 78% specificity, outperforming traditional nursing assessments, especially under time constraints. However, the limited sample size highlights the need for further validation to confirm the system's effectiveness.

Keywords. Nursing Process, Nursing Diagnosis, Clinical Decision Support Systems, Intensive Care Units

1. Introduction

The Nursing Process (NP) serves as a multi-step structured framework enabling nurses to apply scientific knowledge and optimize patient care. It encompasses five

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interconnected steps: assessment, nursing diagnosis (ND), planning, implementation, and evaluation[1].

NDs represent clinical judgments about health conditions in terms of problems and risks [1]. They are fundamental for selecting nursing interventions and predicting patient outcomes [2], including quality of life, and organizational outcomes such as length of stay, hospital costs, etc. Nurses utilize Standardized Nursing Languages (SNLs) to document NDs, e.g., the NANDA-I classification system [1]. At the bedside, nurses continuously collect observations to identify signs and symptoms, which inform NDs [1]. However, challenges arise in ND decision-making and hence in building care plans [3]. This is particularly the case in Intensive Care Units (ICUs), where rapid evaluations are critical, and integrating extensive data along with their translation into SNLs, amidst time constraints and high workloads, is complex. Consequently, clinical decision support systems for the nursing process (NP-CDSSs) are considered as promising to improve these tasks. Despite the establishment of an international standard consensus in 2016 to guide NP-CDSS development [4], implementation challenges persist, including inadequate integration of NP-CDSSs with biomedical data, insufficient prioritization mechanisms for NDs, and lack of automation for linking assessments to diagnoses [4]. We developed VIGIL Care, a NP-CDSS, to enhance ND decision-making in critical care settings at the Lebanese Hospital Geitaoui–UMC, a 200-bed University Medical Center (UMC) in Beirut (Lebanon), equipped with a basic hospital information system (HIS) HIMSS EMRAM Level 2, that enables only access to administrative, laboratory and pharmacy data, while all clinical information remains paper-based.

2. Methods

We used a four-step methodology to select ICU-relevant NDs from the NANDA-I handbook [1], refine their indicators, and build VIGIL Care, a rule-based CDSS, connected to the basic HIS of the Lebanese Hospital Geitaoui–UMC.

Step 1: A panel of 13 ICU nursing experts, each with postgraduate qualifications and over 10 years of experience, evaluated the 277 NDs of the NANDA-I Handbook (2024-2026) [1] for relevance to ICU care, and for criticality (from life-threatening to not critical) and prevalence (almost always to rarely present) using a 4-point scoring system. This assessment utilized a Delphi method across two rounds to achieve consensus leading to including ICU-relevant NDs that scored 3 or higher in criticality or prevalence. Results were cross-checked against literature, validating 32 NDs as the most frequent or critical in ICU settings. We selected 10 of the 32 NDs to initiate and validate the VIGIL Care CDSS (inadequate nutritional intake, risk for impaired water-electrolyte balance, risk for imbalanced blood pressure, ineffective breathing pattern, risk for acute confusion, risk for infection, risk for adult pressure injury, risk for falls, risk for shock, risk for thrombosis).

Step 2: Within NANDA-I, diagnostic indicators are categorized as defining characteristics, related factors, and risk factors, in addition to associated conditions and at-risk population. Traditionally, three indicators are needed to trigger a ND [3]. However, Hao et al. [3] proposed to also integrate the relevance (high, moderate, minor) of indicators, demonstrating that this enhances nursing practice. A new panel, made of three nurse managers/researchers with over 15 years of experience and including an internal medicine physician, further refined the NANDA-I indicators (2024-2026) [1] to retain only those deemed highly or moderately relevant. Out of the 412 indicators

associated to the 10 selected NDs, 217 were actually retained, and 28 new indicators were added by experts because considered of high relevance. The NP-CDSS was designed to trigger a ND if one highly relevant or at least three moderately relevant indicators were identified during assessment.

Step 3: An electronic nursing assessment form was created, including patient demographics, medical history, and a checklist for physical examination. The electronic nursing assessment form and NDs were programmed in Python within VIGIL Care, developed as a standalone web application created using the Flask framework, offering an overview of patient medical risks. The platform is interfaced to the HIS through an API, allowing to access administrative, laboratory, and pharmacy data. Each ND is triggered by logical rules based on expert-defined conditions and variables, considering the relative weights and associations of underlying factors. Explanations are displayed for each triggered ND, detailing the conditions and values that prompted its proposal, allowing clinicians to knowledgeably confirm, reject, or modify NDs in a free-text option. The user interface provides a holistic summary of patient data, including demographics, deterioration risk, medical diagnoses, infectious status, critical laboratory values, etc. To enhance the management of priority interventions, prompted NDs are ranked according to their significance as established by experts, classified as critical, important, or normal.

Step 4: A prospective system evaluation with the 10 selected NDs was conducted on 20 randomly selected pseudonymized ICU clinical cases. We compared NDs suggested by VIGIL Care (i) when processing HIS-only information, and (ii) when processing both the electronic nursing assessment form and HIS information, with NDs determined by an expert committee deemed as the gold standard. This was subsequently compared with NDs documented by the nurses in charge of those patients. The study was approved by the Institutional Review Board of the Lebanese Hospital Geitaoui–UMC.

3. Results

VIGIL Care demonstrated an overall sensitivity of 86% and specificity of 78%, surpassing nurses 'overall sensitivity (66%) and specificity (73%). This was also observed for each ND, except for the risks of infection and shock where nurses were superior. The system achieved 100% sensitivity for the risk of adult pressure injuries and the risk for thrombosis, as the system classifies all ICU patients at high risk for both risks based on administrative data; however, the specificity for thrombosis could not be evaluated since all selected cases were positive. VIGIL Care matched or exceeded nursing specificity for all NDs except the risk of falls. HIS data alone yielded the lowest overall sensitivity (54%) but the highest specificity (90%). Notably, the risk of impaired water-electrolyte balance showed low sensitivity for nurses but high sensitivity and specificity for both VIGIL Care and HIS modules, in contrast to the fall risk when processing HIS-only data (0% sensitivity). Results are displayed in Table 1.

4. Discussion

It is important to first note that the VIGIL Care system performs better (86% sensibility) when working with patient data that includes nursing assessment, compared to when only HIS data is processed (54% sensibility). This highlights the critical role of nursing assessment, should further proof be needed. VIGIL Care's sensitivity surpassing that of

the nursing team is consistent with the performance of other NP-CDSSs [2,3,5]. Nurses must exercise clinical judgment while navigating a complex array of patient data under time constraints, workload, and patient acuity [2]. In this context, NP-CDSSs are valuable for helping nurses gather data from diverse sources and identify implicit connections, facilitating accurate diagnoses, critical for high-quality patient care. A significant finding illustrating this point is the low sensitivity for the risk of impaired water-electrolyte balance among nurses, while VIGIL Care showed high sensitivity and specificity. This gap often stems from nurses not having enough time to review biological results, leading to underdiagnose NDs highly influenced by those factors. This underscores the need for systems like VIGIL Care that can automatically prompt NDs based on biological data [6]. Conversely, the fall risk, which relies heavily on clinical data, shows higher specificity for the nurses and comparable sensitivity among nurses and the NP-CDSS.

Table 1. Comparison of sensitivity and specificity of VIGIL Care working with HIS-only and HIS-enriched data integrating nursing assessment, and ICU nurses on 10 NDs and 20 real pseudonymized patient cases.

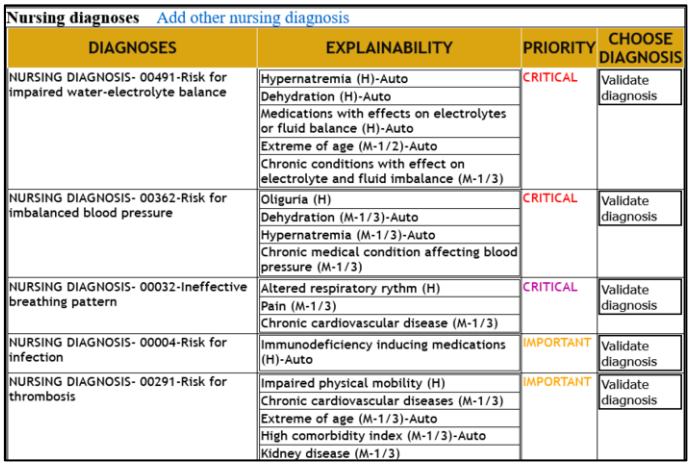
Nursing Diagnosis	Gold Standard selection (20 cases)	ICU Nurse		Vigil Care (Nursing Assessment + Admin, Lab & Pharmacy Data)		ONLY HIS: Admin, Lab & Pharmacy Data)	
		Sens.	Spec.	Sens.	Spec.	Sens.	Spec.
Inadequate nutritional intake	**12**	50%	75%	83%	100%	17%	100%
Risk for impaired water-electrolyte balance	**17**	35%	100%	94%	100%	82%	100%
Risk for imbalanced blood pressure	**16**	44%	75%	81%	75%	44%	100%
Ineffective breathing pattern	**10**	70%	60%	90%	60%	20%	80%
Risk for acute confusion	**9**	22%	91%	78%	100%	67%	100%
Risk for infection	**18**	94%	50%	88.9%	100%	44.4%	100%
Risk for adult pressure injury	**17**	88%	33%	100.0%	0%	100.0%	0%
Risk for adult falls	**16**	81%	75%	87.5%	25%	0.0%	100%
Risk for shock	**14**	71%	67%	42.9%	100%	28.6%	100%
Risk for thrombosis	**20**	75%	-	100.0%	-	100.0%	-
Mean	-	66%	73%	86%	78%	54%	90%

Sens= sensibility; Spec=specificity; lab= laboratory; Admin=administrative; ICU= Intensive care Unit

Another key finding is that when the system automatically classifies patients as high risk for an ND based on a highly relevant factor, such as the risks for adult pressure injury or thrombosis in ICU patients, the nurse's contextual knowledge enhances the accuracy of her judgment. This outperforms knowledge-based rules, leading to higher specificity for nurses and underscoring the importance of preserving nurses' decision-making. At the ND level, VIGIL Care's sensitivity was lower than that of nurses only for the risks of infection and shock. Thus, it is important to reassess the rules for these NDs to improve the system's sensitivity. VIGIL Care demonstrated a 100% sensitivity and a 0% specificity for the risks of adult pressure injury and thrombosis, as the system classifies all ICU patients as high risk based on administrative data. In these situations, nurse's knowledge enhances her judgment accuracy compared to knowledge-based rules.

VIGIL Care benefits from involving nurses at all stages of its development and testing. It critically reevaluates and refines NANDA-I factors by considering associated conditions alongside signs and symptoms when triggering data. Additionally, the approach complies with the 2016 international consensus for NP-CDSS development [4], but also incorporates prioritization of NDs (based on expert consensus) to assist nurses in addressing critical tasks first. The explainability accompanying each ND supports nurses in accepting or rejecting the proposed diagnoses (figure 1). A key observation during the evaluation of VIGIL Care, supported by the literature, is that NP-CDSSs offer significant benefits for novice nurses [2,6]. Limitations of this study include the small

number of tested NDs and patient cases; however, real case data as used in this study, which is crucial for more accurate assessment.



Nursing diagnoses Add other nursing diagnosis

DIAGNOSES	EXPLAINABILITY	PRIORITY	CHOOSE DIAGNOSIS
NURSING DIAGNOSIS- 00491-Risk for impaired water-electrolyte balance	Hypernatremia (H)-Auto	CRITICAL	Validate diagnosis
	Dehydration (H)-Auto		
	Medications with effects on electrolytes or fluid balance (H)-Auto		
	Extreme of age (M-1/2)-Auto		
	Chronic conditions with effect on electrolyte and fluid imbalance (M-1/3)		
NURSING DIAGNOSIS- 00362-Risk for imbalanced blood pressure	Oliguria (H)	CRITICAL	Validate diagnosis
	Dehydration (M-1/3)-Auto		
	Hypernatremia (M-1/3)-Auto		
	Chronic medical condition affecting blood pressure (M-1/3)		
NURSING DIAGNOSIS- 00032-Ineffective breathing pattern	Altered respiratory rythm (H)	CRITICAL	Validate diagnosis
	Pain (M-1/3)		
	Chronic cardiovascular disease (M-1/3)		
NURSING DIAGNOSIS- 00004-Risk for infection	Immunodeficiency inducing medications (H)-Auto	IMPORTANT	Validate diagnosis
NURSING DIAGNOSIS- 00291-Risk for thrombosis	Impaired physical mobility (H)	IMPORTANT	Validate diagnosis
	Chronic cardiovascular diseases (M-1/3)		
	Extreme of age (M-1/3)-Auto		
	High comorbidity index (M-1/3)-Auto		
	Kidney disease (M-1/3)		

Figure 1. Screenshot of VIGIL Care CDSS

5. Conclusions

This study presents the development of VIGIL Care, a NP-CDSS designed to enhance NDs in ICU settings. The Vigil Care system exhibited superior sensitivity and specificity compared to traditional nursing assessment, particularly under time pressure. These findings highlight the necessity of NP-CDSS to assist nurses, especially novices, in decision-making. Integrating NP-CDSS is crucial for accurately identifying NDs, thereby improving care planning, implementing appropriate interventions, and enhancing overall care quality. While the study's limitations regarding the number of tested NDs and patient cases indicate the need for further validation, future research should focus on increasing the range of tested NDs, evaluating the agreement between system suggestions and nursing assessments, and the usability of VIGIL Care, in addition to linking NDs with recommended interventions and outcomes for a complete NP.

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